Klawock Lake Watershed
Sockeye Spawning Habitat Assessment

Prince of Wales Island, Alaska

by

Cathy Needham[1],

Robina Moyer[1],

Christine Woll[2]

and

Mary Richards[2]

[1] Kai Environmental Consulting Services, Juneau, Alaska
[2] The Nature Conservancy, Juneau, Alaska

January 2018

ACKNOWLEDGEMENTS

We would like to thank ………

- Colin Shanley, The Nature Conservancy, for mapping assistance
- Michael Kampnich, The Nature Conservancy, for photos and impressions regarding Threemile Creek
- Sheila Jacobson, U.S. Forest Service, for providing fish barrier information, document editing/review
- Emil Tucker, U.S. Forest Service, for providing additional analysis interpretation between floodplains and alluvial fans
- Mary Edenshaw for providing information regarding Klawock-Heenya lands
- Kathryn Erickson, Kai Environmental Consulting Services, for document editing
- Pete Brown and Henry Kennedy for conducting 3 summers of spawning habitat data
- Quinn Aboudara and Tars for assisting with stream habitat surveys
- This work was funded in part by the Gordon and Betty Moore Foundation and additional funds were provided by a sub-award through the North Pacific Research Board.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

LIST OF APPENDICES

1.0 Executive Summary

The Klawock Lake watershed, located on Prince of Wales Island in Southeast Alaska, historically supported large sockeye salmon runs important to multiple user groups. In recent times, these runs have significantly decreased, and have impacted local communities both culturally and economically. Assessing sockeye spawning habitat in three main sub-basins of the Klawock Lake watershed is one step in evaluating and addressing potential concerns with the reduced returns. This study focused on the Hatchery Creek, Threemile Creek and Inlet Creek sub-basins. Sockeye salmon spawning surveys were conducted around the peak return of fish from 2014-2016. A desktop comparison of current and historical aerial imagery was conducted to depict landscape changes. Fish habitat surveys were conducted to document channel geomorphologies and availability of key habitat features such as large wood and pools. Additional features, such as a legacy beaver dam on Hatchery Creek and a double culvert system on Threemile Creek were evaluated.

Data showed that sockeye salmon continue to utilize habitat in all three sub-basins for spawning. The Hatchery Creek sub-basin dataset is limited, however survey data allowed for it to be listed in the State of Alaska Anadromous Waters Catalog. Hatchery Creek data was also collected to evaluate a legacy beaver dam for removal, in order to open up approximately 2.9 kilometers of potential upstream good-quality spawning habitat. The beaver dam has been storing a large amount of sediment, so it was recommended the downstream impacts from adding sediment to a floodplain channel bet taken into consideration prior to making a decision about removal.

The Threemile Creek sub-basin continues to be an important sockeye spawning system in Klawock Lake, but analysis shows that historical landscape changes related to timber harvest, road building, and sub-division building have degraded and reduced historical sockeye spawning habitat. A double culvert system at the Klawock-Hollis Highway has changed the downstream hydrology of a historical alluvial fan channel type. Further, the culverts likely hinder fish passage for adults into upstream habitat. Before improvements near this site occur, a detailed hydrological analysis and potential impacts to a downstream subdivision needs to occur. There are potential restoration opportunities for upstream habitat restoration, but it is recommended to evaluate whether past restoration activities such as culvert removal, riparian thinning and sediment control are working first.

The Inlet Creek sub-basin also continues to support returning sockeye salmon for spawning. Currently, the sub-basin functions well and provides good spawning habitat. The systems is limited in instream large wood and large wood recruitment, therefore they system would benefit from monitoring of habitat degradation, and future consideration of large wood restoration should the habitat degrade.

2.0 Introduction

Klawock Lake is located on western Prince of Wales Island, in Southeast Alaska. The lake itself is approximately 1,133 hectares and is fed by numerous tributary streams with the overall watershed being approximately 11,736 hectares. The Klawock Lake Watershed is host to numerous species of anadromous fish, including sockeye salmon (*Onchorhynchus nerka*). While Klawock Lake has been a productive sockeye salmon fishery for centuries, it has seen significant declines in returns over recent decades (Ratner et al., 2006). This is of concern from cultural, subsistence, economic and ecological perspectives, and work has been ongoing to identify reasons for the decline.

Numerous studies over the years have attempted to investigate Klawock Lake sockeye salmon declines and watershed health, including a watershed assessment (CCTHITA and USFS, 2002), a mark-and-recapture study to better estimate sockeye salmon escapement and returns in Klawock Lake (Cartwright and Conitz, 2006), and a historical retrospective analysis of the entire sockeye system (Woll and Prussian 2016). Threemile Creek, Halfmile Creek, Hatchery Creek, and Inlet Creek have been identified as the stream systems which produce the highest number of sockeye salmon in the Klawock Lake Watershed (Cartwright and Lewis, 2004). In addition to population and habitat studies, there is interest in habitat restoration and enhancement opportunities in the Klawock Lake Watershed. A suite of restoration work identified in the "Klawock Watershed Restoration Master Plan" (Keta Engineering, 2003) was completed in the mid-2000s by the Klawock Lake Watershed Council (Klawock Watershed Council, 2008). However, some projects were never completed.

Most of the Klawock Lake watershed is privately owned by two Alaska Native Village Corporations and has been extensively harvested for timber beginning in the 1970s. Since then, the area has seen continued residential and light industrial development, and road construction. The Hatchery and Threemile Creek basins are located primarily on land owned by Klawock Heenya Corporation (KHC) and were logged in the 1980s. Although the Alaska Forest Resources and Practices Act (FRPA) was passed in 1978, it was not until 1991 that it was updated to include guidelines for riparian buffers on private lands (ADNR, 2016a). As a result, timber was harvested within the riparian zones of both streams.

Beginning in 2014, The Nature Conservancy began conducting sockeye salmon spawning surveys in portions of Hatchery, Threemile, and Inlet Creeks to document where sockeye salmon are currently spawning. The investigation expanded to include an analysis of historical imagery of each sub-basin to assess how the overall stream systems may have changed over time. In 2015 and 2016, stream habitat surveys were conducted on portions of Hatchery, Threemile, and Inlet Creeks to further assess the available spawning habitat, as well as potential spawning habitat that is currently not being utilized. While Halfmile Creek has also been identified as a sockeye spawning system, current habitat survey work is not included in this study due to not being able to safely access the creek during high flows. Further, lakeshore spawning was not addressed. The objective of these works is to understand historical changes and current habitat conditions in important sockeye salmon spawning streams and identify opportunities for restoration and enhancement of this habitat in the Klawock Lake Watershed.

3.0 Methods

3.1 Study Area

3.1.1 Hatchery Creek Sub-basin History and Description

Hatchery Creek is located on the western side of Klawock Lake (Figure 1). The Hatchery Creek sub-basin is 1,979 hectares and encompasses 43.13 stream kilometers including several tributaries which feed into the main channel before it empties into Klawock Lake (CCTHITA and USFS, 2002). Timber harvest has occurred over approximately 646 hectares (low estimate) within the sub-basin occurring in the early 1980s (Woll and Prussian, 2016). There is a network of 26.07 kilometers of logging roads in the basin, some of which have been decommissioned (CCTHITA and USFS, 2002). Because these roads are on privately held land, all vehicle access is limited by one gated access road, located off of the Craig-Klawock Highway. KHC shareholders may request access to the area free of charge, while non-shareholders must procure a land use permit.

The road network passes through the Crab Creek watershed, which drains west to Crab Bay near Craig, before entering the Hatchery watershed. While the road bed is intact, it is overgrown in many sections and there is no regular road maintenance, however, it is still passable with a four-wheel drive vehicle. A logging road crosses the section of the Hatchery Creek surveyed in this study, but there are no roads parallel to the surveyed area.

The main channel of Hatchery Creek is classified as a third order stream where the portion of the stream surveyed is identified as moderate floodplain channels (Strahler, 1964, SEAK Hydro, 2016). In the Alaska Department of Fish & Game (ADFG) mark-and-recapture study conducted in Klawock Lake, Hatchery Creek was identified as a known sockeye salmon spawning stream (Cartwright and Conitz, 2006). However, the ADFG Anadromous Waters Catalog (AWC) does not currently list Hatchery Creek as having sockeye salmon present. The AWC lists pink salmon (*Onchorhynchus gorbuscha*) and coho salmon (*O. kisutch*) as present in Hatchery Creek. Historical estimates of available salmon spawning area were not calculated for Hatchery Creek, however the system was mapped denoting marsh and muskeg areas, as well as noting coho salmon rearing habitats (Edgington and Larson, 1979, Woll and Prussian, 2016). There have been no known in-stream restoration projects on the surveyed section of Hatchery Creek, however there have been restoration projects within the Hatchery Creek sub-basin, mostly focused on road closures and fish passage.

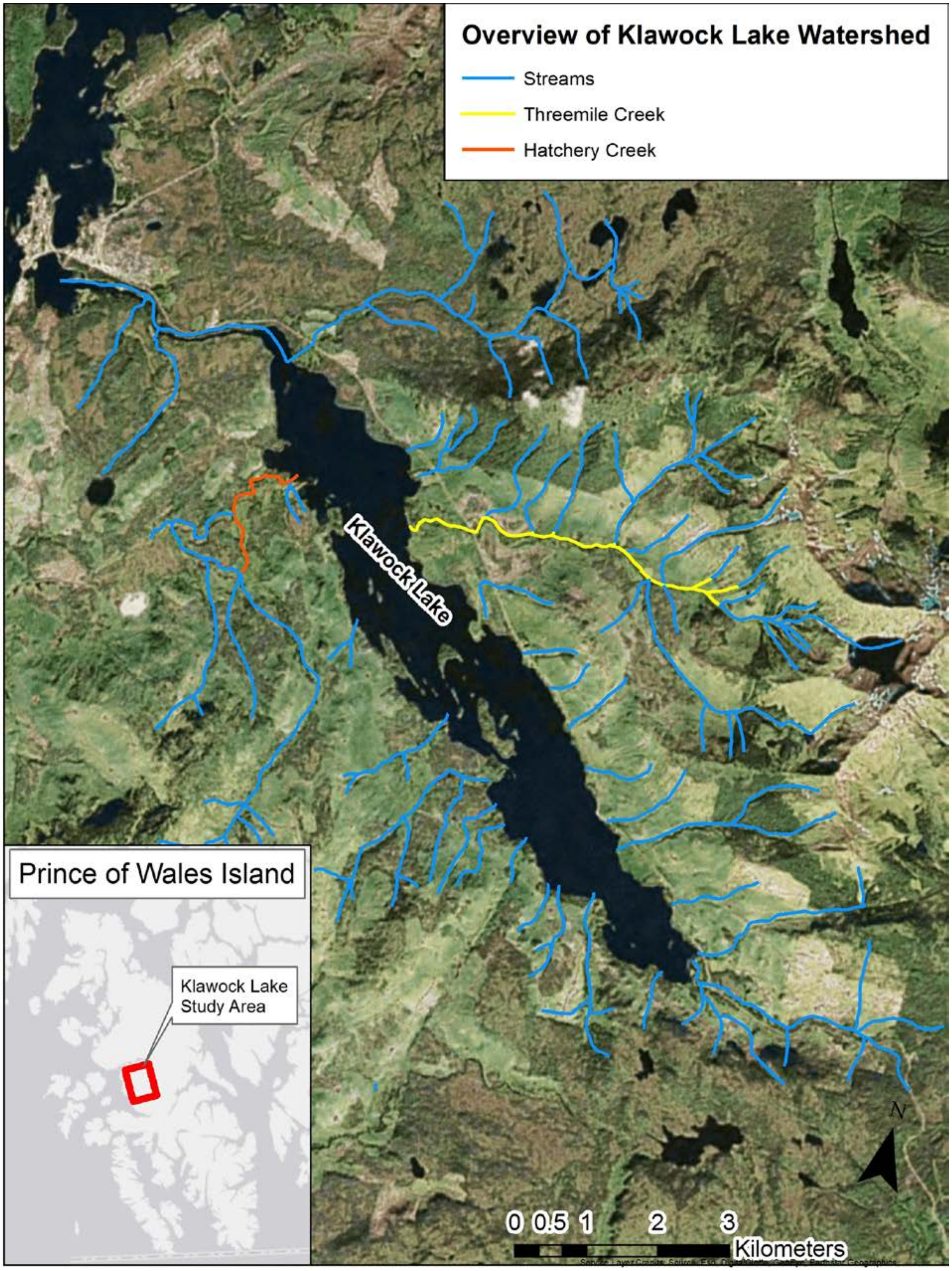

Figure 1: Overview of the Klawock Lake Watershed on Prince of Wales Island, Alaska. Threemile Creek, Hatchery Creek and Inlet Creek are highlighted as important sockeye salmon drainages within the system.

