Fishery Data Series No. 14-36

Hydrologic Investigations in Support of Reservations of Water for Sitkoh Creek, Alaska

by

Jarrod J. Sowa

August 2014

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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HYDROLOGIC INVESTIGATIONS IN SUPPORT OF RESERVATIONS OF WATER FOR SITKOH CREEK, ALASKA

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ABSTRACT

The Sitkoh Creek watershed, located on Chichagof Island near Angoon, supports a number of anadromous fish species. Through a process of ranking priority watersheds for the protection of instream flow, Alaska Department of Fish and Game, Division of Sport Fish selected Sitkoh Creek as a candidate water body for a reservation of water. Two anadromous reaches of the creek were selected for protection of instream flows. In order to collect the data necessary to file an application, hydrologic data were collected over eight years at nine locations within the Sitkoh Creek watershed. A streamgage was operated on the mainstem of Sitkoh Creek near the outlet of Sitkoh Lake from June 16, 2006 to October 14, 2011. Instantaneous measurements of discharge were taken concurrently at a site near the mouth of the creek. A positive linear relationship was found to exist between these stations. Streamflow data collected at the stations, and the relationship in discharge between them, were used to prepare two reservation of water applications for the protection of fish habitat, migration and propagation. The applications were filed using three years of preliminary data and accepted by Alaska Department of Natural Resources with a priority date of October 25, 2010. After five years of streamflow data were collected and analyzed, updated streamflow statistics and instream flow requests were submitted to and accepted by the Alaska Department of Natural Resources on April 18, 2013. The applications are now in pending status until the adjudication process begins. The mean annual discharge of the creek at the streamgage averaged 74 ft^3/s. The mean monthly discharge ranged from 30 ft^3/s in July to 147 ft^3/s in October. Stream discharge measured on the mainstem indicated that there was a gain in discharge between stations along the length of the creek during all seasons.

Key words: Sitkoh Creek, streamgage, discharge, reservation of water, instream flow

INTRODUCTION

Alaska's rivers and lakes support some of North America's most viable and productive salmon fisheries. Over 17,000 streams, rivers, or lakes have been identified throughout the state as being important for spawning, rearing or migration of anadromous fish (Johnson and Daigneault 2013). These anadromous fish populations are very important both culturally and economically to the State. Fish migration, spawning, rearing, and ultimately fish productivity in these water bodies are dependent upon sufficient seasonal quantities of water. To complete their life cycles, fish populations are dependent upon in-channel and floodplain habitat types created by the natural flow regime (Poff et al. 1997). Demand for water to support hydroelectric power generation, petroleum production, mining, water supply (including out-of-state export), residential, forestry, agriculture, and other projects have the potential to modify the naturally occurring instream flows to which fish have adapted (Poff et al. 1997).

The Fish and Game Act requires the Alaska Department of Fish and Game (ADF&G), to "manage, protect, maintain, improve, and extend the fish, game and aquatic plant resources of the state in the interest of the economy and general well-being of the state" (AS 16.05.020). One mechanism ADF&G uses to fulfill its mandate is to reserve water in rivers and lakes for fish and wildlife. An appropriation of water that remains within a river is legally defined under Alaskan law (AS 46.15.145) and regulations (11 AAC 93.970) as a reservation of water (reservation). To reserve water, an application with supporting data and analyses must be submitted to the Alaska Department of Natural Resources (DNR). A minimum of five years of mean daily flow data is recommended by DNR to quantify instream flow requirements within an application.

The State of Alaska Legislature amended the Alaska Water Use Act in 1980 to allow instream flows to be legally reserved by a private individual, group, or government agency in order to maintain specific flow rates in a river or volumes and water levels in a lake during specified time periods for one or a combination of four types of uses:

- protection of fish and wildlife habitat, migration, and propagation;

- recreation and parks purposes;
- navigation and transportation purposes; and
- sanitary and water quality purposes.

The priority date for an application is based on the date that it is accepted by DNR. Alaska water law is based on the doctrine of prior appropriation also known as "first in time, first in right". According to the rules of prior appropriation, the right to the requested amount of water is first given to the appropriator who has the earliest priority date to beneficially use the water. Senior water right holders have a legal standing to assert their right against conflicting uses of water from others who do not have a water right or who are junior in priority.

ADF&G began a project in 2001 that ranked Southeast Alaska watersheds by their importance for the protection of instream flows. From this study, Sitkoh Creek ranked 22nd out of the 4,597 watersheds in Southeast (Klein 2012). In 2003, ADF&G began a multi-year project funded by the Alaska Sustainable Salmon Fund to collect the hydrologic data necessary to file reservations to protect instream flows within the Sitkoh Creek watershed. Before this study began, no hydrologic data existed that could be used to support reservations. This report summarizes an eight year study to collect the streamflow data necessary to file reservations for two reaches of Sitkoh Creek.

OBJECTIVE

The objective of this project was to collect the hydrological data necessary to file reservations to reserve instream flows within two reaches (A and B) of Sitkoh Creek. Four tasks were necessary to complete this objective:

1. install and operate a streamgage at the outlet of Sitkoh Lake for five years to quantify streamflows within Reach B;
2. collect a sufficient number of instantaneous measurements of discharge near the downstream end of the creek within Reach A to determine the relationship between Reach A and Reach B streamflows;
3. correlate measurements within Reach A with concurrent streamflows from the streamgage located in Reach B to estimate streamflows within Reach A using a simple linear regression model; and
4. complete and file reservations for two reaches of Sitkoh Creek to protect fish habitat, migration, and propagation.

STUDY AREA

Sitkoh Creek is located in Southeast Alaska on Chichagof Island across Chatham Strait from the community of Angoon (Figure 1). This creek has been specified as important to anadromous fish under Alaska state statute AS 16.05.871 as AWC number 113-59-10040 by ADF&G (Johnson and Daigneault 2013). Coho salmon (*Oncorhynchus kisutch*), pink salmon (*O. gorbuscha*), sockeye salmon (*O. nerka*), chum salmon (*O. keta*), steelhead trout (*O. mykiss*), rainbow trout (*O. mykiss*), cutthroat trout (*O. clarki*), and Dolly Varden (*Salvelinus malma*) utilize this reach of Sitkoh Creek for either a portion or all of their spawning, incubation, rearing, and migratory life phases (Johnson and Daigneault 2013).

Fish weirs that operated on Sitkoh Creek in 1936, 1937, 1982, 1990, 1993, 1996, and from 2003 to 2008 showed escapement counts of adult steelhead trout ranging from 392 to 1,108 with an average of 705 adult steelhead a year (Love and Harding 2012). A multi-year assessment of the steelhead population was initiated in 2003 by ADF&G to collect a variety of biological and population demographic data (Love and Harding 2008). A steelhead habitat capability study was also initiated by ADF&G in 2005 and completed in 2007 (Crupi and Nichols 2012).

The creek flows approximately 3.5 miles from Sitkoh Lake to saltwater at Sitkoh Bay. Two major unnamed tributaries enter the creek downstream of the lake and are herein referred to as Tributary One and Skiff-Logjam Creek (Figure 2). Downstream of the lake outlet is a 0.75 mile section of floodplain habitat characterized by large wood, gravel bars, and gravel-sand-silt substrate. Approximately one mile below this section is a canyon with bedrock walls, deep pools, and boulder-cobble-large gravel substrates. From the canyon downstream to Sitkoh Bay is another flood plain reach with high densities of large wood.

Sitkoh Lake sits at an elevation of 200 ft. and is surrounded by mountains reaching 2,500 ft. in elevation. The lake has a surface area of 189 ha, is 2.5 miles long, and has a maximum depth of 138 ft. Three sizeable unnamed tributaries enter the lake and are referred to as East Cabin Creek, Anniversary Creek, and West Cabin Creek. Two U.S. Forest Service cabins are located on the lake and are accessible by floatplane and logging roads (Figure 2).

Sitkoh Creek is located within the northern temperate rainforest that dominates the Pacific Northwest coast of North America. This area’s weather is characterized by a cool maritime climate with abundant year round precipitation (Nowacki et al. 2001). The Sitkoh Creek drainage is primarily within the Tongass National Forest, with the exception of a small native allotment near the creek mouth. Timber harvest occurred within the watershed between 1969 and 1974 and included logging of the spruce-hemlock forest surrounding the lake and creek.

METHODS

REACH DELINEATION

The funding for the project limited its scope to reaches of the stream identified as supporting anadromous fish. Reservation reach boundaries were further refined so as to minimize the difference in flows (from accretion and reduction) within each reach. United States Geologic Survey (USGS) topographic maps, ground reconnaissance, drainage basin characteristics, and the AWC were used to aid in the selection of reach boundaries.

Two reaches (A and B) of Sitkoh Creek were selected for instream flow protection (Figure 2). Reach A began at the mouth of the creek at mean lower low water and extended upstream 1.4 miles to the confluence with Tributary One. Reach B began just upstream of Reach A and extended upstream 2.5 miles to the outlet of Sitkoh Lake (Figure 2).

HYDROLOGIC DATA STUDY DESIGN

ADF&G operated a streamgaging network to collect the hydrologic data necessary to reserve streamflows within the two identified reaches. A streamgaging network consists of an index streamgaging station that is operated over a period of many years, and an associated network of semi-permanent stations (e.g., streamgages, staff gages, instantaneous discharge measurements), which are operated concurrently on nearby reaches, tributaries, and sometimes streams, if hydrologically similar (Klein 2013).

To describe hydrologic conditions within Reach A, streamgage 10301 was installed near the downstream end of the reach (Figure 3). This gage was operational from May 27, 2003 until November 29, 2004 when a high flow event eroded the streambank and destroyed the site. To replace this gage, ADF&G installed streamgage 10302 also near the downstream end of Sitkoh Creek (Figure 3). This gage was operational from April 11, 2005 until November 22, 2005 when another high flow event similarly eroded the streambank at the gage site. Streamflow data records collected at the two streamgage sites were not of sufficient length to meet DNR's recommendation that five years of streamflow data be used to file a reservation. Scoping for a new gage site began the following spring, but a suitable site could not be found within Reach A.