3.1.2 Threemile Creek Sub-basin History and Description

Threemile Creek is located on the eastern side of Klawock Lake and the Creek's sub-basin is 2,111 hectares and encompasses 46.67 stream kilometers (Figure1). Timber harvest occurred in the sub-basin in 1987 with approximately 715 hectares (low estimate) harvested (Woll and Prussian, 2016). There are 28.8 kilometers of logging roads in the sub-basin, the vast majority of them have been decommissioned for motorized traffic through the use of water bars and removal of culverts (CCTHITA and USFS, 2002). Despite this, there is still evidence of human activity in the form of litter and abandoned equipment, including hand tools and parts of vehicles. While some of this is historic, other items appear recent. Although the logging roads in the area are officially decommissioned, sections showed potential use by all-terrain-vehicles. The Klawock-Hollis Highway crosses Threemile Creek approximately half a mile before the creek drains into Klawock Lake, at mile marker 12. No additional roads cross the stream in the surveyed area, but former logging roads run parallel to the creek on both sides. The City of Klawock has applied for water withdrawal rights on Threemile Creek for "beneficial use," however the permit is pending and the area is not currently listed as a drinking water exclusion area (ADEC, 2016; ADNR, 2016b). KHC subdivided their property around the mouth of Threemile Creek in 1991, creating the Klawock Lake Subdivision (M. Edenshaw, personal communication). Lots were given to shareholders in the same year. Access to the lots was already in place at this time, as a logging road was constructed in the 1980s. Development in the Klawock Lake Subdivision likely did not begin until the early 2000s.

The main channel of Threemile Creek is classified as a third order stream, the portion of the stream surveyed is identified as having medium width moderate gradient mixed control and medium floodplain channel types (SEAK Hydro, 2016). The AWC lists coho, pink, and sockeye salmon as present in Threemile Creek, with sockeye salmon limited to the first mile of the creek. Available salmon spawning area in Threemile Creek was estimated prior to timber harvest as 5,846 m^2 (Edgington and Larson, 1979), and historical observations of the system note that this stream has "ideal" habitat and that sockeye spawned "for a long distance" (Moser, 1898). There have been no known in-stream restoration projects in the surveyed portion of Threemile Creek, however extensive restoration work has occurred in the Threemile Creek sub-basin, including culvert replacements, erosion control, and road decommissioning.

3.1.3 Inlet Creek Sub-basin History and Description

Inlet Creek is located on the southeastern side of Klawock Lake. The sub-basin is 961 hectares and includes 21.4 stream kilometers (Figure 1). Timber harvest was relatively low in the Inlet Creek sub-basin, relative to other sub-basins in Klawock Lake, with approximately 157 hectares (low estimate) being harvested (Woll and Prussian, 2016). There are 13.52 kilometers of logging roads in the sub-basin, with the status of the road system being largely unknown (CCTHITA and USFS, 2002). The Klawock-Hollis Highway crosses Inlet Creek and its tributaries at least eight times. The surveyed portion of Inlet Creek included the mouth to the Klawock-Hollis Highway on the main channel.

The main channel of Inlet Creek is classified as a third order stream, where the portion of the stream surveyed is classified as medium floodplain channel type (SEAK Hydro, 2016). The

AWC lists coho, pink, and sockeye salmon present in Inlet Creek throughout the mainstem, as well as steelhead trout (*Onchorhynchus mykiss).* Available salmon spawning area estimated by Edgington and Larson (1979) prior to timber harvest in the watershed, was 2,640 m^2. There have been no known in-stream restoration projects that have occurred in the surveyed reach of Inlet Creek, and very little has been documented regarding restoration work in the Inlet Creek sub-basin, with the exception of a few culvert replacements.

3.2 Spawning Surveys

Sockeye salmon spawning surveys were completed in late summer from 2014-2016. The surveys were performed weekly in the mainstems of Threemile Creek and Inlet Creek for each year. Hatchery Creek was also surveyed however, surveys were limited by access and the time it took to traverse the mainstem. Therefore, Hatchery Creek was only surveyed one to three times each year. Spawning surveys consisted of a two-person crew walking along each stream to observe the presence of sockeye salmon, as well as identify and map areas where sockeye salmon construct spawning redds.

When crews encounter an area in the stream where more than five sockeye salmon are present or where they have identified a sockeye salmon redd, they mark the location with a GPS waypoint point. Then they tally the number of live sockeye salmon and sockeye salmon carcasses associated with the waypoint. If the sockeye salmon is actively spawning, such as constructing a redd, laying eggs, or milting, then the number of spawning sockeye salmon is also recorded. When redds were identified, the length and width of the spawning area was recorded in association with the waypoint. Other information gathered included the type of habitat (i.e. riffle, pool, etc.) and dominant factor driving habitat (i.e. woody debris, bedrock, stream bend, etc.).

A summary table for each sub-basin was created, to represent the sum total of fish observed during each spawning survey. The field crew also recorded the approximate spawning area, when spawning sockeye salmon were present, and that information is presented as total spawning area across the surveyed section of creek for an individual spawning survey. Next, a summary table of dominant habitat type was created by taking the total number of observations for “pools”, “riffles”, “runs”, and a “mix” for each season for each creek system. This summary would represent the dominant habitat type that sockeye salmon are utilizing in each sub-basin for spawning. Finally, data were tabulated and input into Geographical Information Systems (GIS) software. Data across the three years of surveys were pooled for each sub-basin and the total spawning area over time was represented on maps.

3.3 Historical Aerial Imagery Analysis

Historical aerial imagery from 1948, 1972 and 2015 were available for the Klawock Lake watershed. Aerial imagery from each year were geo-referenced in GIS. For reference, the stream habitat survey lines from 2015 and 2016 were presented on each aerial image, to show the images were in the same extent. Features identifiable in the images were noted, including changes in stream course, timber harvest, constructed roads and development. The comparison across years is meant to be descriptive in nature about the changes in each stream system over time.

3.4 Stream Habitat Surveys

3.4.1 Stream Habitat Survey Field Methods

Stream habitat surveys were completed on lower Threemile Creek and on Inlet Creek in July of 2015 and on upper Threemile Creek and on Hatchery Creek in July of 2016. Stream habitat surveys in 2015 followed the protocols of the U.S. Forest Service (USFS) Tier 2 aquatic habitat survey (USFS, 2001). In 2016, habitat surveys followed methods established by ADFG for Southeast Alaska, which is an adaptation of the USFS Tier 2 aquatic habitat survey (Nichols et al., 2013). Spatial data was recorded with the use of a handheld GPS at approximately 20 meter intervals. Notable stream features, such as riparian disturbance, potential barriers to fish passage, and large accumulations of wood are documented with additional notes and photos.

In general, stream segments were broken into reaches based on changes in gradient, substrate, and riparian conditions. At the beginning of each reach, average channel bed width was measured and the value is used to establish size criteria for macro pools and key wood; large wood (smaller than key wood) size criteria is constant regardless of channel bed width. Pools, key wood and large wood were counted for each reach. Substrate data was recorded using the pebble count method within representative areas of each reach. In 2016, a channel type verification (CTV) cross-section was performed in each reach, where additional measurements such as bankfull width and incision depth, were recorded and riparian vegetation was documented. Riparian vegetation was identified from 0-30 meters on each bank using a dichotomous key adapted from Viereck et al. (1992); this key can be found in Appendix A. In 2015, the survey team performed a rapid assessment; therefore no cross-sectional data was recorded nor was riparian vegetation keyed out. All waypoints, stream measurements and tallies from both years were recorded.

3.4.2 Stream Habitat Survey Data Analysis

Extensive work has been done in Southeast Alaska by the USFS, ADFG, and others to establish protocols for stream surveys and standard metrics for comparison of anadromous fish habitat. Paustian et al. (2010) have developed a USFS Channel Type User Guide which documents conditions for the channel types commonly encountered in Southeast Alaskan stream systems. This document also summarizes the suitability of each channel type as spawning and rearing habitat for pink, coho, sockeye, chum (*Oncorhynchus keta*), and Chinook salmon (*O. tshawytscha*), steelhead trout (*Oncorhynchus mykiss*), and Dolly Varden (*Salvelinus malma).* A summary of this guide was used to channel type surveyed reaches and for information regarding habitat suitability during analysis (Table 1).

The USFS Habitat Management Objectives (2007) uses survey data from 279 stream reaches to establish reference metrics for habitat conditions found in floodplain, moderate gradient mixed control, high gradient contained, and moderate/low gradient contained stream channels (Table 2). Tucker and Caouette (2008) also used this dataset in their statistical analysis of aquatic habitats in the Tongass National Forest (Table 3). The results of these two documents provide quantitative reference metrics for habitat conditions, as well as corresponding qualitative values.

Using the data collected during surveys, metrics were calculated for width-to-depth ratio, total large wood pieces per meter, total key wood pieces per meter, total number of macropools per kilometer, and macropool spacing. Statistical analysis of Forest Service datasets (Tucker and Caouette, 2008) revealed three habitat variables which show consistent difference between managed and unmanaged watersheds. These parameters are width/depth ratio, key woody debris, and pool density, and appear strongest in flood plain channels and moderate gradient mixed control reaches. Width-to-depth ratio is an indicator of a stream channel's stability, while large and key wood in a stream plays an important role in habitat creation in a stream by slowing stream flow and creating pools (Tucker and Caouette, 2008). Pools provide additional complexity in the stream course, and provide food and cover conditions (Tucker and Caouette, 2008).

The results of the five calculated metrics were next compared with established USFS metrics and assigned to the appropriate percentile (Table 2) within the appropriate stream process group (USFS, 2007). Each metric was then assigned a qualitative value of "fair," "good," or "excellent" habitat conditions for salmonid species based on its percentile rank; this value assignment was made using criteria established in Tucker and Caouette (2008) in Table 3. Qualitative values were then assigned a value of 1, 2, or 3, which correspond to a value of fair, good, or excellent, respectively. A final score was calculated for each reach by taking the average of the metric scores and the final score was used as the value representing the overall value of the stream reach as fish habitat. In 2015, width-to-depth ratio was not available because no cross-sectional data was recorded, therefore the final score was an average of four metrics rather than five.

Table 1: Available spawning and rearing area by channel type for select anadromous fish in Southeast Alaska streams (Paustian et al., 2010). The channel types below correspond to those found in Hatchery, Threemile and Inlet creeks in the Klawock Watershed on Prince of Wales Island, Alaska.

Channel Type:*	**LCM**		**MCM**		**MMM**		**MMS**		**FPS**		**FPM**	
Species	**Spawning**	**Rearing**	**Spawning**	**Rearing**	**Spawning**	**Rearing**	**Spawning**	**Rearing**	**Spawning**	**Rearing**	**Spawning**	**Rearing**
Coho salmon	Moderate	Moderate	Low	Moderate	Moderate	Low	Moderate	Moderate	High	High	High	High
Pink salmon	Moderate	Negligible	Low	Negligible	Moderate	Negligible	Moderate	Negligible	Moderate	Negligible	High	Negligible
Chum salmon	Moderate	Negligible	Low	Negligible	Moderate	Negligible	Moderate	Negligible	Moderate	Negligible	High	Negligible
Sockeye salmon	Low	Negligible	Negligible	Negligible	Low	Negligible	Low	Negligible	High	Negligible	High	Negligible
Chinook salmon	Negligible	Negligible	Negligible	Negligible	High	Low	Low	Low	Low	Negligible	Moderate	Moderate
Dolly Varden char	High	High	Negligible	Moderate	High	High	High	High	Moderate	High	High	High
Steelhead trout	Moderate	High	Low	Moderate	High	Low	Low	Low	High	High	High	High

** LCM = Medium Low Gradient Contained Channel; MCM = Moderate Gradient Contained Channel; MMM = Medium Moderate Gradient Mixed Control Channel; MMS = Small Moderate Gradient Mixed Control Channel; FPS = Small Floodplain; FPM = Moderate Floodplain*

Table 2: Selected percentiles for habitat metrics in unmanaged channels by channel type based on reference streams in Southeast Alaska (USFS, 2007).

Habitat Variable*	Percentiles	Process Group=FP**	Process Group=MM**	Process Group=MC/LC**	Process Group=HC**	Channel Type=FPS**	Channel Type=FPM**	Channel Type=FPL**	Channel Type=MMS**
WD	25	16.5	10.4	9.2	8.3	10.9	18.5	23.1	10.2
	50	19.3	15.3	14.5	11.1	14.9	20.2	27.2	14.2
	75	26.7	22.4	21.0	13.0	19.0	32.8	43.6	22.0
TLWD/M	25	0.26	0.27	0.20	0.23	0.24	0.31	0.15	0.27
	50	0.36	0.38	0.28	0.34	0.40	0.37	0.17	0.38
	75	0.50	0.50	0.42	0.48	0.55	0.50	0.46	0.51
TKWD/M	25	0.04	0.05	0.05	0.07	0.10	0.06	0.02	0.06
	50	0.10	0.12	0.07	0.08	0.17	0.11	0.03	0.12
	75	0.15	0.14	0.09	0.27	0.25	0.15	0.08	0.14
POOLS/KM	25	30	40	30	50	30	30	10	50
	50	45	60	50	60	40	40	20	60
	75	70	70	60	100	70	60	25	70
POOL SPACE	25	1.4	2.8	2.2	2.4	2.2	1.3	1.7	2.8
	50	2.2	4.0	3.7	3.4	3.2	1.8	2.7	4.0
	75	3.5	5.8	4.8	5.7	5.1	2.2	3.2	5.8

**WD = Width-to-Depth Ratio; TLWD/M = Total Large Wood/Meter; TKWD/M = Total Key Wood/Meter; Pools/KM = Marcopools per kilometer; Pool Space = (Stream Length/Average Channel Bed Width)/Number of Macropools*

***FP = Floodplain; MM = Moderate Gradient Mixed Control: MC/LC = Moderate Gradient/Low Gradient Contained; HC = High Gradient Contained; FPS = Small Floodplain; FPM = Moderate Floodplain; FPL = Large Floodplain; MMS = Small Moderate Gradient Mixed Control Channel*

Table 3: Interpretation criteria for specific variables habitat metrics based on reference streams in Southeast Alaska (Tucker and Caouette, 2008).

Habitat Variable*	< 25th Percentile	> 25th and < 75th	> 75th
WD	Fair	Good	Fair
TLWD/M	Fair	Good	Excellent
TKWD/M	Fair	Good	Excellent
POOLS/KM	Fair	Good	Excellent
POOL SPACE	Excellent	Good	Fair

**WD = Width-to-Depth Ratio; TLWD/M = Total Large Wood/Meter; TKWD/M = Total Key Wood/Meter; Pools/KM = Marcopools per kilometer; Pool Space = (Stream Length/Average Channel Bed Width)/Number of Macropools*

3.5 Culvert Assessment

In September of 2015, The Nature Conservancy completed a fish passage assessment on the double culverts located on Threemile Creek at the Klawock-Hollis Highway crossing. Protocols of ADFG Level 1 fish passage assessments were employed (Eisenman and O'Doherty, 2014). These protocols include surveying culverts for type, sole outfall height, constriction, and other physical parameters. Data was analyzed by classifying culverts as green, gray, or red, based on these protocols; these classifications are meant to reflect adequacy of fish passage for juvenile salmon. The following interpretation can be made for each of the culvert classifications:

- Green: Conditions at the crossing are likely to be adequate for fish passage.
- Gray: Conditions at the crossing may be inadequate for fish passage.
- Red: Conditions at the crossing are likely to be inadequate for fish passage.

The decision matrix from Eisenmen and O'Doherty (2014) was used to classify each culvert as red, gray, or green. In determining how culverts may impact the migration of adult salmon, Table 4 was used to determine adult salmon migration blockages for species in the Klawock watershed.

Table 4. Adult salmonid migration blockages, as modified from the Tongass National Forest Stream Classification Field Guide (USFS, 2015).

Criterion	Sockeye	Coho	Steelhead	Pink/Chum	Dolly Varden
Maximum Fall Height: a blockage is presumed if fall height exceeds:	3.05m (10ft)	3.35m (11ft)	3.96m (11ft)	With pools: 1.22m (4ft) Without pools 0.9m (3ft)	1.83m (6ft)
Steep channel: a blockage is presumed if channel steepness is greater than the following (without resting places for fish):	>696m (225ft) @ 12% gradient >30.5m (100ft) @ 16% gradient >15.2m (50ft) @ 20% gradient			>30.5m (100ft) @ 9% gradient	>15.2m (50ft) @ 30% gradient
Pool Depth: a blockage is presumed if pool depth is less than the following (and pool is unobstructed by boulders or bedrock):	1.25 x jump height, except that there is no minimum pool depth for falls: (a) <1.2m (4ft) in the case of coho and steelhead; and (b) <0.6m (2ft) in the case of other anadromous fish species.				

4.0 Survey Results

4.1 Hatchery Creek

4.1.1 Hatchery Creek Spawning Surveys

Spawning surveys for sockeye salmon were conducted on the lower mainstem and Tributary 2 of Hatchery Creek on September 10, 2014, starting from the mouth of the creek and working as far as the crew could get in and out from Klawock Lake in one day. In 2015, a spawning survey was completed on September 15 in the same location. On September 29, 2015, the survey crew conducted a survey on the upper watershed where tributaries of Hatchery Creek crossed old logging roads. No sockeye salmon were documented in the upper watershed of Hatchery Creek. The field notes reflect beaver activity and removed road crossings. In 2016, spawning surveys were conducted on August 24, September 14, 20, and 30 on the lower section. Table 5 summarizes the spawning survey data in lower Hatchery Creek.

Table 5. Results of sockeye salmon spawning habitat surveys on Hatchery Creek, in the Klawock Lake Watershed.

Hatchery Creek					
Survey Date	**Live Sockeye**	**Spawning Sockeye**	**Sockeye Carcass**	**Redds**	**Spawning Area (m^2)**
9/10/2014	16	11	0	6	7.5
9/15/2015	35	29	3	8	124
8/24/2016	High and dark water prevented observations				
9/14/2016	High and dark water prevented observations				
9/20/2016	15	1	14	5	112
9/30/2016	No fish in creek				

Table 6 represents the summary of the number of times a habitat type was observed with spawning sockeye salmon in Hatchery Creek, for each year spawning surveys were conducted.

Table 6. Number of times a habitat type was used for each year of sockeye salmon spawning surveys were conducted in Hatchery Creek in the Klawock Lake Watershed.

	Hatchery Creek			
	Pool	**Riffle**	**Run**	**Mix**
2014	0	3	2	1
2015	4	2	1	0
2016	3	1	0	0
Total	**7**	**6**	**3**	**1**

Figure 2 shows the location of spawning areas in survey data gathered in Hatchery Creek depicted by the size of the area used for spawning. For all three years, sockeye salmon were not documented in the lowest section of Hatchery Creek, possibly because fish would be difficult to observe in the slower moving deeper tannic colored water. The main section of the creek consistently surveyed between years is a tributary to the mainstem of Hatchery Creek, and correlates to the beginning of the reach that the stream habitat surveys occurred (see Section 4.1.3).

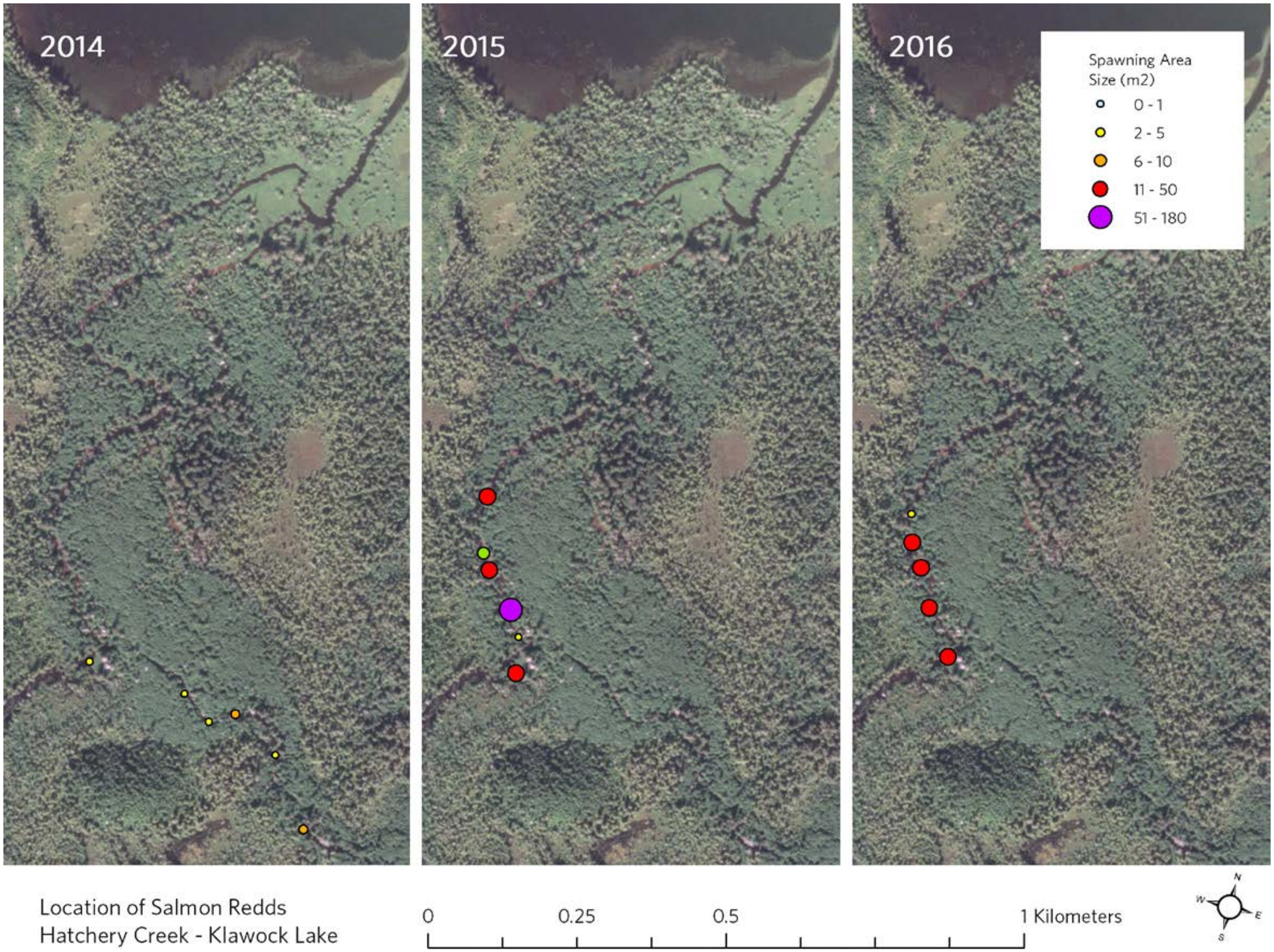

Figure 2. Sockeye salmon spawning areas in Hatchery Creek sub-basin of the Klawock Lake Watershed on Prince of Wales Island, Alaska.