Since site conditions were not ideal for a streamgage in Reach A, it was decided to scope for a new site near the upstream end of the creek. In the spring of 2006, a suitable site for a streamgage was found at the outlet of Sitkoh Lake near the upstream boundary of Reach B (Figure 3). Streamgage 10303 was installed on June 16, 2006 and remained in operation until October 14, 2011. Streamflow data from this gage were used to describe hydrologic conditions within Reach B (from the lake outlet to the confluence with Tributary One).

To determine the relationship between streamflows in Reach B (streamgage 10303) with streamflows in Reach A, instantaneous discharge measurements were taken near the bottom of Reach A at discharge station 10309 (Figure 3). Streamflows estimated using this relationship were used to describe hydrologic conditions within Reach A.

To determine the contribution of streamflows from various tributaries, instantaneous measurements of discharge were taken periodically when time allowed. Discharge measurement stations were located at the downstream end of Tributary One (station 10304), on the mainstem of Sitkoh Creek just upstream of Tributary One (station 10305), at the downstream end of Skiff-Logjam Creek (station 10306), at the downstream end of East Cabin Creek (station 10307), and at the downstream end of Anniversary Creek (station 10308) (Figure 3 and Table 1).

GAGING STATION

The objective of operating a streamgage is to obtain a continuous record of discharge at the site (Carter and Davidian 1968). The collection of stage and direct measurements of discharge are essential components in the operation of a streamgage. A continuous record of stage is obtained by installing instruments that sense and record water-surface elevation in the stream relative to an established datum (staff gages, for this project). Direct measurements of discharge are taken at different times of year and with varying flow rates in order to define the stage-discharge relationship (rating curve) and to detect the timing and magnitude of changes to this relationship over time. ADF&G followed USGS streamgage operation protocols and procedures described in Rantz and others (1982) and Klein (2013).

Rantz and others (1982) provides guidance for selection of a streamgage site. The ideal site includes a straight section of stream upstream and downstream of the site where flow is confined to one channel, and where the streamgage site is far enough upstream from the confluence with another stream so as to not be affected by backwater. Each streamgage for this project was located in a pool, with a stable hydraulic control, and far enough upstream of confluences so as not to be affected by backwater.

Table 1.–Sitkoh Creek Streamgage and discharge measurement station locations and periods of record.

Station #	Station type	Station location	Latitude	Longitude	Period of operation
10301	Streamgage	Downstream end Sitkoh Creek	57° 31' 07.68" N	134° 57' 56.32" W	05/27/2003 to 11/29/2004
10302	Streamgage	Downstream end Sitkoh Creek	57° 31' 11.04" N	134° 58' 43.56" W	04/11/2005 to 11/22/2005
10303	Streamgage	Outlet of Sitkoh Lake	57° 30' 50" N	135° 02' 31.92" W	06/16/2006 to 10/14/2011
10304	Discharge	Downstream end Tributary One	57° 31' 13.9" N	134° 59' 41.6" W	08/30/2006 to 10/22/2007
10305	Discharge	Sitkoh Creek upstream of Tributary One	57° 31' 05.32" N	134° 59' 50.11" W	08/30/2006
10306	Discharge	Downstream end of Skiff Logjam Creek	57° 30' 57.38" N	135° 02' 17.79" W	06/16/2006 to 06/04/2008
10307	Discharge	Downstream end of East Cabin Creek	57° 30' 49.37" N	135° 03' 08.77" W	06/16/2006 to 06/04/2008
10308	Discharge	Downstream end of Anniversary Creek	57° 30' 37.21" N	135° 02' 51.94" W	08/31/2006 to 05/30/2007
10309	Discharge	Downstream end of Sitkoh Creek	57° 31' 09.12" N	134° 57' 34.96" W	03/01/2005 to 10/14/2011

At streamgage stations 10301 and 10302, vented General Electric® Druck PDCR 1830 pressure transducers[1], +/- 0.1% accuracy, were used to measure water level (stage). The transducers were housed within 1½-inch perforated wellheads that were driven through an undercut stream bank and into the stream substrate. A vented polyurethane cable ran from the transducer through flexible metal conduit and was wired to a Campbell Scientific® Instruments CR10X data logger housed in a weather-proof box. The data logger was programmed to turn on the sensors and record stage at 15-minute intervals and ambient internal data logger air temperature at four-hour intervals.

To measure stage and water temperature at streamgage 10303, one Insitu® Level Troll 500 pressure transducer was housed in 1¼-inch pipe driven through the streambank and secured to the streambed with custom pipe brackets and 5/8-inch rebar. The pressure transducer was programmed to measure stage and water temperature on the quarter hour.

A staff gage was installed within each streamgage pool to measure the water surface elevation (WSE) independent of the transducer. At installation, the transducers were programmed to read the corresponding staff gage WSE. At each site visit, the staff gage and transducer WSE were compared to ensure stage was being accurately measured by the transducer. To monitor possible changes in the elevation of the staff gage, three reference marks (RMs), consisting of large galvanized lag screws driven into spruce trees, were established near each gage. During the installation of the streamgages, the difference in the elevations of the RMs in relation to the staff gage was measured using standard differential surveying techniques (Kennedy 1990). The RM and staff gage elevations were surveyed at a minimum once a year and also when the streamgages were removed.

DISCHARGE MEASUREMENTS

Streamflow, or discharge, is defined as the volume rate of flow of water and is typically reported in cubic feet per second (ft^3/s or cfs; Buchanan and Somers 1969). Discharge is determined by measuring the average velocity, depth, and width of sub sections across the stream. Discharge measurements were collected using a top set wading rod and either a Price AA or Pygmy velocity meter. A JBS Energy, Inc. AquaCalc® electronic digital counter was used to record the transect parameters, count meter revolutions, and to calculate discharge. During high water conditions, a Streampro© Acoustic Doppler Current Profiler (ADCP) was used to measure discharge. One person with a rope crossed the creek near the discharge transect, and the tethered Streampro© was towed back and forth across the river to take a discharge measurement. Using a Bluetooth connection, data collected by the ADCP was recorded on a ruggedized laptop computer.

Discharge measurements were taken following USGS protocols periodically throughout the year and during periods of extreme low and high flows (Rantz and others 1982). During winter when the creek was covered in ice, the ice was removed approximately three feet upstream and downstream of the transect in order to collect a discharge measurement.

SITE VISITS

Site visits to streamgages 10301 and 10302 were made eight times from May 2003 to October 2004 and five times from April 2005 to October 2005. To access Sitkoh Creek, a floatplane was chartered

[1] Product names used in this report are included for scientific completeness and do not constitute a product endorsement.

from Juneau to the mouth of the creek at Sitkoh Bay. From there staff walked along a trail to the streamgage sites. During a typical site visit, data were downloaded from the data logger, stream discharge was measured, staff gage readings were taken, and routine gage maintenance was performed. Data were downloaded from the transducer using a Palm Pilot™ or an InSitu Rugged Reader™ handheld computer. Discharge measurement data, staff gage readings, and other site visit notes were recorded in waterproof field notebooks. Photographs of the staff gage, discharge measurement transect, and the stream were typically taken at every visit.

Site visits to streamgage 10303 and discharge measurement station 10309 were made five to six times a year over their five years of operation. Typically, a helicopter was chartered from Juneau to transport two staff to the mouth of the creek to take a discharge measurement at station 10309. While that measurement was being taken, the helicopter transported two other staff to streamgage 10303. During longer site visits and when time allowed, discharge measurements were also taken at other discharge measurement stations.

After a site visit, discharge measurement data were downloaded from the AquaCalc® or ADCP laptop to MS Excel®, pictures were downloaded and labeled, and data were downloaded from the Palm Pilot or Rugged Reader to a desktop computer. Transducer stage, staff gage readings, air temperature, and discharge measurement data were imported into the Water Information System Kisters Incorporated© (WISKI©) hydrological software package database for storage and analysis.

STREAMFLOW RECORDS COMPUTATION

Streamflow records computation is a step by step process in which stream stage measured at the streamgage is converted to discharge using the stage-discharge relationship (rating curve). Before being converted to discharge, the stage record was corrected for movement of the staff gage, transducer movement and drift, and fill and scour of the hydraulic control. WISKI© was used to develop rating curves, make corrections to the stage record, apply rating curves to corrected stage values to calculate 15 minute discharges, and summarize these discharges to mean daily, mean monthly, and mean annual flow values. Missing or suspect data caused by ice, operator error, or recorder malfunction were estimated by using the hydrographic- and climatic comparison method (Rantz and others 1982). This included comparison of water temperatures measured by the transducer, looking at nearby weather records, trends of the hydrograph, and instantaneous discharge measurements.

Computed discharge values were typically summarized as mean daily, mean monthly, and mean annual flow values for the water year (October 1-September 30). The procedures used to compute streamflow records coincide with those described in Rantz and others (1982), Kennedy (1983), and Klein (2013).

Mean daily flow records computed for each gage were analyzed by a series of Statistical Analysis System® programs to estimate the annual, monthly, and mean daily summaries and flow duration values for specified time periods. Mean annual flow was estimated as a mean of the annual mean daily flow values over all complete water years of record. Mean monthly flows were estimated as the mean of monthly mean daily flows for all complete months over the entire period of record. Duration estimates represent the expected frequency of occurrence of mean daily flows within the specified time periods. The durations of daily mean flows were calculated as the percentiles of the empirical distribution of observed values within the specified time periods over the period of record. This provided an estimate of the percentage of time a given mean daily flow was equaled or exceeded within the distribution of mean daily flows for each time period analyzed.