4.1.2 Hatchery Creek Historical Aerial Imagery Analysis

The Hatchery Creek watershed aerial imagery shows no difference in stream course or vegetation structure between 1948 and 1972 (Figure 3). Current aerial imagery shows the addition of a logging road and timber harvest around the habitat surveyed area (Figure 3). The stream course does not appear to be altered, however the channel appears wider in locations where tree canopy has been removed; this may be a result of beaver activity, or may have been obscured by vegetation in the past. Further, there are areas where beaver activity have created ponds of water as identified in Figure 3. Overall, this aligns with current observations on the ground, where beaver activity has been extensive in the Hatchery Creek drainage and to an extent may be blocking sockeye salmon access to spawning habitat.

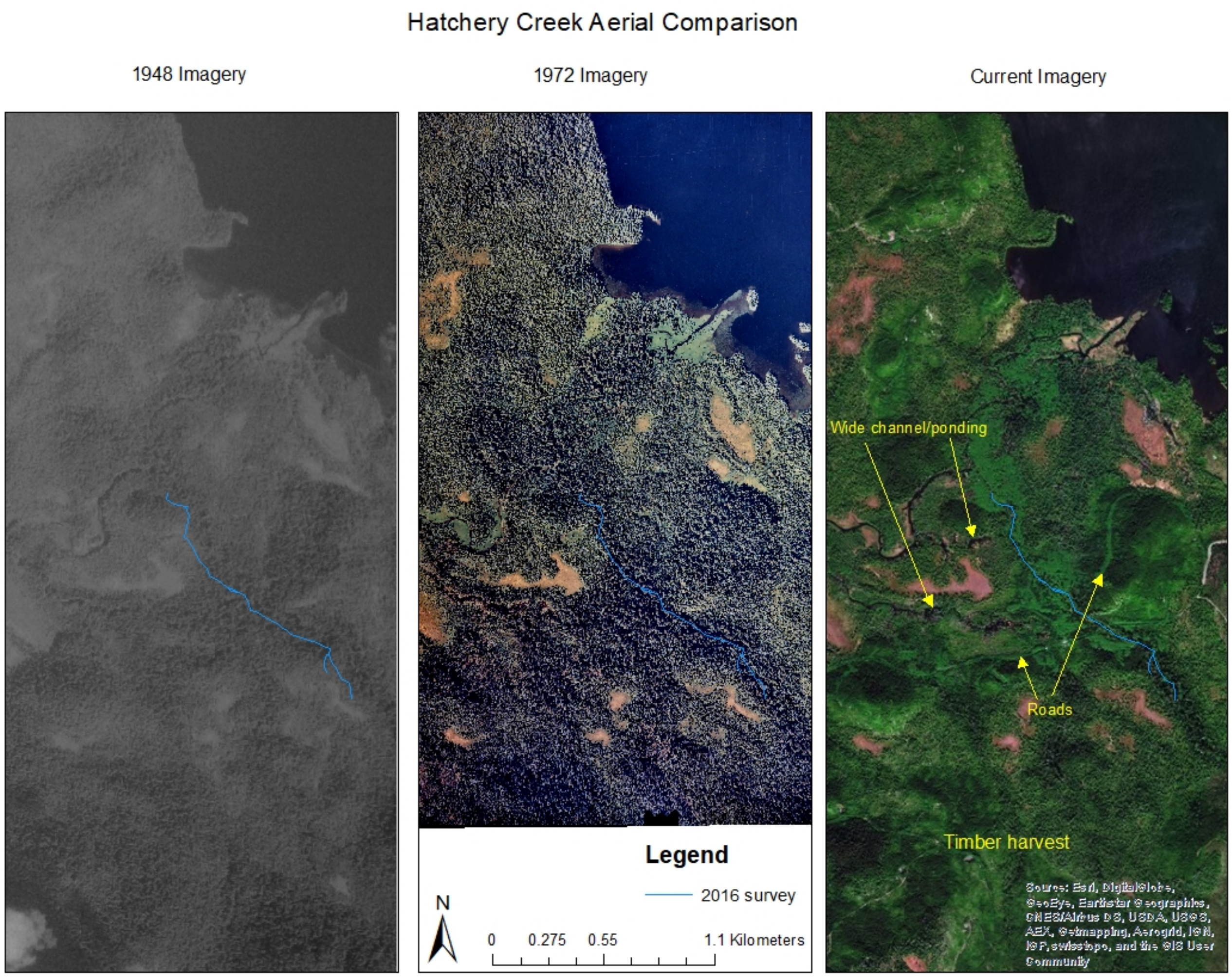

Figure 3. Aerial imagery comparison of the Hatchery Creek sub-basin in the Klawock Lake Watershed on Prince of Wales Island, Alaska. Imagery is from 1948, 1972 and 2015.

4.1.3 Hatchery Creek Stream Habitat Survey

On July 11, 2016, a stream habitat survey was completed on 1,775 meters of Tributary 2 on Hatchery Creek by staff from The Nature Conservancy, Kai Environmental Consulting, and Klawock Cooperative Association (Figure 4). A primary goal of the survey was to assess the habitat upstream of a long standing beaver dam for its suitability as sockeye salmon habitat. The site was accessed via logging roads and the survey began at a steel girder bridge which crosses Tributary 2 (Appendix B, Photo 1). The survey crew initially worked in the downstream direction until they encountered the aforementioned beaver dam (Appendix B, Photo 2). The dam measured approximately 1.35 meters tall with a 1-meter-deep pool immediately downstream. Height measurements were taken from the top of the dam due to unconsolidated substrate in the pool below the dam; pool depth was taken from the stream bank in the deepest portion of the pool safely accessible. The last 400 meters above the beaver dam, the stream widened into a palustrine forested floodplain with skunk cabbage and small trees submerged in standing water; this habitat appeared forced due to beaver dam construction. The field crew then returned to the bridge and worked upstream until encountering a distinct reach break, which was based on a significant change in channel conditions.

Three separate reaches were identified in the survey area. Appendix B contains photos of typical conditions in each reach, with Reach 1 correlating to Photos 3 and 4, Reach 2 correlating to Photos 5 and 6 and Reach 3 correlating with Photos 7 and 8. Reaches 1 and 2, below the bridge, were characterized by wide, braided stream beds and young growth riparian vegetation, while Reach 3 above the bridge was narrower, more singular with intact riparian vegetation (Figure 4). Overall, the gradient of the surveyed section was low and consistent with alluvium banks and gravel substrate. Reach information is summarized in Tables 7 and 8.

Table 7: Reach data for Hatchery Creek drainage in the Klawock Lake Watershed in Klawock, Alaska

Reach	Length (m)	Average Channel Bed Width (m)	Channel Type*	Bank Composition	Substrate**		
					Dominant	Sub Dominant	Next Sub Dominant
1	874	11.2	FPM	Alluvium	CGR	VCG	MGR
2	133	12	FPM	Alluvium	MGR	CGR	ORG
3	535	13.4	FPS	Alluvium	VCG	SC	LC

**FPM = Moderate Floodplain; FPS = Small Floodplain*
*** CGR = Coarse Gravel; MGR = Medium Coarse Gravel; VCG = Very Coarse Gravel; SC = Small Cobble; LC = Large Cobble; ORG = Organic*

As described in Section 3.4.2, metrics were calculated from the survey data for comparison to established metrics for unmanaged streams in Southeast Alaska (Table 2). The metrics for the three reaches surveyed in Hatchery Creek are shown in Table 8.

Table 8: Metrics calculated from data taken during stream surveys in Hatchery Creek, Klawock Lake Watershed in Klawock, Alaska.

Reach	Width to Depth	Large Wood/Meter	Key Large Wood/Meter	Pools/ kilometer	Pool Spacing
1	17.78	0.19	0.08	65	1.4
2	29.80	0.08	0.06	38	2.2
3	15.23	0.19	0.10	67	1.1

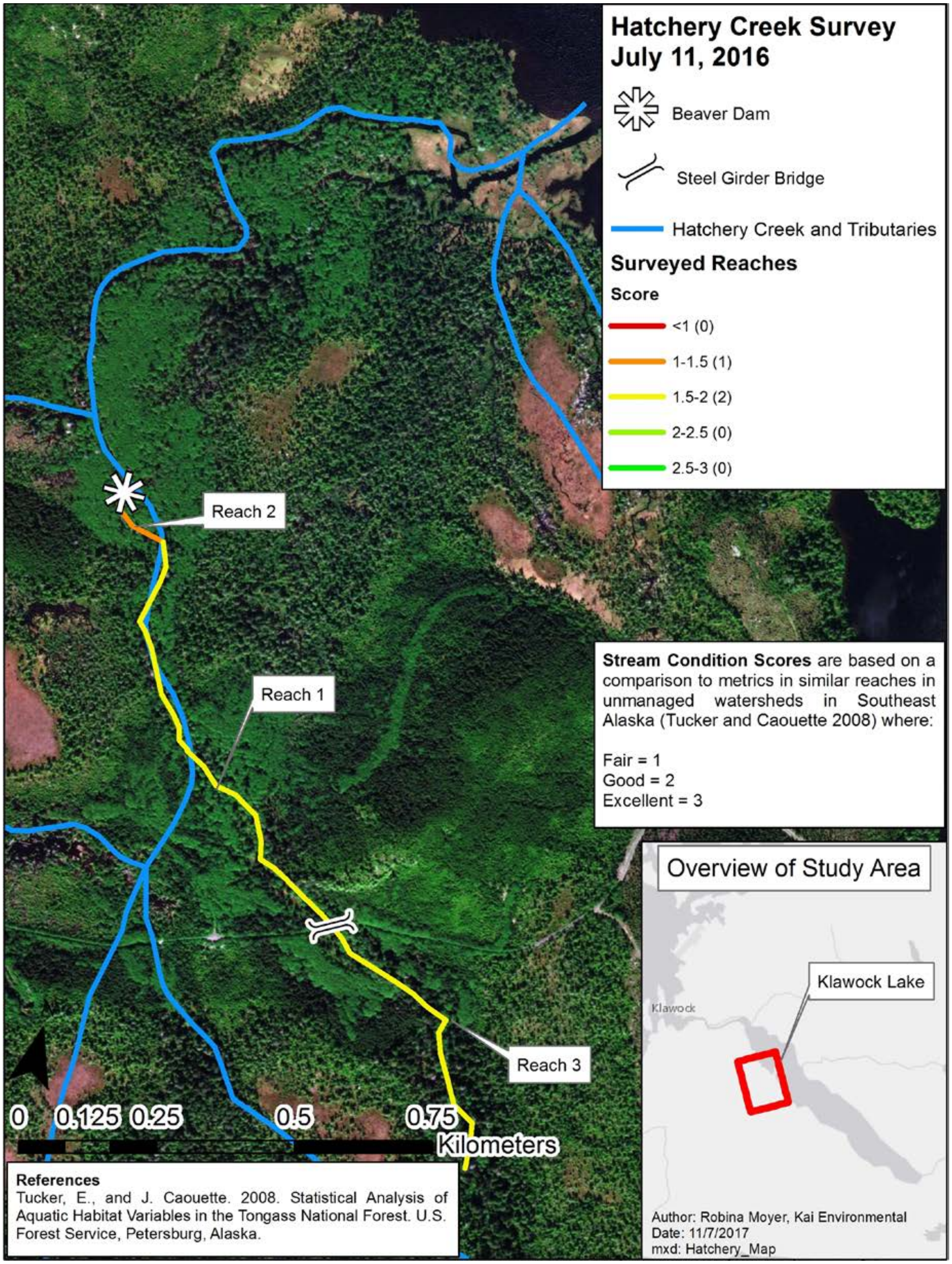

Figure 4: Hatchery Creek Survey Area in Klawock Lake Watershed, Klawock, Alaska. Map shows surveyed reaches and habitat condition scores based on an analysis of the survey data and a comparison to known metrics for Southeast Alaska streams.

Based on the percentile each metric fell into for its given channel type, it was assigned a qualitative value using the information provided in Table 3. The qualitative values for Hatchery Creek are shown in Table 9 with the corresponding numerical score shown in parentheses. A total score for each reach was calculated as the average of the five individual scores, and represented on Figure 4.

Table 9: Qualitative summary of Hatchery Creek reaches based on comparison to established metrics (Tucker and Caouette, 2008; USFS, 2007). Numerical scores are shown in parentheses and correspond to the qualitative score, the final column shows the average of the five individual scores.

Reach	Width to Depth	Large Wood/Meter	Key Large Wood/Meter	Pools/ kilometer	Pool Spacing	Score
1	Fair (1)	Fair (1)	Good (2)	Excellent (3)	Good (2)	1.8
2	Good (2)	Fair (1)	Good (2)	Good (2)	Fair (1)	1.6
3	Good (2)	Fair (1)	Good (2)	Good (2)	Excellent (3)	2

4.1.3.1 Channel Substrate and Geometry

As shown in Table 9, the width-depth ratio for Reach 1 of Hatchery Creek was in the "fair" range, while Reaches 2-3 were in the "good" range. All three reaches had alluvium bank composition and predominately gravel substrate. Reach 1, the longest of the three, was dominated by coarse gravel substrate, with subdominant substrates of very coarse and medium gravel. The dominate substrate in Reach 2 was medium gravel with coarse gravel and organic material as subdominant substrate and Reach 3 was dominated by very coarse gravel with large and small boulders as the subdominant substrate (Table 7).

Reaches 1-2 had wide, braided channel morphology, with three mapped side channels longer than 50 meters and several side channels shorter than 50 meters. Reach 3 was a singular consolidated channel bed, with only one mapped side channel. This side channel may have been a tributary, it was at the upper end of the survey and as its upstream confluence with the main channel was never found (Figure 4). Bank erosion and undercutting was minimal in the surveyed reaches. All three reaches were classified as small or moderate floodplains, which have a high rating for sockeye spawning habitat and a negligible rating for sockeye salmon rearing habitat (Table 1).

4.1.3.2 Instream Wood and Riparian Vegetation

The large wood per meter values for all three reaches of Hatchery Creek were below the 25th percentile and thus had a "fair" value. The key wood per meter values for the surveyed area were between the 25th and 75th percentiles, falling into the "good" range (Table 9).

The riparian vegetation in Reach 1 was dominated on the left bank by a mix of broad leaf and coniferous species, primarily Western hemlock (*Tsuga heterophylla*), red alder (*Alnus rubra*), and to a lesser extent, Sitka spruce (*Picea sitchensis*) with an occasional yellow cedar. The right bank of Reach 1 was dominated by red alder. The entirety of Reach 2 was dominated by red alder, while Reach 3 was dominated by Western hemlock with the occasional spruce or cedar (Table 10). Vegetation class codes may be found in Appendix A.

Table 10: Riparian vegetation classifications for surveyed reaches of Hatchery Creek in the Klawock Lake Watershed in Klawock, Alaska. Class codes are adapted from Viereck et al. (1992), key to the class codes can be found in Appendix A. Left and Right Bank are identified by looking downstream.

Reach	Left Bank 0-5m	Left Bank 5-10m	Left Bank 10-20m	Left Bank 20-30m	Right Bank 0-5m	Right Bank 5-10m	Right Bank 10-20m	Right Bank 20-30m
1	IC1	IC1	IC1	IC1	IB1a	IB1a	IB1a	IB1a
2	IB1a	IB1a	IB1a	IB1a	IB1a	IB1a	IB1a	IB1a
3	IA1b	IA1b	IA1b	IA1b	IA1b	IA1b	IA1b	IA1b

4.1.3.3 Pool Habitat

In Hatchery Creek, the pools per kilometer metric was "excellent" throughout Reach 1 and "good" in Reaches 2 and 3, indicating that key wood is present and functioning within the stream bed (Table 9). The pool spacing (length of the stream surveyed/channel bed width/total number of pools) was "good" in Reach 1, "fair" in Reach 2 and "excellent" in Reach 3.

4.2 Threemile Creek

4.2.1 Threemile Creek Spawning Surveys

From 2014-2016, spawning surveys were conducted on Threemile Creek up to the Klawock-Hollis Highway each week starting the last week of August through the first week of October. Table 11 summarized the data collected during the spawning surveys. Two additional surveys were conducted above the Klawock-Hollis Highway on Threemile Creek in 2015. On September 14, 2015 there were 19 live but not spawning sockeye salmon observed. On September 24, 2015 there were 6 live and spawning sockeye salmon observed.

Table 11. Results of sockeye salmon spawning habitat surveys on Threemile Creek, in the Klawock Lake Watershed.

Threemile Creek					
Survey Date	**Live Sockeye**	**Spawning Sockeye**	**Sockeye Carcass**	**Redds**	**Spawning Area (m^2)**
9/5/2014	No fish in creek				
9/9/2014	237	30	2	12	157
9/15/2014	76	6	0	1	0
9/24/2014	320	168	8	55	398
10/1/2014	136	68	4	20	48
8/26/2015	156	2	2	1	102
9/2/2015	324	115	3	33	458
9/9/2015	629	350	13	148	823
9/17/2015	253	187	20	91	302
9/22/2015	268	209	28	82	418
10/2/2015	119	6	96	44	222
8/23/2016	New beaver dam blocking fish (7 live at mouth)				
8/31/2016	32	28	0	7	53
9/13/2016	399	358	19	115	577
9/16/2016	High and dark water prevented observations				
9/21/2016	175	138	19	64	349
9/27/2016	110	105	9	30	231
10/4/2016	50	39	5	4	40

Table 12 represents the summary of the number of times a habitat type was observed with spawning sockeye salmon in Threemile Creek, for each year spawning surveys were conducted.

Table 12. Number of times a habitat type was used for each year of sockeye salmon spawning surveys were conducted in Threemile Creek in the Klawock Lake Watershed

	Threemile Creek			
	Pool	**Riffle**	**Run**	**Mix**
2014	4	4	11	0
2015	19	26	27	4
2016	22	23	23	3
Total	**45**	**53**	**61**	**7**

Figure 5 shows the location of sockeye salmon spawning in survey data gathered on Threemile Creek, depicted by the size of the area utilized. The 2014 spawning survey area was less than what was documented in 2015 and 2016, which correlates to the lower spawning area (m^2) shown in Table 11. As seen in Figure 5, sockeye salmon currently concentrate spawning to the lower portion of the creek, below the Klawock-Hollis Highway crossing.

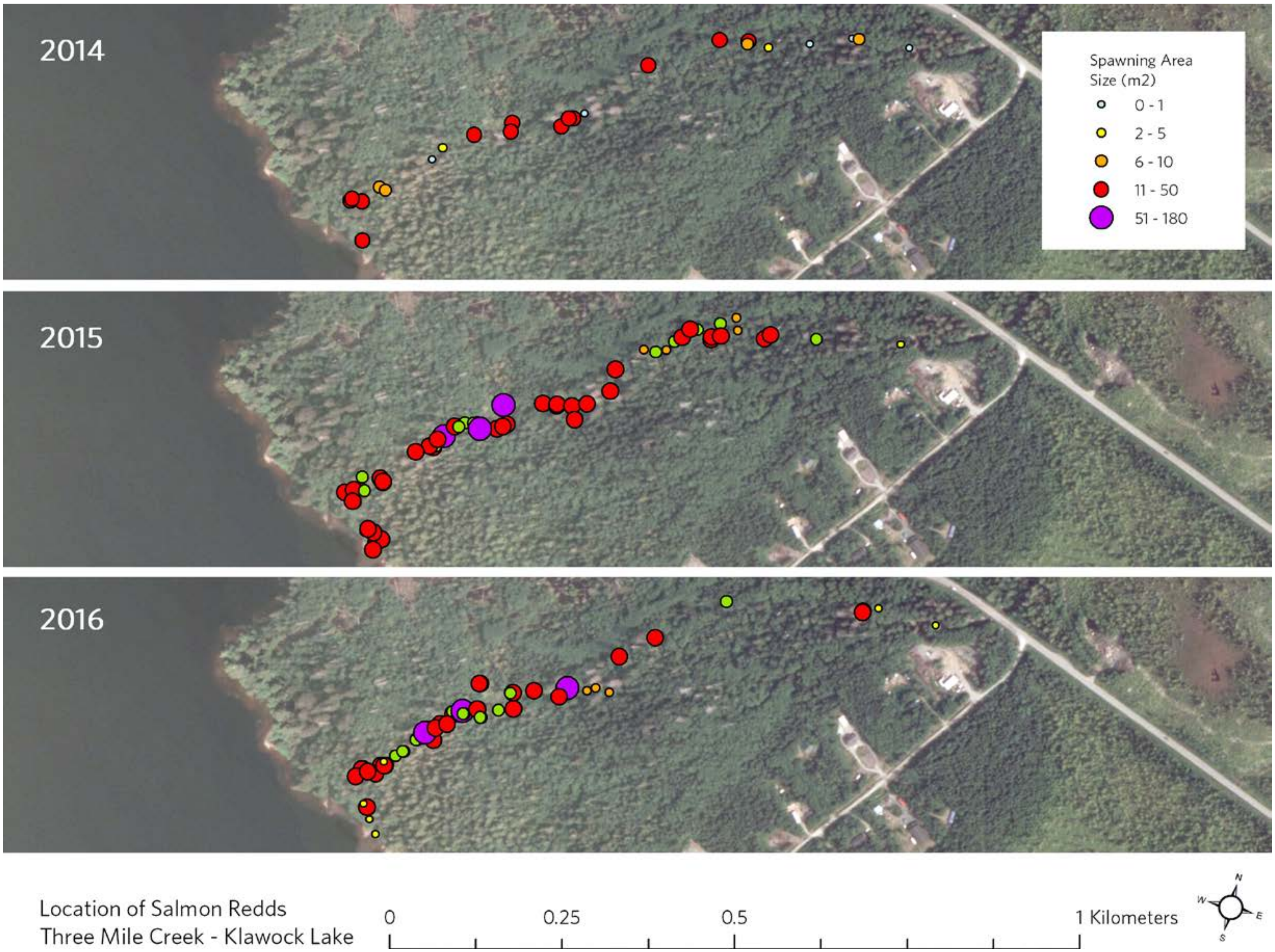

Figure 5. Sockeye salmon spawning areas in Threemile Creek sub-basin of the Klawock Lake Watershed on Prince of Wales Island, Alaska.