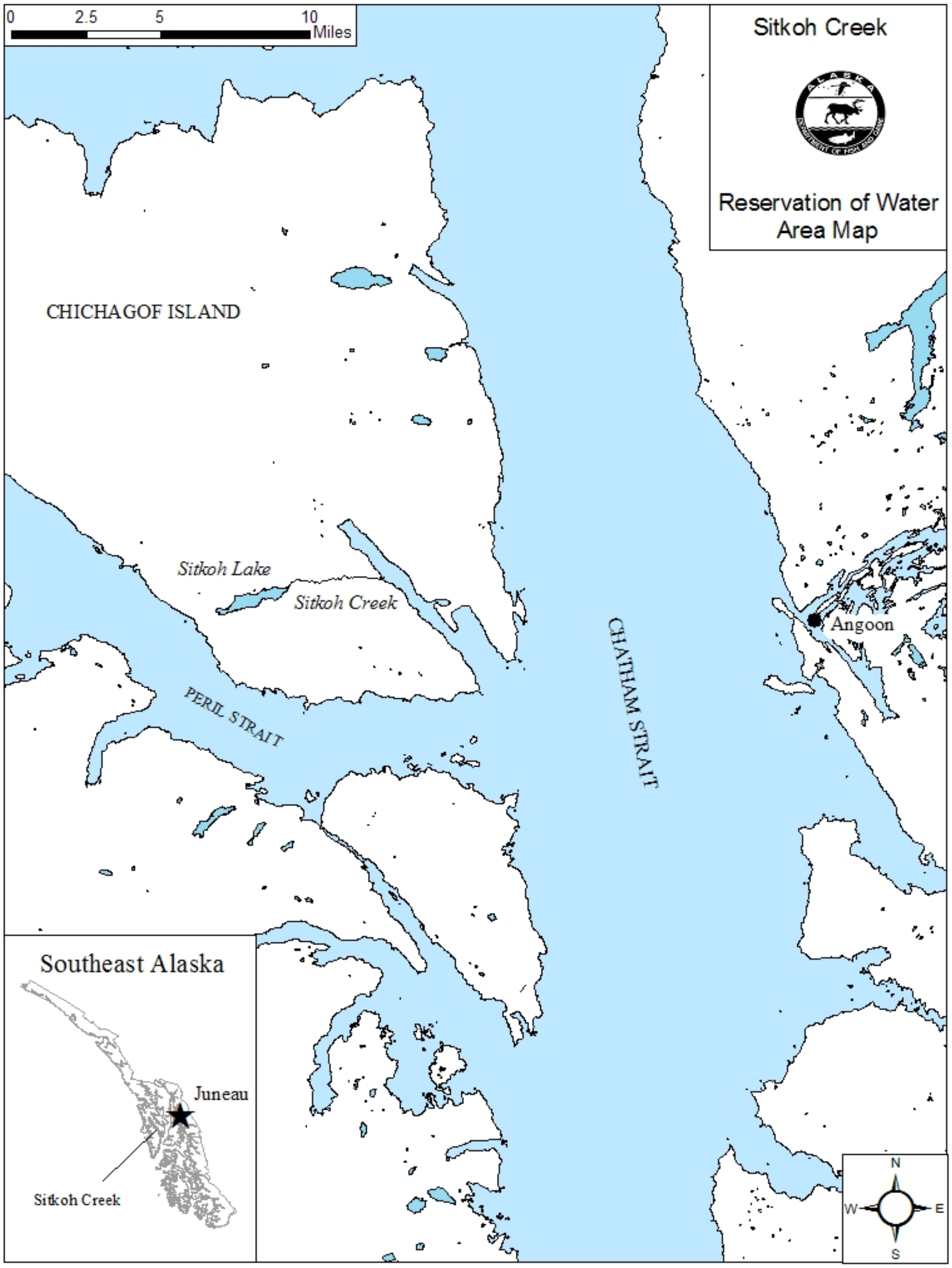

Figure 1.–Location of the Sitkoh Creek watershed in Southeast Alaska near Angoon.

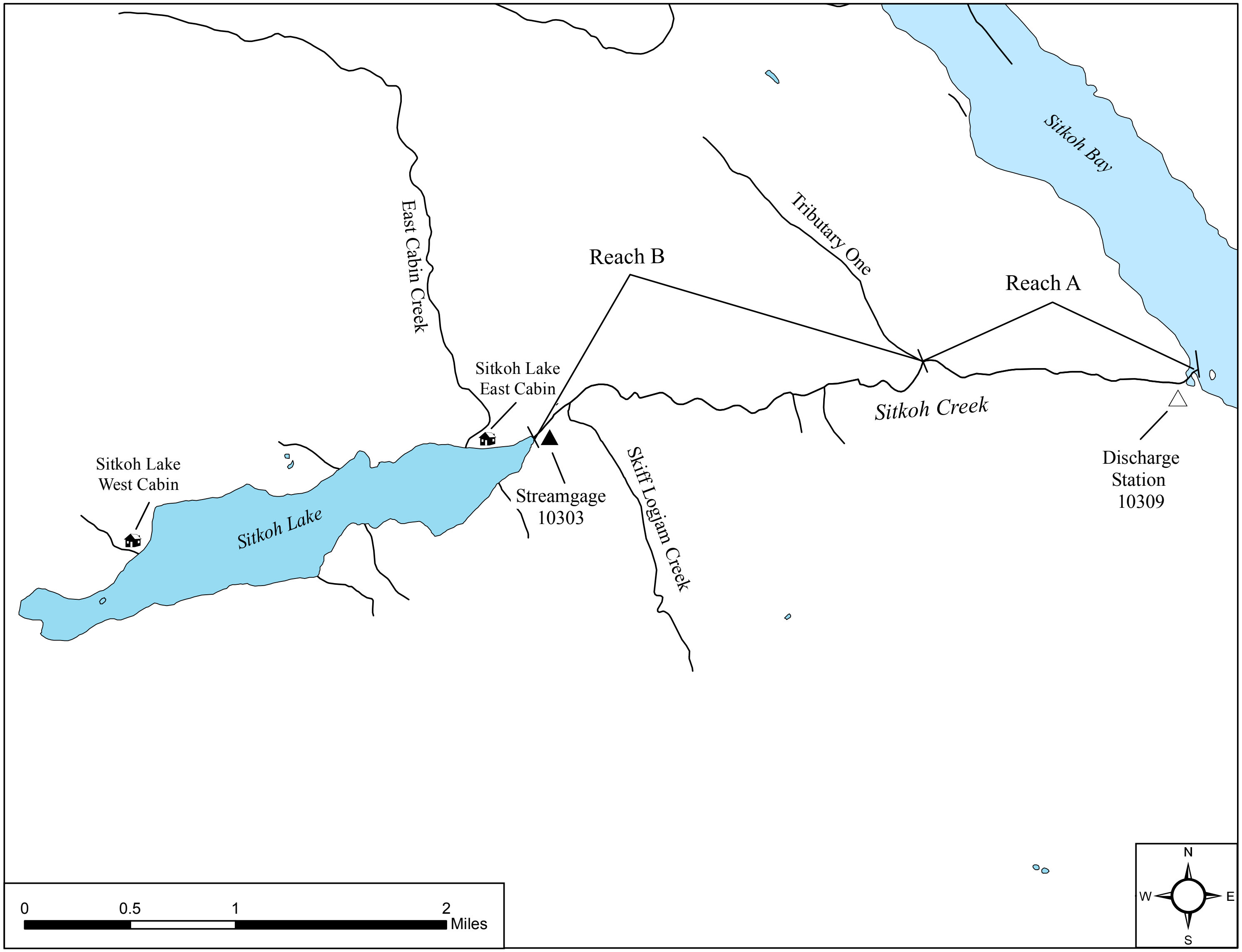

Figure 2.–Location of reservation of water reach boundaries, streamgage10303, and discharge station 10309 within Sitkoh Creek watershed.

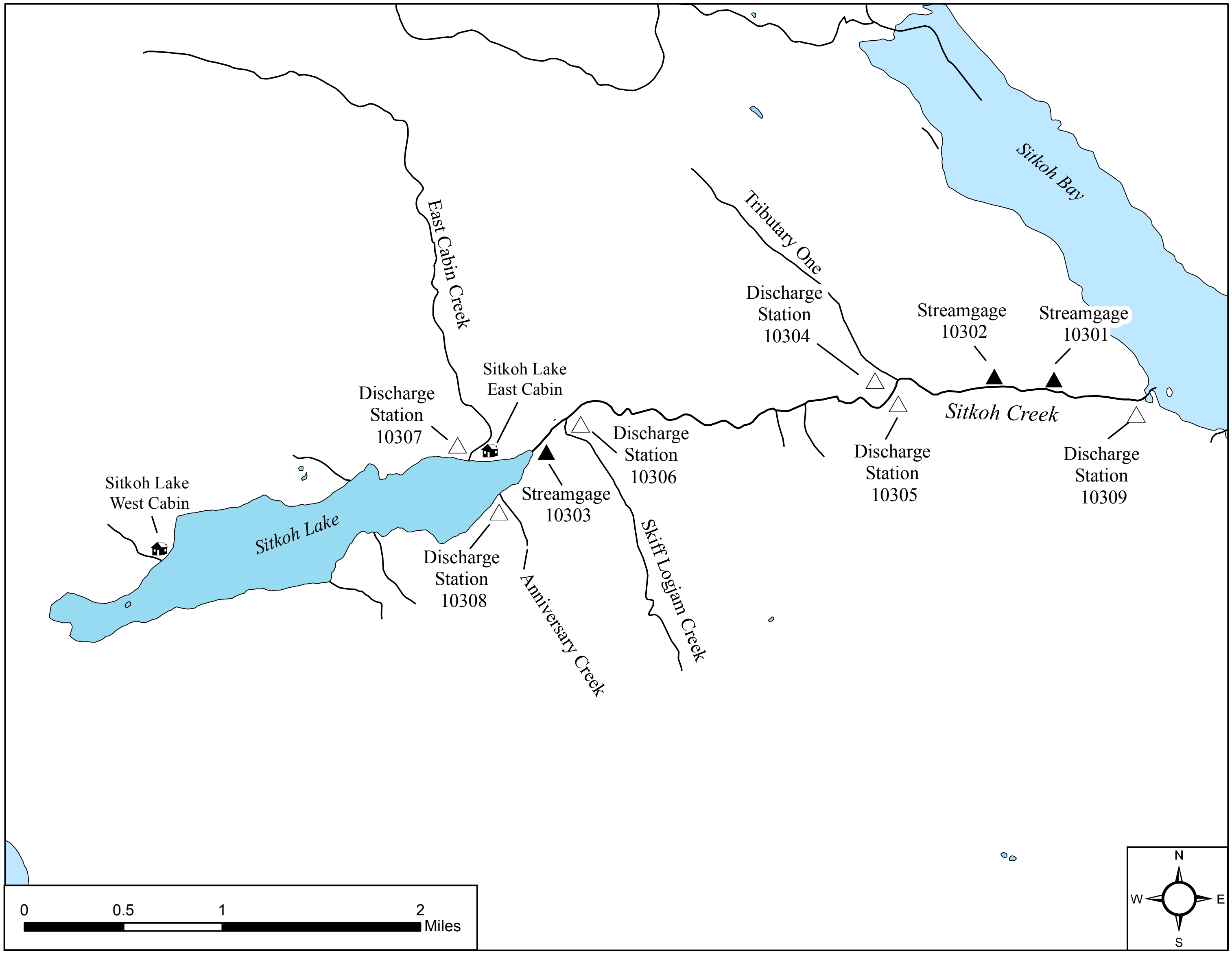

Figure 3.–Location of streamgage and discharge measurement stations within the Sitkoh Creek watershed.