4.2.2 Threemile Creek Historical Aerial Imagery Analysis

The Threemile creek drainage into Klawock Lake has shown the most dramatic changes when comparing aerial imagery. The 1948 imagery shows high gradient channels carved into the mountain with timber intact, and no roads or development (Figure 6). As noted on Figure 6, the 1948 aerial imagery shows there are two channels into the lake, where the eastern channel appears predominant. In the 1972 imagery the primary change is the addition of the Klawock-Hollis Highway. There is also a rock pit present. In this imagery, the eastern channel into Klawock Lake is less pronounced and is likely becoming dewatered as flows are re-directed from its natural course after the Klawock-Hollis road was built (CCTHITA and USFS, 2002).

In the current imagery, the Threemile Creek sub-basin has timber harvest, roads associated with timber harvest, and a residential subdivision. The subdivision is located directly where the previous eastern channel into the lake was located in the 1948 imagery, and it was noted in CCTHITA and USFS (2002) that the channel has been inactive for years. As a result, significant habitat and subsequent salmon spawning potential has been lost (CCTHITA and USFS, 2002).

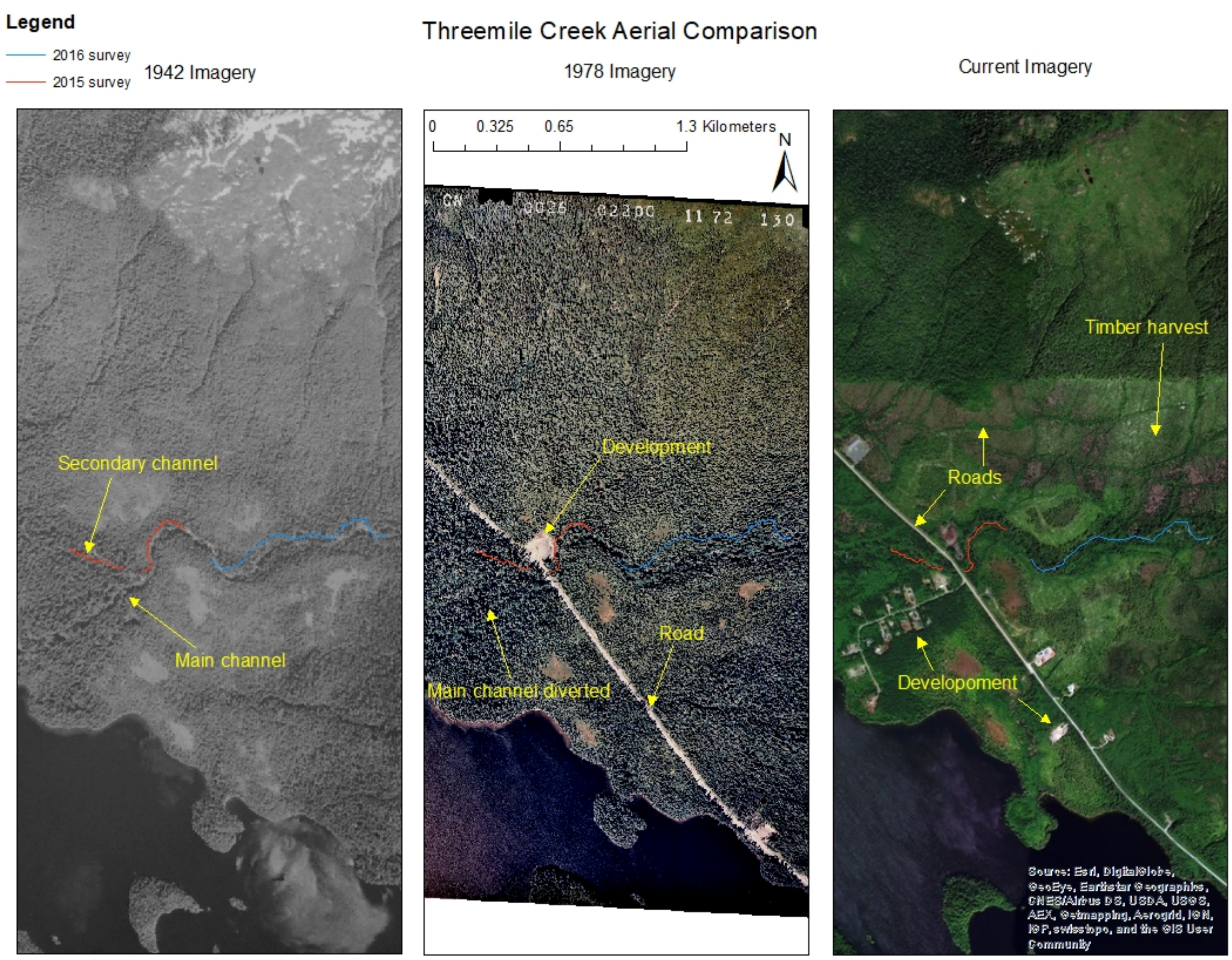

Figure 6. Aerial imagery comparison of the Threemile Creek sub-basin in the Klawock Lake Watershed on Prince of Wales Island, Alaska. Imagery is from 1948, 1972 and 2015, and the 2015 and 2016 stream habitat surveyed reaches are included for orientation.

4.2.3 Threemile Creek Stream Habitat Assessment

On July 14, 2015 a habitat survey was completed on approximately 760 meters of Threemile Creek by staff from The Nature Conservancy. The creek was accessed from the Klawock-Hollis Highway, and the survey took place in two reaches. The first reach included the creek approximately 327 meters downstream of the Klawock-Hollis Highway bridge and the second reach included approximately 433 meters above the bridge. These two reaches are depicted on Figure 7 as reaches 1 and 2 respectively.

On July 12 and 13, 2016 a habitat survey was completed on 2,000 meters of Threemile Creek (Figure 7) by staff from The Nature Conservancy, Kai Environmental Consulting, and Klawock Cooperative Association. The creek was accessed from the Klawock-Hollis Highway, where the crew entered the stream above the highway bridge , walked upstream until the channel began to narrow and consolidate, and began their survey. The upstream terminus of the survey was determined by logistical and time constraints, but it corresponded with a bedrock chute that was approximately 1.5 meters high with a 0.8 meters plunge pool (Appendix C, Photo 9). The percent gradient was approximated to be 70-90%. Given those measurements, the chute was likely a barrier to passage for adult chum and pink salmon, and a potential barrier to passage for adult king, coho, and sockeye salmon depending on the condition of the fish (Powers and Orsborn, 1985). Six reaches mapped in 2016 are shown as reaches 3-8 on Figure 7. A photo log representing each reach may be found in Appendix C (Photos 10-24).

Reach information for all eight reaches are summarized in Table 13. The extended stream survey data for Reaches 1 and 2 Tier I survey may be found in Appendix D. The 2016 habitat surveyed consisted of alternating stretches of bedrock substrate with a moderate gradient and flatter, slower stretches of pools and riffles with gravel and cobble substrate. The bedrock sections were typically confined to a single channel, while the others widened into braided channels. Undercut bank erosion was observed throughout the surveyed area (Appendix C, Photo 24). Eight distinct reaches were identified within the surveyed area of Threemile Creek; their attributes are summarized in Table 13.

Table 13: Reach data collected in 2016 for Threemile Creek drainage in the Klawock Lake Watershed in Klawock, Alaska

Reach	Length (m)	Average Channel Bed	Channel Type*	Bank Composition	Substrate**		
					Dominant	Sub	Next Sub
1	327	13.3	FPM	-	VCG	SC	CGR
2	433	19.4	FPM	-	VCG	CGR	LC
3	85	10.7	MCM	Mixed	BR	SC	VCG
4	268	18.9	LCM	Mixed	VCG	SC	LC
5	82	15.2	LCM	Mixed	BR	SC	VCG
6	437	14.1	MMM	Alluvium	SC	CGR	LC
7	242	12.4	FPM	Alluvium	VCG	CGR	SC
8	443	13.4	MMS	Alluvium	SC	VCG	CGR

**MCM = Medium Moderate Gradient Contained Channel; LCM = Medium Low Gradient Contained Channel; MMM = Medium Moderate Gradient Mixed Control Channel; MMS = Small Moderate Gradient Mixed Control Channel*
*** BR = Bedrock; CGR = Coarse Gravel; MGR = Medium Coarse Gravel; VCG = Very Coarse Gravel; SC = Small Cobble; LC = Large Cobble*

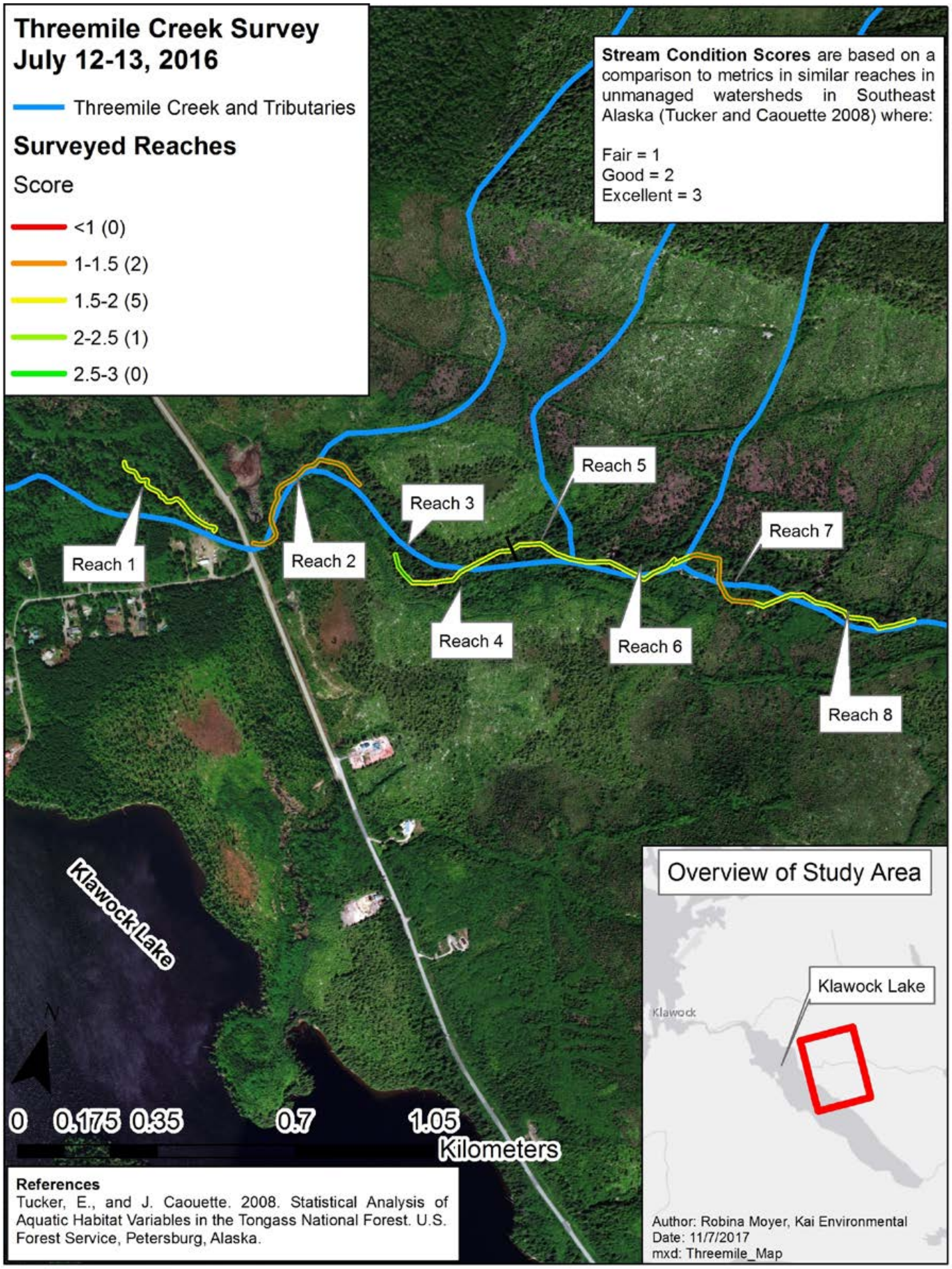

Figure 7: Threemile Creek Survey Area in Klawock Lake Watershed, Klawock, Alaska. Map shows surveyed reaches and habitat condition scores based on an analysis of survey data and a comparison to known metrics for Southeast Alaska streams.