RESULTS

HYDROLOGIC DATA

Streamgage 10301 was operated from May 27, 2003, until a high flow event destroyed the gage site on November 29, 2004. Eight discharge measurements ranging from 27 ft^3/s to 306 ft^3/s were taken at the site from May 28, 2003 to October 8, 2004 (Table 2). Due to incorrect programming of the data logger, wiring to the data logger coming loose, and loss of power to the data logger, stage data from the transducer was not available or was inaccurate for long periods of the record. Mean daily flow data from the streamgage could not be calculated accurately due to these issues.

Streamgage 10302 was operated from April 11, 2005 through November 22, 2005, when a high flow event destroyed the gage site. Five discharge measurements ranging from 9.2 ft^3/s to 125 ft^3/s were taken at the site from April 12, 2005 to October 28, 2005 (Table 2). Mean daily flow data could not be processed due to an insufficient number of discharge measurements being taken at the site to develop an accurate rating curve at higher stage values.

Streamgage 10303 was operated from June 16, 2006 and remained in operation until October 14, 2011. Thirty seven measurements of instantaneous discharge, ranging from 13 ft^3/s to 254 ft^3/s, were taken at the site from May 3, 2006 to October 14, 2011 (Table 2). Mean annual flow at the site ranged from 65 to 82 ft^3/s and averaged 74 ft^3/s for water years 2007 to 2011. The highest flow recorded at the gage was 772 ft^3/s on October 23, 2008 and the lowest flow recorded at the gage was 8.3 ft^3/s on July 17, 2009. Flows were typically lowest during dry spells after most if not all of snow had melted from the watershed which typically occurred from mid-July to mid-August (Figure 4). Flows began to increase from these lows due to rainfall events and typically peaked mid-October to the first week of November during rain on snow events. Flow decreased throughout the winter as the lake slowly drained and began to increase again due to snowmelt from late March to early April. Spring flows typically peaked from the snowmelt in the middle of May and then slowly decreased into August. Appendix A contains mean daily and mean monthly flows summarized by water year. The durations of mean daily flows are also presented in this appendix.

Instantaneous measurements of discharge were periodicaly taken at stations 10304, 10305, 10306, 10307, 10308, and 10309 during the project (Table 3). The number of measurements taken at each site ranged from one on the mainstem upstream of Tributary One (station 10305) to 22 measurements taken at the mouth (station 10309). The lowest discharge measured was 0.50 ft^3/s at Tributary One on July 31, 2007 (discharge station 10304) and the highest was 306 ft^3/s at the mouth (discharge station 10309) on May 1, 2009.

Table 2.–Instantaneous measurements of discharge taken at streamgages 10301, 10302 and 10303.

Date	Discharge (ft3/s)
Streamgage 10301	
05/28/2003	51
06/17/2003	27
06/20/2003	84
10/23/2003	138
10/25/2003	254
03/24/2004	38
10/04/2004	42
10/08/2004	306
Streamgage 10302	
04/12/2005	92
05/29/2005	17
06/24/2005	27
08/16/2005	9.2
10/28/2005	125
Streamgage 10303	
05/03/2006	54
05/04/2006	95
06/16/2006	17
08/29/2006	27
11/21/2006	25
01/23/2007	62
04/04/2007	21
05/29/2007	155
05/29/2007	173
05/30/2007	254
05/30/2007	212
05/31/2007	231
05/31/2007	178
05/31/2007	216
07/30/2007	18
10/22/2007	150
02/15/2008	55
04/23/2008	56
06/04/2008	128
08/21/2008	24
10/28/2008	147
12/18/2008	28
02/25/2008	13
05/01/2009	186
06/02/2009	119
08/21/2009	47
10/13/2009	36
01/22/2010	53
04/09/2010	44
07/02/2010	52
09/08/2010	44
10/27/2010	35
01/13/2011	21
05/04/2011	81
06/23/2011	15
09/08/2011	100
10/14/2011	55

Note: Stream flow values in this report are based on USGS guidelines for daily mean discharge (http://wdr.water.usgs.gov/current/documentation.html#sqw, accessed January 7, 2014): Values of daily mean discharge are shown to the nearest hundredth of a cubic foot per second for discharges of less than 1 ft^3/s; to the nearest tenths between 1.0 and 10 ft^3/s; to whole numbers between 10 and 1,000 ft^3/s; and to three significant figures above 1,000 ft^3/s. The number of significant figures used is based solely on the magnitude of the discharge value. The same rounding rules apply to discharge values listed for partial-record stations.

Table 3.–Instantaneous measurements of discharge taken at discharge stations 10304, 10305, 10306, 10307, 10308, and 10309 and concurrent mean daily flow from streamgage 10303.

	Station 10303[a]	Station 10304[b]	Station 10305[b]	Station 10306[b]	Station 10307[b]	Station 10308[b]	Station 10309[b]
Date	Discharge (ft^3/s)						
03/01/2005	-	-	-	-	-	-	165
06/16/2006	17	-	-	5.1	4.7		-
08/29/2006	23	-	-	4.2	-	-	31
08/30/2006	22	1.2	30	-	-	-	42
08/31/2006	30	-	-	-	27	0.81	-
04/04/2007	21	-	-	-	-	-	21
05/29/2007	153	-	-	100.0	-	-	-
05/30/2007	233	-	-	-	-	3.70	-
5/31/20007	178	-	-	-	49.0		-
07/30/2007	18	-	-	2.6	-	-	-
07/31/2007	18	0.5	-	-	-	-	25
08/01/2007	17	-	-	-	4.4	-	-
08/31/2007	17	-	-	-		-	15
10/22/2007	149	17.0	-	22.0	42.0	-	254
02/01/2008	39	-	-	-	-	-	91
04/23/2008	60	-	-	-	-	-	99
06/04/2008	124	-	-	35.0	30.0	-	-
08/21/2008	25	-	-	-	-	-	30
02/25/2009	14	-	-	-	-	-	14
05/01/2009	204	-	-	-	-	-	306
08/21/2009	77	-	-	-	-	-	90
10/13/2009	33	-	-	-	-	-	41
01/22/2010	56	-	-	-	-	-	79
04/09/2010	43	-	-	-	-	-	61
07/02/2010	48	-	-	-	-	-	78
09/08/2010	43	-	-	-	-	-	53
05/04/2011	81	-	-	-	-	-	181
06/23/2011	15	-	-	-	-	-	20
09/08/2011	100	-	-	-	-	-	114
10/14/2011	55	-	-	-	-	-	72

Note: Stream flow values in this report are based on USGS guidelines for daily mean discharge (http://wdr.water.usgs.gov/current/documentation.html#sqw, accessed January 7, 2014): Values of daily mean discharge are shown to the nearest hundredth of a cubic foot per second for discharges of less than 1 ft^3/s; to the nearest tenths between 1.0 and 10 ft^3/s; to whole numbers between 10 and 1,000 ft^3/s; and to three significant figures above 1,000 ft^3/s. The number of significant figures used is based solely on the magnitude of the discharge value. The same rounding rules apply to discharge values listed for partial-record stations.

Note: "-" indicates that no measurement was taken on this day.

[a] Mean Daily discharge

[b] Instantaneous discharge.

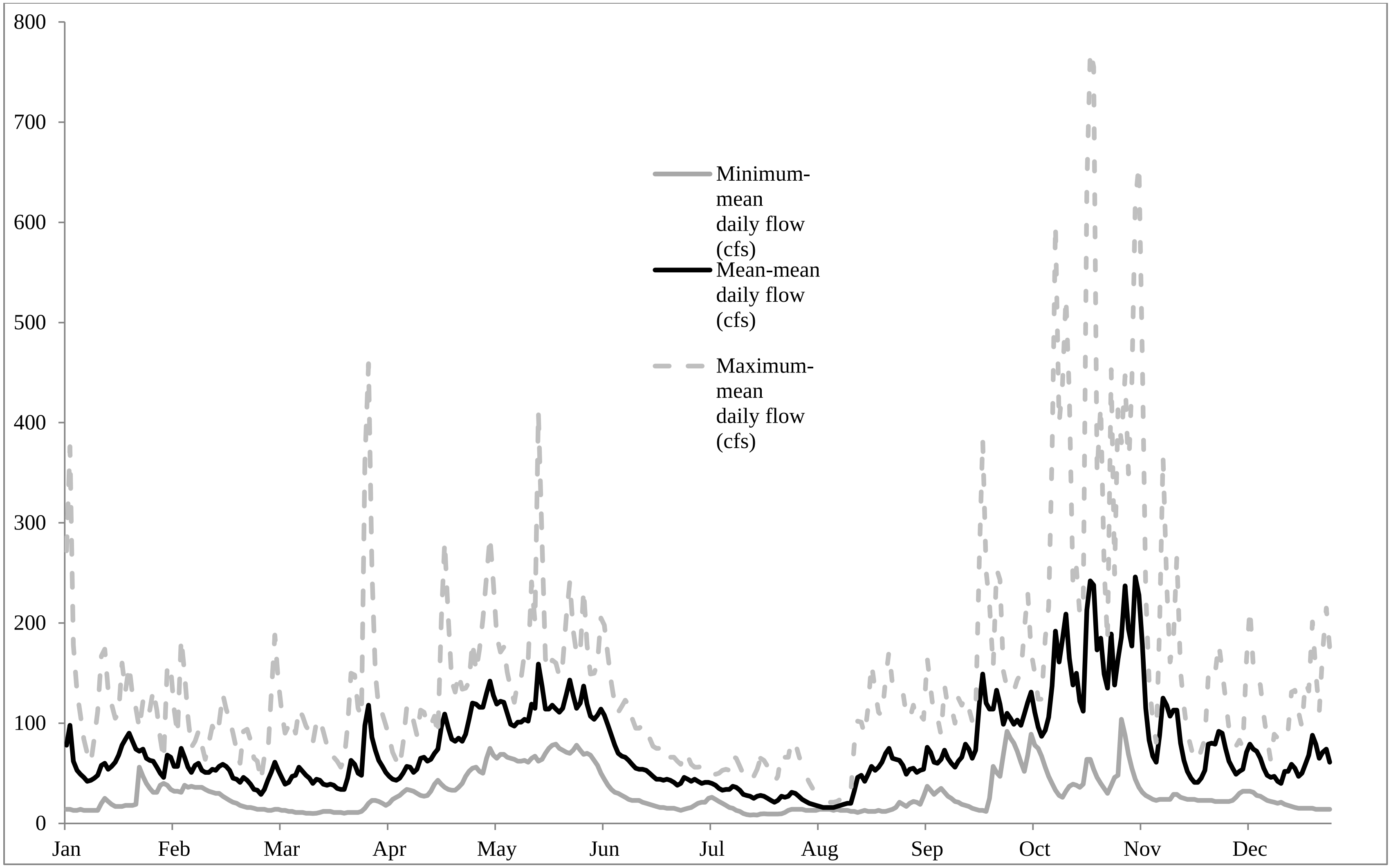

Figure 4.–Annual hydrograph of minimum, mean, and maximum mean daily flows (in cfs) for Sitkoh Creek (October 1, 2006 to September 30, 2011) based on data from streamgage 10303 located at the outlet of Sitkoh Lake.

HYDROLOGIC RELATIONSHIP BETWEEN STATIONS

A simple linear regression model was used to estimate the relationship between streamflow at discharge station 10309, located at the mouth of Sitkoh Creek, and streamgage 10303, located at the outlet of Sitkoh Lake. Instantaneous discharge measurements collected at discharge station 10309 were regressed against the corresponding mean daily discharge values from streamgage 10303 (Table 4). The relationship showed a positive linear relationship, with a coefficient of determination (R^2) of 0.93 (Figure 5). For discharge station 10309, mean daily discharge values from June 16, 2006 to October 14, 2011 were estimated from the respective regression parameters.

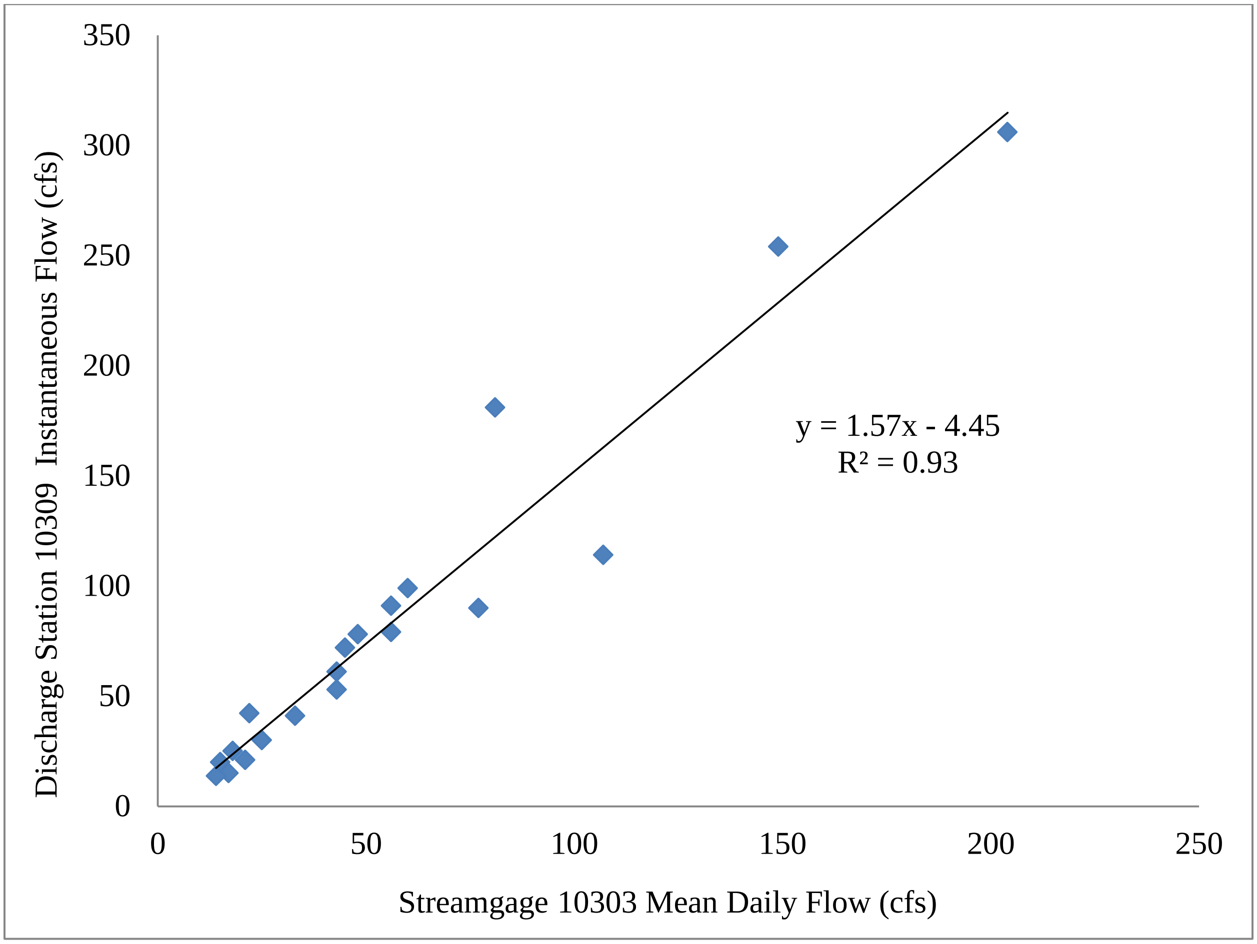

Figure 5.–Simple Linear Regression model used to estimate relationship of streamflows between discharge station 10309 (located in Reach A near the mouth of Sitkoh Creek) and streamgage 10303 (located in Reach B at the outlet of Sitkoh Lake).

APPLICATION FOR RESERVATION OF WATER

Preliminary streamflow data were used to prepare applications for two reaches of Sitkoh Creek. These applications were based on three years of data and included the following components: 1) maps and legal descriptions describing the reach boundaries, streamgage location, and discharge station locations; 2) hydrologic data collected within the watershed; 3) description and justification of the method used to quantify instream flow needs; 4) fish species periodicity chart (Appendix D); and 5) the water quantities requested by time period for each reach. The applications for Reach A and Reach B were accepted by DNR. Reach A was given Land Administration System (LAS) number 27864 and Reach B was given LAS number 27865, respectively. Both applications were given a priority date of October 25, 2010. Following five years of data collection, updated flow statistics and instream flow requests were submitted to DNR on April 18, 2012.

DISCUSSION

According to ADF&G's anadromous waters catalog, over 17,000 stream rivers or lakes have been specified as supporting anadromous fish populations in Alaska (Johnson and Daigneault 2013). These waterbodies are all potentially subject to water withdrawals and modification of their natural streamflows, although most waterbodies in the state are currently not subject to withdrawals, diversions, or impoundments of water and remain free flowing at this time. It is important to protect these unallocated streamflows before competition over the water arises. In 2005, total freshwater surface withdrawals in Alaska were 393 million gallons per day (MGD), compared to 4,190 MGD in Washington and 22,200 MGD in California (Kenney 2009).

ADF&G has filed applications for reservation of water for 213 river reaches and 4 lakes since 1980 and has been granted certificates for 79 river reaches and 1 lake (Klein 2013). There are potentially tens of thousands more stream reaches where instream flows can still be protected within the state. One major stumbling block to filing more application is the lack of available streamflow data that can be used to file reservation of water applications. Only 128 continuous streamgages were operated by the USGS in federal Water Year 2012 (October 1, 2001 through September 30, 2012) (Klein 2013). Recognizing this data limitation, ADF&G began a program in 2001 to collect streamflow data at important fisheries throughout the state.

Sitkoh Creek is an important freshwater fishery that provides habitat for many fish species at various life stages. Prior to this project, no known streamflow data had been collected within the watershed. This project collected five years of streamflow data to support applications for reservations of water within two reaches of Sitkoh Creek.

The stream banks at the lower portion of Sitkoh Creek eroded fairly frequently and were not adequate for the long term stability required to operate a streamgage. Two initial attempts to operate streamgages in the lower reaches were not successful, due in part to stream bank erosion which caused the equipment to become dislodged by high flow events. The initial transducer and associated data logger and power source selected for the project also proved to be difficult to operate in a remote environment. Wires that connected the transducer to the data logger and to the power source were prone to become disconnected at times, which caused loss of stage record data. Programming of the data loggers was also difficult which resulted in additional loss of records.