Data collected showed that Reach 1 was classified as a floodplain, a professional call made by the field crew to how field conditions at the time were observed; however others have indicated it may also be classified as an alluvial fan. Metrics in this current study do not include a comparison for alluvial fan systems, but they do for floodplains. Therefore, in this study Reach was interpreted as a floodplain system. Metrics were calculated from the survey data for comparison to established metrics for unmanaged streams in Southeast Alaska (Table 2). The metrics for Threemile Creek are shown in Table 14.

Table 14: Metrics calculated from data taken during stream surveys in Threemile Creek, Klawock Lake Watershed on Prince of Wales Island, Alaska

Reach	Width to Depth	Large Wood/Meter	Key Large Wood/Meter	Pools/ kilometer	Pool Spacing
1	-	0.39	0.20	31	2.5
2	-	0.30	0.09	21	2.5
3	9.29	0.27	0.36	47	2.0
4	11.64	0.13	0.07	19	2.8
5	8.88	0.04	0.10	24	2.7
6	15.00	0.14	0.28	18	3.9
7	15.15	0.10	0.08	12	6.5
8	9.57	0.21	0.10	29	2.5

The calculated metrics (Table 14) were then compared to established metrics for similar unmanaged streams in Southeast Alaska (USFS, 2007). The Threemile Creek metrics were broken into the appropriate percentile based on the results shown in Table 2 and the corresponding qualitative descriptor was assigned from the values given in Table 3 (USFS, 2007, Tucker and Caouette, 2008). These results are summarized in Table 15. The final score is the calculated average of the numerical value associated with the five qualitative descriptors. Note that width-to-depth ratio was not calculated for Reaches 1 and 2, therefore their final score is based on an average of four qualitative descriptors.

Table 15: Qualitative summary of Threemile Creek reaches based on comparison to established metrics (Tucker and Caouette, 2008; USFS, 2007). Numerical scores are shown in parentheses and correspond to the qualitative score, the final column shows the average of the five individual scores (average of four scores for Reaches 1 and 2).

Reach	Width to Depth	Large Wood/Meter	Key Large Wood/Meter	Pools/ kilometer	Pool Spacing	Score
1	N/A	Good (2)	Good (2)	Fair (1)	Fair (1)	1.5
2	N/A	Good (2)	Fair (1)	Fair (1)	Fair (1)	1.0
3	Good (2)	Good (2)	Excellent (3)	Good (2)	Excellent (3)	2.4
4	Good (2)	Fair (1)	Good (2)	Fair (1)	Good (2)	1.6
5	Fair (1)	Fair (1)	Excellent (3)	Fair (1)	Good (2)	1.6
6	Good (2)	Fair (1)	Excellent (3)	Fair (1)	Good (2)	1.8
7	Fair (1)	Fair (1)	Good (2)	Fair (1)	Fair (1)	1.2
8	Fair (1)	Fair (1)	Good (2)	Fair (1)	Excellent (3)	1.6

4.2.3.1 Channel Substrate and Geometry

Reaches 3, 4 and 6 of Threemile Creek had "good" width-depth-ratios, while Reaches 5, 7 and 8 fell below the 25th percentile and fell into the "fair" range (Table 15). Reaches 3-5 had mixed bedrock and alluvium bank composition, while Reaches 6-8 had alluvium banks. There is no data for width-to-depth ratio or bank composition data for Reaches 1 and 2. As shown in Table 13, the surveyed reaches had dominant substrate that ranged from very coarse gravel to bedrock; while the subdominant substrates ranged from coarse gravel to large cobbles.

The channel types surveyed in Threemile Creek were variable, but generally low and moderate gradient contained channels dominated the surveyed areas. Reaches 1 and 2 were small floodplains, while Reach 7 was a moderate floodplain. Channel morphology was predominately single, contained channels, with the exception of Reaches 3 and 7 which had braided channels, Reach 7 was a short (242m), relatively flat section of creek which spread out into multiple channels and had more floodplain-like morphology. Throughout all of the reaches, erosion and undercutting were observed in areas with alluvium banks (Appendix C, Photos 25 and 26). Based on channel type, Reach 3 provides negligible sockeye salmon spawning habitat; Reaches 4-6 and Reach 8 provide a low amount of sockeye salmon spawning habitat, while Reaches 1 and 2 and Reach 7 have a high amount sockeye salmon spawning habitat (Table 13 and 1). All eight reaches had a low amount of sockeye salmon rearing habitat.

In Reach 1 of the stream habitat survey on Threemile Creek, the field crew noted that a private resident in the Klawock Lake Subdivision constructed a dike on Threemile Creek downstream of the Klawock-Highway culverts, in order to keep the creek from flooding its banks and onto adjacent residential property (Photo 27). This observation was also detailed in CCTHITA and USFS (2002) which noted that the dike was constructed after large rainstorms in mid-October of 1999 when Threemile Creek nearly accessed the historic eastern channel through the middle of the subdivision (Figure 6). The dike is approximately 1.5 meters high, and runs along the left bank (looking downstream) for approximately 137 meters.

Photo 27. Threemile Creek looking downstream from Klawock-Hollis Highway bridge showing the dike installed by a resident of the Klawock Lake Subdivision, Klawock, Alaska.

4.2.3.2 Instream Wood and Riparian Vegetation

Reach 1, 2 and 3 had a “good” large wood per meter value, while the other Reaches all had a “fair” value, meaning they fell below the 25th percentile. For key wood per meter, Reaches 3, 5 and 6 had an “excellent” value, Reaches 1, 4, 7 and 8 were a “good” value, and Reach 2 was a “fair” value. Field crews also noted that key wood pieces in Reach 1 have been cut out in order to allow water flow through rather than around the large woody debris (Photo 28).

Photo 28: Large woody debris in Threemile Creek that has been cut out in order to allow water to flow, Klawock, Alaska.

Riparian vegetation information is not available for the first two reaches, however there is residential development in Reach 1 where riparian vegetation has been disturbed. For Reaches 3-8, the first 10 meters of the left bank were dominated by a mix of conifers and broadleaf trees, primarily Western hemlock, Sitka spruce, and red alder; from 10-20 meters, the overstory was dominated by red alder. On the right bank, the most common vegetation was 25-60% canopy coverage, dominated by western hemlock and Sitka spruce, with sporadic yellow cedar (Table 16).

Table 16: Riparian vegetation classifications for surveyed reaches of Threemile Creek in the Klawock Lake Watershed in Klawock, Alaska. Class codes are adapted from Viereck et al. (1992), key to the class codes can be found in Appendix A.

Reach	Left Bank 0-5m	Left Bank 5-10m	Left Bank 10-20m	Left Bank 20-30m	Right Bank 0-5m	Right Bank 5-10m	Right Bank 10-20m	Right Bank 20-30m
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	IC1	IC1	IB3	IB3	IA2b	IA2b	IA2b	IB2
4	IC2	IC2	IA2b	IA2b	IC2	IC2	IA2b	IA2b
5	IC1	IC1	IC1	IB1a	IC1	IA2b	IA2b	IA2b
6	IC2	IC2	IB1a	IB1a	IC2	IA2b	IA2b	IA2b
7	IC1	IC1	IB1a	IB1a	IB1a	IB1a	IA2b	IA2b
8	IA2b	IB1a	IB1a	IB1a	IA1d	IA1d	IA2b	IA2b

4.2.3.3 Pool Habitat

Pools per kilometer were "good" in Reach 3 and "fair" in the other seven reaches. Pool spacing was "excellent" in Reaches 3 and 8, "good" in Reaches 4-5 , and "fair" in Reach 1, 2 and 7.

4.2.4 Threemile Creek Culvert Assessment

Threemile Creek crosses the Klawock-Hollis Highway at approximately the 12-mile marker. At this location on Threemile Creek, there are double culverts in place to pass water and fish. On September 24, 2015, The Nature Conservancy staff collected culvert data to assess the function of the culverts for fish passage. Table 17 represents the data taken for each culvert, where culvert 1 is located on the right (looking downstream) and culvert 2 is on the left (looking downstream).

Table 17. Culvert data for the double culverts on Threemile Creek at the Klawock-Hollis Highway, in the Klawock Lake Watershed on Prince of Wales Island, Alaska. Culvert 1 is the culvert on the right looking downstream and culvert 2 is the culvert on the left.

Measurement	Culvert 1	Culvert 2
Culvert type	Squash pipe	Squash pipe
Culvert material	Structural Aluminum Pipe	Structural Aluminum Pipe
Structure type	3	3
Culvert length	23.2 meters	23.2 meters
Culvert gradient	0.13%	0.09%
Corrugation width	7.6 centimeters	7.6 centimeters
Inlet width	4.6 meters	4.6 meters
Inlet height	0.9 meters	0.9 meters
Inlet substrate depth	0 meters	0.3 meters
Inlet rust line height	0.7 meters	0.5 meters
Inlet sedimentation	No	Yes
Outlet width	4.6 meters	4.6 meters
Outlet height	0.9 meters	0.9 meters
Outlet substrate depth	0 meters	0 meters
Outfall height	0.7 meters	0.6 meters
Overall rating	Red	Red

Photo 29 shows the double culvert system looking downstream at the inlet of both culverts, and Photo 30 shows the same culverts looking upstream at the outlet of both culverts. Table 18 is the excerpt row from the decision matrix in Eisenmen and O'Doherty (2014) that pertains to the culvert types analyzed above.

Table 18. Excerpted row from decision matrix in Eisenmen and O'Doherty (2014), based on the culvert types analyzed on Threemile Creek in the Klawock Lake watershed on Prince of Wales Island.

Structure Type	Green	Gray	Red
Pipe arch or circular CMP (span width greater than 4 feet), less than 2 x 6 inch corrugations, not embedded	Culvert gradient less than 0.5%, AND outfall hgt. = 0, AND construction ratio greater than 0.75 OR fully backwatered	Culvert gradient 0.5 to 2.0%, OR less than or equal to 4-inch outfall hgt., OR construction width ratio of 0.5 to 0.75	Culvert gradient greater than 2.0%, OR outfall hgt. greater than 4 inches, OR construction ratio less than 0.5

Comparing the data collected to the culvert type indicated the overall rating for both pipes was "red", meaning the pipes are likely inadequate for passing juvenile fish (see Section 3.5). While overall perch height on either culvert does not indicate that the culverts would block adult fish passage (Table 4), pool depth was not measured so whether the culverts hinder adult passage cannot be entirely determined. Further, cross-sectional data was not collected, and therefore no further recommended analysis (such as FishXing) could be performed.