The stream banks at the lake outlet proved to be more stable and provided a more suitable location for a streamgage. We also used a new type of transducer at this station that was more reliable and simple to operate. The In-Situ brand transducer that was used was a compact sealed unit that was easily programmable, had no wiring that could become dislodged, and was powered by AA lithium type batteries that provided power for up to five years before needing to be replaced.

Stream discharge measured at the streamgage located at the lake outlet and concurrent discharge measurements taken at the mouth showed that there is a gain in discharge along the length of the creek during all seasons (Table 3). During long dry periods in late summer when the snowpack has completely melted from the watershed, the lake provides the majority of the water to the mainstem, and there is little contribution from tributary streams. This observation was also documented in the winter during long cold dry periods. During periods of rainfall and snowmelt, measurements indicate that Sitkoh Creek gains significant discharge from Skiff Logjam Creek.

The five years of data collected at the streamgage were used to quantify available instream flows within Sitkoh Creek. Instream flows were requested to attempt to mimic the natural seasonal patterns of streamflows to which fish have adapted and are dependent upon. All requested flows were near the mean daily flow for the requested time periods. Although not requested, research has shown that flows near bankfull are needed to maintain the channels sediment, riparian vegetation, and floodplain habitat (Leopold et al. 1964; Reiser et al. 1985, Schmidt and Potyondy 2004). Changes in the magnitude, frequency, timing, and duration of these flows could directly lead to biological and geomorphic changes (Whiting 2002).

The accepted applications have not been adjudicated by DNR. If Certificates of Reservations are granted, streamflows within approximately 3.5 river miles of fish habitat would be protected. Klein (2012) provides further information on DNR's water right process. At this time, no major water withdrawals occur within the Sitkoh Creek watershed. Hydrologic data collection on Sitkoh Creek has been completed and streamgage 10303 has been removed.

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APPENDIX A:
ADF&G STREAMGAGE 10303 DATA SUMMARY

Appendix A1.–Streamgage 10303 Water Year 2007 mean daily discharge values reported in cubic feet per second.

	Mean daily discharge (ft^3/s)											
Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	132	106	22	272	32	27	31	118	149	48	17	24
2	98	88	22	376	32	29	28	112	150	44	17	22
3	73	69	23	178	31	34	25	118	160	43	16	21
4	193	55	26	131	42	31	21	128	205	45	16	19
5	231	44	30	108	49	28	25	134	198	47	16	27
6	151	36	57	84	49	30	28	154	167	46	15	70
7	113	31	163	70	45	37	49	176	140	44	15	89
8	84	28	215	61	41	40	80	149	119	41	15	77
9	68	26	157	51	38	40	116	124	111	40	15	74
10	58	24	118	47	34	35	116	109	117	46	15	66
11	60	23	96	39	32	33	102	105	123	51	14	58
12	59	24	83	35	31	32	88	109	118	67	14	50
13	55	24	74	34	30	31	86	109	105	65	14	42
14	83	24	62	33	30	30	84	107	95	57	14	37
15	110	24	50	49	30	29	85	118	95	49	13	43
16	91	29	42	67	40	27	91	142	98	49	13	76
17	75	29	38	63	57	26	86	147	93	52	13	127
18	92	26	50	58	60	30	85	132	85	47	13	115
19	97	25	64	63	56	28	86	126	77	41	13	112
20	89	23	131	62	51	27	87	135	75	36	13	119
21	89	24	133	70	44	29	91	140	74	35	13	149
22	136	23	111	64	39	32	101	137	71	32	14	138
23	163	23	96	56	35	38	131	147	68	29	13	110
24	181	23	82	57	32	45	149	160	64	27	12	96
25	160	23	124	62	31	42	134	170	58	25	12	106
26	178	23	201	56	30	38	135	187	55	23	13	127
27	154	23	151	48	29	35	141	164	55	22	14	122
28	119	22	111	43	28	37	137	139	54	20	16	100
29	90	22	171	41	-	35	137	153	53	22	23	92
30	72	22	215	37	-	34	129	233	51	18	20	85
31	93	-	175	33	-	33		178	-	18	17	-
Total	3,447	986	3,093	2,448	1,078	1,022	2,684	4,360	3,083	1,229	458	2,373
Mean	111	33	100	79	39	33	90	141	103	40	15	79
Max	231	106	215	376	60	45	149	233	205	67	23	149
Min	55	22	22	33	28	26	21	105	51	18	12	19
Acre Feet	6,837	1,956	6,135	4,856	2,138	2,027	5,324	8,648	6,115	2,438	908	4,707
Water Year 2007	Total 26,261			Mean 72		Max 376		Min 12		Acre Feet 52,090		

Note: Stream flow values in this report are based on USGS guidelines for daily mean discharge (http://wdr.water.usgs.gov/current/documentation.html#sqw, accessed January 7, 2014): Values of daily mean discharge are shown to the nearest hundredth of a cubic foot per second for discharges of less than 1 ft^3/s; to the nearest tenths between 1.0 and 10 ft^3/s; to whole numbers between 10 and 1,000 ft^3/s; and to three significant figures above 1,000 ft^3/s. The number of significant figures used is based solely on the magnitude of the discharge value. The same rounding rules apply to discharge values listed for partial-record stations.

Appendix A2.–Streamgage 10303 Water Year 2008 mean daily discharge values reported in cubic feet per second.

	Mean daily discharge (ft³/s)											
Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	80	380	51	46	39	71	33	104	129	56	57	35
2	143	447	43	53	38	57	35	129	121	56	48	38
3	140	306	36	74	38	63	35	151	133	57	41	41
4	120	164	35	70	38	59	31	122	124	55	35	60
5	113	123	33	60	37	50	34	122	110	54	30	60
6	171	98	32	52	37	51	45	123	105	53	26	54
7	150	81	32	46	36	67	45	111	99	49	24	46
8	124	69	32	41	36	90	42	91	90	50	22	47
9	107	59	32	38	36	102	39	85	82	53	21	47
10	105	58	31	37	36	95	47	106	77	54	20	48
11	115	65	31	37	38	86	44	141	73	53	19	66
12	109	63	30	36	49	74	69	145	74	56	24	73
13	135	62	29	42	57	58	113	170	80	57	32	67
14	130	59	60	47	53	58	111	163	78	52	35	77
15	116	61	89	43	56	52	98	241	75	46	32	125
16	99	184	85	54	63	44	98	201	74	43	31	118
17	87	267	80	68	44	56	107	411	76	39	33	120
18	146	152	70	115	26	67	88	282	79	38	31	110
19	182	117	59	157	41	66	68	164	76	54	29	95
20	142	90	50	128	43	59	59	154	72	65	27	99
21	118	76	46	100	92	56	56	163	75	63	25	89
22	149	62	45	81	94	64	55	160	77	57	26	78
23	126	54	79	68	83	96	60	145	71	48	33	73
24	110	55	42	58	65	93	80	159	66	41	60	66
25	104	56	32	54	62	77	80	207	66	47	72	57
26	106	73	11	49	38	71	73	241	62	71	80	51
27	149	77	89	46	67	64	120	193	59	66	73	47
28	167	73	72	41	67	56	181	169	70	66	61	69
29	152	72	61	40	68	53	152	171	67	84	51	135
30	160	61	52	40	-	47	123	163	59	80	43	138
31	413	-	45	39	-	40	-	141	-	67	39	-
Total	4,268	3,564	1,814	1,860	1,477	2,042	2,221	5,128	2,499	1,730	1,180	2,229
Mean	138	119	59	60	51	66	74	165	83	56	38	74
Max	413	447	142	157	94	102	181	411	133	84	80	138
Min	80	54	29	36	26	40	31	85	59	38	19	35
Acre Feet	8,465	7,069	3,598	3,689	2,930	4,050	4,405	10,170	4,957	3,431	2,340	4,421
Water Year 2008		Total 30,012		Mean 82		Max 447		Min 19		Acre Feet 59,530		

Note: - No Data

Note: Stream flow values in this report are based on USGS guidelines for daily mean discharge (http://wdr.water.usgs.gov/current/documentation.html#sqw, accessed January 7, 2014): Values of daily mean discharge are shown to the nearest hundredth of a cubic foot per second for discharges of less than 1 ft^3/s; to the nearest tenths between 1.0 and 10 ft^3/s; to whole numbers between 10 and 1,000 ft^3/s; and to three significant figures above 1,000 ft^3/s. The number of significant figures used is based solely on the magnitude of the discharge value. The same rounding rules apply to discharge values listed for partial-record stations.

Appendix A3.–Streamgage 10303 Water Year 2009 mean daily discharge values reported in cubic feet per second.

	Mean daily discharge (ft³/s)											
Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	114	117	124	15	114	13	22	204	121	46	14	86
2	127	122	95	14	88	14	20	247	124	41	13	69
3	150	124	74	13	76	14	18	286	132	36	13	56
4	125	104	62	13	62	14	20	240	139	33	13	47
5	100	89	55	14	52	13	24	187	140	29	13	41
6	89	90	53	13	47	14	26	171	136	26	14	37
7	78	120	56	13	69	16	28	160	126	24	14	33
8	75	102	61	13	85	15	31	151	114	22	15	29
9	70	83	104	13	72	14	34	135	97	20	19	32
10	63	65	146	13	60	13	33	121	86	18	21	85
11	93	56	138	20	50	14	35	114	80	16	22	138
12	112	51	108	29	42	19	37	113	72	15	23	116
13	139	54	84	39	36	24	38	109	63	13	24	117
14	164	67	61	66	31	23	38	111	57	12	24	100
15	439	140	49	91	27	21	37	103	55	9.9	25	81
16	526	125	42	91	25	20	42	95	56	8.9	27	79
17	428	94	37	84	23	20	68	104	52	8.3	71	97
18	237	78	32	96	21	21	85	135	47	8.5	101	97
19	255	61	28	113	20	20	84	131	42	8.4	88	85
20	208	51	25	122	18	19	81	122	39	9.3	76	72
21	213	48	23	115	17	18	89	116	37	9.5	76	81
22	636	49	21	95	16	16	87	112	35	9.3	83	134
23	772	62	20	74	16	17	79	111	37	9.4	111	155
24	755	73	18	60	15	17	76	110	36	10	107	165
25	349	83	18	49	14	16	81	122	33	10	144	154
26	184	126	18	44	14	17	84	133	30	11	172	254
27	150	136	18	42	14	20	87	126	41	12	139	243
28	181	149	17	38	13	21	102	111	64	13	140	152
29	453	180	17	43	-	20	138	122	59	14	131	110
30	249	153	17	158	-	23	174	145	51	14	131	87
31	144	-	16	155	-	23	-	133	-	14	108	-
Total	7,678	2,852	1,637	1,758	1,137	549	1,798	4,380	2,201	531	1,972	3,032
Mean	248	95	53	57	41	18	60	141	73	17	64	101
Max	772	180	146	158	114	24	174	286	140	46	172	254
Min	63	48	16	13	13	13	18	95	30	8	13	29
Acre Feet	15,230	5,657	3,247	3,487	2,255	1,089	3,566	8,688	4,366	1,052	3,911	6,014
Water Year 2009		Total 29,525		Mean 81		Max 772		Min 8.3		Acre Feet 58,560		

Note: - No Data

Note: Stream flow values in this report are based on USGS guidelines for daily mean discharge (http://wdr.water.usgs.gov/current/documentation.html#sqw, accessed January 7, 2014): Values of daily mean discharge are shown to the nearest hundredth of a cubic foot per second for discharges of less than 1 ft^3/s; to the nearest tenths between 1.0 and 10 ft^3/s; to whole numbers between 10 and 1,000 ft^3/s; and to three significant figures above 1,000 ft^3/s. The number of significant figures used is based solely on the magnitude of the discharge value. The same rounding rules apply to discharge values listed for partial-record stations.

Appendix A4.–Streamgage 10303 Water Year 2010 mean daily discharge values reported in cubic feet per second.

	Mean daily discharge (ft^3/s)											
Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	81	104	103	44	61	128	115	105	68	53	15	20
2	72	123	90	35	54	188	109	98	64	48	15	28
3	61	121	92	31	47	142	98	82	58	43	14	35
4	52	122	76	28	40	112	86	68	50	49	13	33
5	68	620	61	25	36	90	71	65	44	48	12	37
6	112	658	50	23	47	98	63	69	38	45	13	57
7	98	464	41	25	82	102	57	69	34	40	14	52
8	81	231	35	53	92	84	50	66	31	33	14	43
9	67	141	31	85	77	114	43	65	30	29	14	39
10	56	103	28	112	64	107	37	64	28	28	14	35
11	47	81	27	167	56	97	32	62	26	28	14	31
12	40	103	25	174	53	92	30	62	27	31	13	27
13	33	116	23	133	52	80	28	63	26	28	13	25
14	28	201	22	119	100	101	27	60	24	27	13	22
15	26	161	21	105	129	104	28	65	23	25	12	21
16	32	123	20	110	114	92	32	67	22	24	12	19
17	36	99	23	160	104	78	39	62	22	22	11	18
18	39	82	88	132	90	67	69	64	21	20	12	17
19	38	64	93	100	73	62	203	80	20	19	12	15
20	36	51	73	79	60	62	281	85	19	17	12	14
21	39	43	56	65	51	55	204	91	18	17	12	13
22	63	37	44	55	44	49	142	84	19	16	12	13
23	85	38	38	47	39	65	108	77	26	18	14	12
24	90	44	36	40	37	150	86	73	32	20	19	25
25	208	72	52	35	40	148	75	71	33	20	23	98
26	418	147	95	31	43	115	106	70	32	20	25	124
27	256	141	123	31	41	107	120	73	33	19	24	102
28	179	126	110	41	62	361	123	78	30	18	23	102
29	213	148	90	43	-	459	114	79	27	17	21	122
30	162	137	71	57	-	253	102	75	30	16	19	108
31	122	-	55	64	-	150	---	70	-	15	21	-
Total	2,938	4,701	1,792	2,249	1,788	3,912	2,678	2,262	955	853	475	1,307
Mean	95	157	58	73	64	126	89	73	32	28	15	44
Max	418	658	123	174	129	459	281	105	68	53	25	124
Min	26	37	20	23	36	49	27	60	18	15	11	12
Acre Feet	5,827	9,324	3,554	4,461	3,546	7,759	5,312	4,487	1,894	1,692	942	2,592
Water Year 2010	Total 25,910		Mean 71		Max 658		Min 11		Acre Feet 51,930			

Note: - No Data

Note: Stream flow values in this report are based on USGS guidelines for daily mean discharge (http://wdr.water.usgs.gov/current/documentation.html#sqw, accessed January 7, 2014): Values of daily mean discharge are shown to the nearest hundredth of a cubic foot per second for discharges of less than 1 ft^3/s; to the nearest tenths between 1.0 and 10 ft^3/s; to whole numbers between 10 and 1,000 ft^3/s; and to three significant figures above 1,000 ft^3/s. The number of significant figures used is based solely on the magnitude of the discharge value. The same rounding rules apply to discharge values listed for partial-record stations.

Appendix A5.–Streamgage 10303 Water Year 2011 mean daily discharge values reported in cubic feet per second.

	Mean daily discharge (ft^3/s)											
Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	86	221	74	14	38	15	113	50	70	17	19	104
2	74	407	59	14	71	14	93	65	63	20	17	118
3	64	349	47	13	184	14	78	75	58	21	16	102
4	58	440	49	24	150	13	79	81	53	21	17	108
5	91	353	83	39	106	13	66	89	48	25	18	104
6	134	258	76	57	76	12	55	91	43	29	17	165
7	118	200	62	56	57	12	46	90	39	30	16	135
8	115	145	53	47	45	11	48	92	35	29	15	107
9	124	107	45	40	43	11	52	85	31	26	14	106
10	185	83	39	33	61	11	49	84	28	23	13	88
11	216	79	34	28	81	10	44	83	26	21	14	70
12	368	198	31	25	97	9.9	45	74	24	19	13	57
13	599	367	28	21	89	9.8	63	67	23	17	13	48
14	399	240	26	19	71	10	71	67	23	15	13	44
15	228	149	24	17	54	11	63	69	23	14	18	41
16	296	106	23	17	43	12	56	70	21	14	78	37
17	197	78	21	17	35	12	49	72	20	13	102	34
18	175	62	19	18	30	12	43	74	19	12	82	32
19	179	51	18	18	30	11	39	70	18	12	66	30
20	136	43	17	18	33	11	36	75	17	12	116	69
21	101	37	16	19	28	11	34	78	16	11	160	263
22	78	32	15	64	24	10	33	79	15	10	132	384
23	64	29	15	122	22	11	33	75	15	9.8	108	252
24	54	27	15	109	19	11	36	72	15	9.3	106	219
25	46	29	15	113	18	11	40	77	15	9.4	98	155
26	40	28	15	133	19	11	47	85	14	9.5	83	111
27	34	26	14	113	18	12	52	84	13	11	73	82
28	30	25	14	85	17	15	55	79	13	18	81	73
29	38	37	14	64	-	23	56	73	15	21	88	93
30	46	78	14	49	-	76	52	69	16	21	74	106
31	48	-	14	40	-	121	---	70	-	20	60	-
Total	4,421	4,284	989	1,446	1,559	547	1,626	2,364	829	540	1,740	3,337
Mean	143	143	32	47	56	18	54	76	28	18	56	111
Max	599	440	83	133	184	121	113	92	70	30	160	384
Min	30	25	14	13	17	10	33	50	13	9	13	30
Acre Feet	8,769	8,497	1,962	2,868	3,092	1,084	3,225	4,689	1,644	1,071	3,451	6,619
Water Year 2011		Total 23,682			Mean 65		Max 599		Min 9.3		Acre Feet 51,910	

Note: - No Data

Note: Stream flow values in this report are based on USGS guidelines for daily mean discharge (http://wdr.water.usgs.gov/current/documentation.html#sqw, accessed January 7, 2014): Values of daily mean discharge are shown to the nearest hundredth of a cubic foot per second for discharges of less than 1 ft^3/s; to the nearest tenths between 1.0 and 10 ft^3/s; to whole numbers between 10 and 1,000 ft^3/s; and to three significant figures above 1,000 ft^3/s. The number of significant figures used is based solely on the magnitude of the discharge value. The same rounding rules apply to discharge values listed for partial-record stations.

Appendix A6.–ADF&G streamgage 10303 monthly exceedance flows reported in cubic feet per second.

	Discharge (ft^3/s)											
% Time exceeded	January	February	March	April	May	June	July	August	September	October	November	December
0	376	184	459	281	411	205	84	172	415	772	658	215
5	157	100	142	142	233	140	63	111	228	428	367	151
10	122	89	104	130	176	124	54	88	155	255	226	124
15	110	76	93	115	163	114	51	74	135	208	161	104
20	93	67	79	107	154	96	47	51	119	181	143	91
25	79	62	67	98	145	80	44	35	110	164	125	83
30	67	57	62	87	137	76	40	30	104	150	121	74
35	63	53	56	85	131	73	31	26	98	142	104	62
40	58	49	46	81	122	68	28	24	88	131	92	59
45	54	45	38	75	118	63	24	22	80	120	82	53
50	49	43	33	67	111	58	21	21	73	113	76	49
55	46	40	30	56	106	53	21	20	66	106	69	43
60	42	38	27	52	93	45	21	19	57	97	62	36
65	40	37	21	47	85	37	20	17	50	90	58	32
70	38	35	19	43	81	33	20	15	45	83	51	30
75	35	32	16	38	77	30	18	14	38	74	43	26
80	30	30	14	35	73	26	16	14	35	65	32	23
85	23	27	13	33	70	23	14	13	30	58	27	20
90	17	20	11	29	67	19	11	13	22	46	24	18
95	13	17	11	25	64	16	9.5	13	20	37	23	15
100	13	13	9.8	18	50	13	8.3	11	12	26	22	14

Note: Stream flow values in this report are based on USGS guidelines for daily mean discharge (http://wdr.water.usgs.gov/current/documentation.html#sqw, accessed January 7, 2014): Values of daily mean discharge are shown to the nearest hundredth of a cubic foot per second for discharges of less than 1 ft^3/s; to the nearest tenths between 1.0 and 10 ft^3/s; to whole numbers between 10 and 1,000 ft^3/s; and to three significant figures above 1,000 ft^3/s. The number of significant figures used is based solely on the magnitude of the discharge value. The same rounding rules apply to discharge values listed for partial-record stations.

APPENDIX B:
ADF&G STREAMGAGE AND DISCHARGE STATION AVAILABLE DATA

Appendix B1.–The following data used for this report are stored in the WISKI database and are available upon request

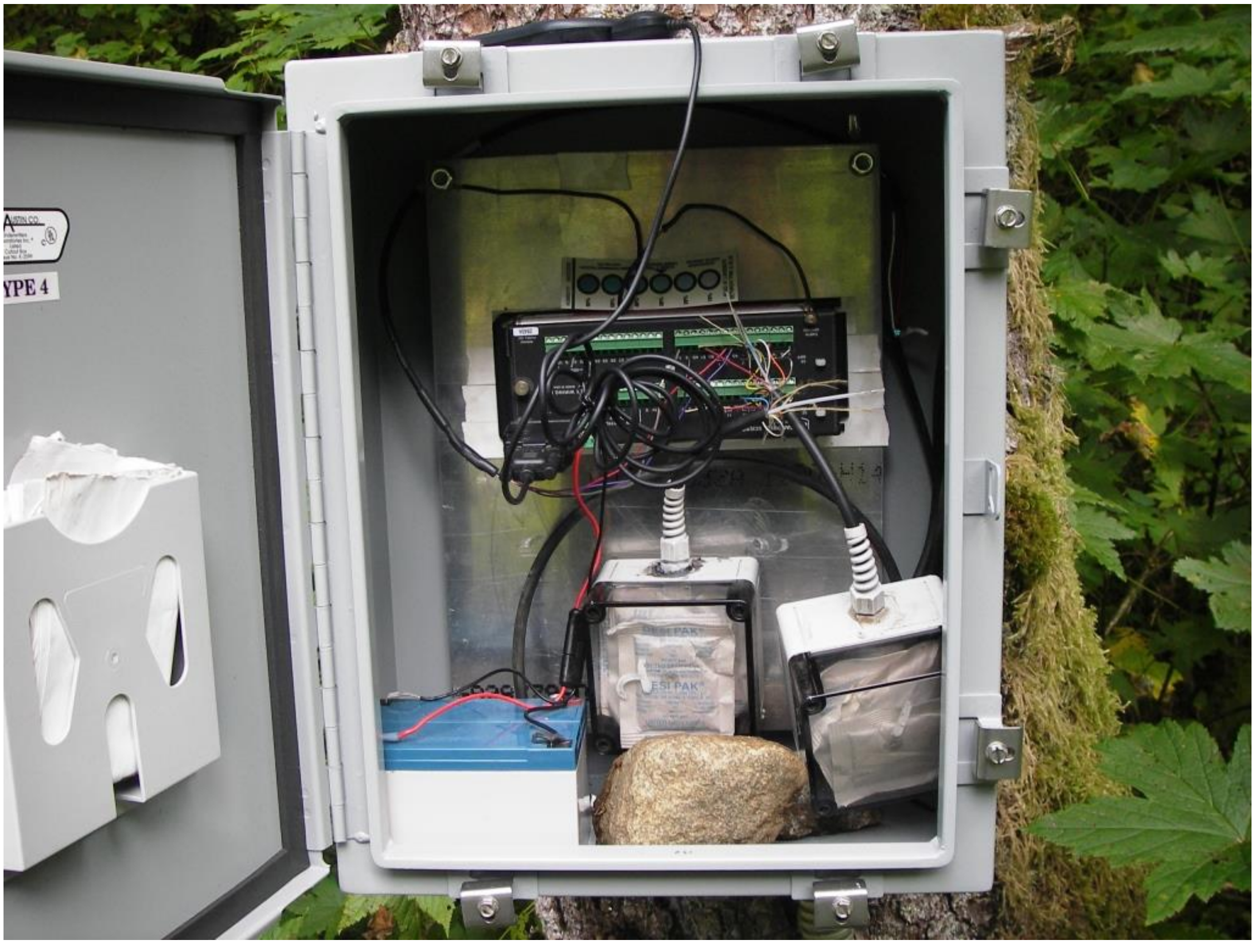
Station	Location	Data Available	WISKI Database Reference
10301	Sitkoh Creek near mouth	Instantaneous Discharge Measurements from 5/28/2003 to 10/8/2004	Sitkoh Cr.Q.Obs.Q
10302	Sitkoh Creek near mouth	Instantaneous Discharge Measurements from 4/12/2005 to 10/28/2005	Sitkoh Creek at.Q.Obs.Q
10303	Sitkoh Creek below lake outlet	Mean Daily Flow from 6/16/2006 to 10/14/2011	Sitkoh Lake outl.Q.DayMean.E
10303	Sitkoh Creek below lake outlet	Instantaneous Discharge Measurements from 05/03/2006 to 10/14/2011	Sitkoh Lake outl.Q.Obs.Q
10304	Tributary One	Instantaneous Discharge Measurements from 8/30/2006 to 10/22/2007	Sitkoh Creek.Tri.Q.Obs.Q
10305	Sitkoh Creek upstream Tributary One	Instantaneous Discharge Measurement from 8/30/2006	Sitkoh Creek ab.Q.Obs.Q
10306	Skiff Logjam Tributary	Instantaneous Discharge Measurements from 6/16/2006 to 6/4/2008	Sitkoh Creek Log.Q.Obs.Q
10307	East Cabin Tributary	Instantaneous Discharge Measurements from 6/16/2006 to 6/4/2008	Sitkoh Lake East.Q.Obs.Q
10308	Anniversary Tributary	Instantaneous Discharge Measurements from 8/31/2006 to 5/30/2007	Sitkoh Lake Anni.Q.Obs.Q
10309	Sitkoh Creek near mouth	Instantaneous Discharge Measurements from 3/1/2005 to 10/14/2011	Sitkoh Cr nr weir.Q.Obs.Q

Note: Contact SARCU Surface Water Data Coordinator ADF&G Division of Sport Fish, Research and Technical Services, 802 3rd St. Douglas, AK 99824.

APPENDIX C:
PHOTOGRAPHS

Appendix C1.–Looking downstream at Sitkoh Creek from the left bank near streamgage 10301 on October 4, 2004, at a discharge of 43 ft^3/s.

Appendix C2.–Looking across Sitkoh Creek from the right bank at streamgage 10302 on October 28, 2005, at a discharge of 125 ft^3/s.



Appendix C3.–Metal enclosure attached to a tree near streamgage 10302 that housed the first data logger and battery used during the project. Note the wiring that was required from both the transducer and battery to the data logger.

Appendix C4.–Landslide in lower reaches of Sitkoh Creek indicating the unstable nature of the stream banks and slopes in this portion of the creek. Photo was taken on October 28, 2005.

Appendix C5.–Looking downstream from streamgage 10303 on the left bank on May 04, 2001 at a discharge of 81 ft^3/s. Note the helicopter used to access the site in the background.

APPENDIX D:
FISH SPECIES PERIODICITY CHARTS

Appendix D1.–Fish species periodicity charts for Sitkoh Creek.

Coho Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage				XXXX	XXXX	XX						
Adult Passage							XXXX	XXXX	XXXX	XXXX		
Spawning								XXXX	XXXX	XXXX		
Incubation	XXXX	XXXX	XXXX	XXXX				XXXX	XXXX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Pink Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage				XXXX	XXXX	X						
Adult Passage							XX	XXXX	XXXX			
Spawning							X	XXXX	XXXX			
Incubation	XXXX	XXXX	XXXX	XXXX			X	XXXX	XXXX	XXXX	XXXX	XXXX
Rearing												

Chum Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage				XXXX	XXXX	X						
Adult Passage							X	XXXX	XXXX	X		
Spawning								XXXX	XXXX	X		
Incubation	XXXX	XXXX	XXXX	XXXX				XXXX	XXXX	XXXX	XXXX	XXXX
Rearing												

Sockeye Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage				XXXX	XXXX	XX						
Adult Passage							XXXX	XXXX	XXXX	XX		
Spawning								XXXX	XXXX	XX		
Incubation	XXXX	XXXX	XXXX	XXXX				XXXX	XXXX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Steelhead Trout	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage					XXXX	XXXX	XXXX					
Adult Passage				XXXX	XXXX	XXXX						
Spawning				XXXX	XXXX	XXXX						
Incubation					XXXX	XXXX	XXXX	XXXX				
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Based upon professional judgment of ADF&G biologists
Smolt passage is for juvenile emigration to estuarine/marine environment
Adult passage: for salmon is immigration: for trout, char, and other species, immigration and emigration.
Incubation life phase includes time of egg deposition to fry emergence
? = Data not available or timing is incomplete
* DV and CT smolt defined as those fish undergoing initial emigration

Dolly Varden	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage				XXXX	XXXX	XXXX						
Adult Passage			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
Spawning									XXXX	XXXX	XXXX	
Incubation	XXXX	XXXX	XXXX	XXXX	XX				XX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Cutthroat Trout	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage			XXXX	XXXX	XXXX	XXXX						
Adult Passage			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		
Spawning				XXXX	XXXX	XXXX						
Incubation					XXXX	XXXX	XXXX					
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Rainbow Trout	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
esident Adult Passage			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		
Spawning			X	XXXX	XXXX	XXXX						
Incubation			X	XXXX	XXXX	XXXX	XXXX	XXXX				
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Based upon professional judgment of ADF&G biologists

Smolt passage is for juvenile emigration to estuarine/marine environment

Adult passage: for salmon is immigration: for trout, char, and other species, immigration and emigration.

Incubation life phase includes time of egg deposition to fry emergence

? = Data not available or timing is incomplete

* DV and CT smolt defined as those fish undergoing initial emigration