In addition to perching, the culverts have very little, if any, substrate present at the inlet, outlet and/or within the culverts. The lack of substrate and/or artificial baffling within the culverts, may present upstream migration difficulties for adult fish during high flow conditions.

Photo 29. Inlet of double culverts on Threemile Creek crossing the Klawock-Hollis Highway, in the Klawock Lake Watershed, Klawock, Alaska.

Photo 30. Outlet of double culverts on Threemile Creek crossing the Klawock-Hollis Highway, in the Klawock Lake Watershed, Klawock, Alaska.

4.3 Inlet Creek

4.3.1 Inlet Creek Spawning Surveys

Spawning habitat surveys were conducted on Inlet Creek starting at the mouth of the creek, working upstream past where Inlet Creek mainstem crosses the Klawock Hollis Highway at mile marker 17, until the creek disperses into muskeg (Figure 8). The spawning surveys were conducted weekly starting the last week of August through the first week of October in 2014-2016. Table 18 summarizes the spawning survey data collected on Inlet Creek. While there was more spawning area utilized below the Klawock-Hollis Highway crossing, spawning sockeye salmon were using the creek throughout the entire surveyed area (Figure 8).

Table 19. Results of sockeye salmon spawning habitat surveys on Inlet Creek, in the Klawock Lake Watershed.

Inlet Creek					
Survey Date	Live Sockeye	Spawning Sockeye	Sockeye Carcass	Redds	Spawning Area (m^2)
9/5/2014	84	30	1	11	27
9/17/2014	64	42	11	25	96
9/23/2014	9	9	0	3	64
9/30/2014	39	13	4	6	16
8/27/2015	77	49	0	16	192
9/1/2015	337	128	0	40	657
9/7/2015	388	268	19	80	536
9/21/2015	202	116	26	52	373
10/1/2015	21	15	2	3	24
8/31/2016	New beaver dam blocking fish (18 live at mouth)				
9/12/2016	575	531	20	135	1529
9/19/2016	264	239	67	76	400
10/3/2016	10	0	3		0
10/11/2016	No fish in creek				

Table 19 represents the summary of the number of times a habitat type was observed with spawning sockeye salmon in Inlet Creek, for each year spawning surveys were conducted.

Table 20. Number of times a habitat type was used for each year of sockeye salmon spawning surveys were conducted in Inlet Creek in the Klawock Lake Watershed

	Inlet Creek			
	Pool	Riffle	Run	Mix
2014	3	11	10	3
2015	21	61	17	3
2016	16	24	16	4
Total	**40**	**96**	**43**	**10**

Figure 8 shows the location of sockeye salmon spawning areas in survey data gathered in Inlet Creek, depicted by the size of the area used for spawning.

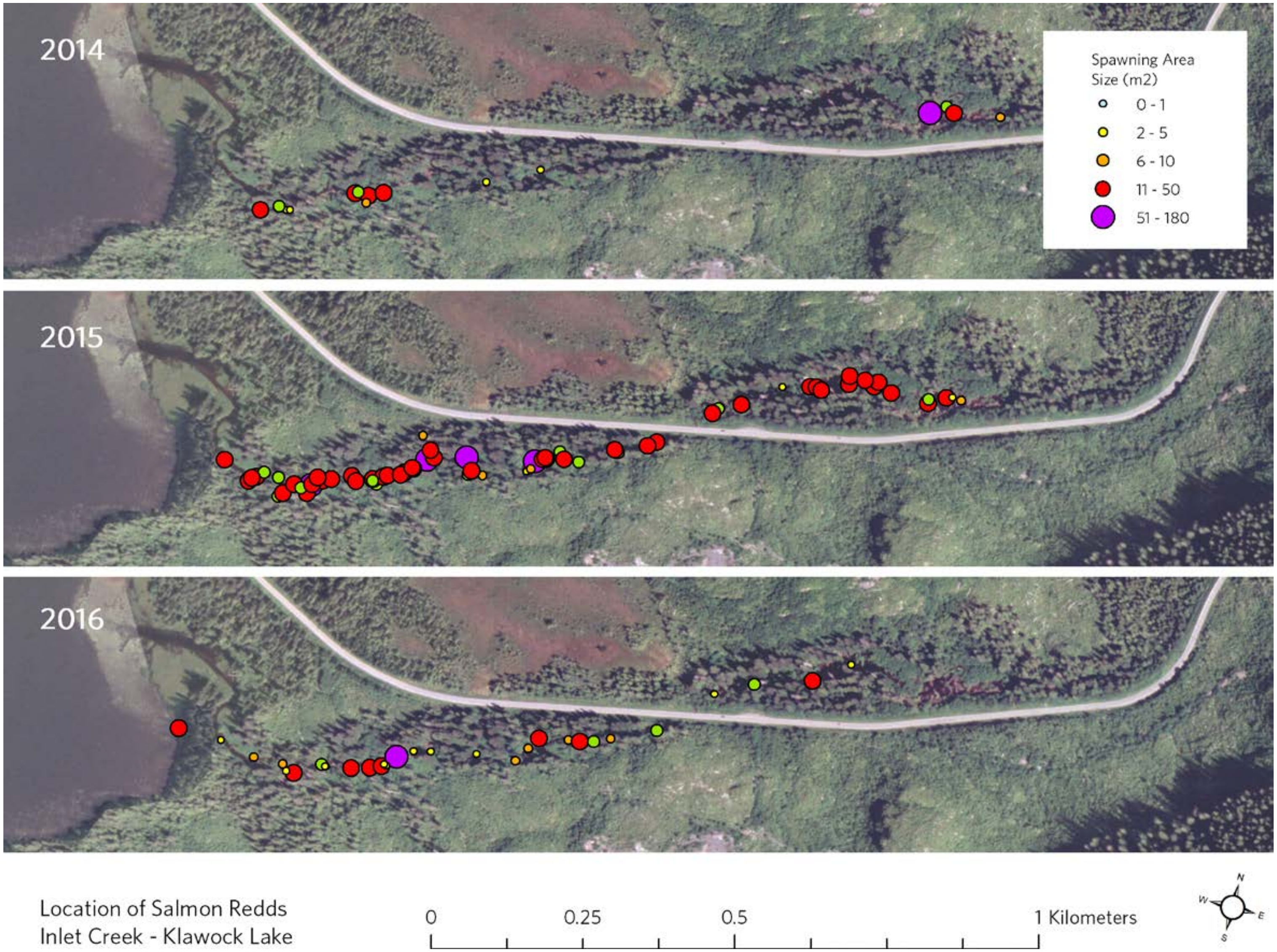

Figure 8. Sockeye salmon spawning areas in Inlet Creek sub-basin of the Klawock Lake Watershed on Prince of Wales Island, Alaska.

4.3.2 Inlet Creek Historical Aerial Imagery Analysis

The 1948 aerial imagery for Inlet Creek shows an intact floodplain stream system, with no development in the sub-basin. By 1972, the Klawock Hollis Highway was constructed, which crosses Inlet Creek in several locations. No other development is noted along Inlet Creek. The current imagery shows additional road building, associated with timber harvest, as well as the beginning of development across the Klawock-Hollis Highway, which now has private residences. The creek channel appears to have remained the same over time, and wide riparian buffers are evident in the current imagery.

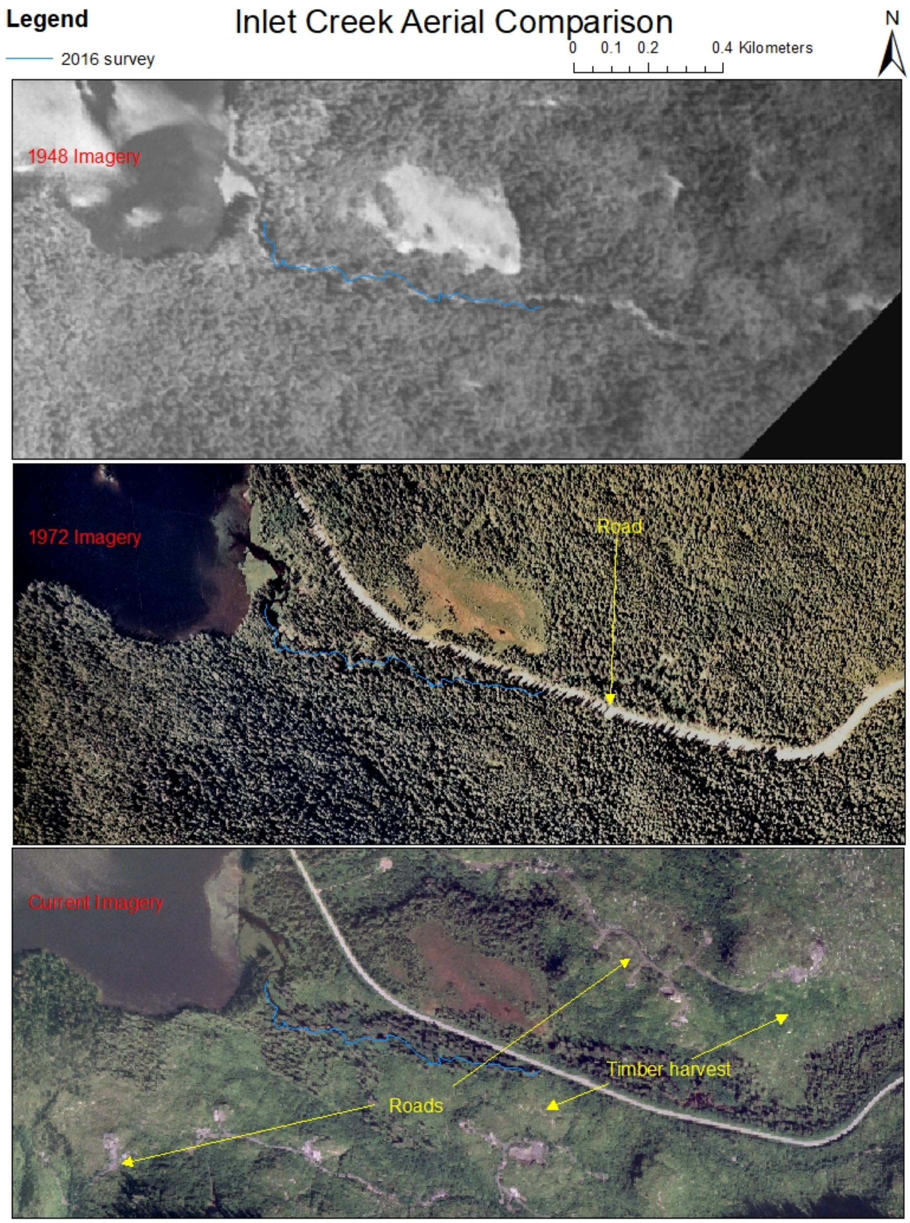

Figure 9. Aerial imagery comparison of the Inlet Creek sub-basin in the Klawock Lake Watershed on Prince of Wales Island, Alaska. Imagery is from 1948, 1972 and 2015.

4.3.3 Inlet Creek Stream Habitat Assessment

A 907 meter section of Inlet Creek up to the crossing with the Klawock-Hollis highway at mile marker 17, was surveyed on July 15, 2015 by The Nature Conservancy. The survey began approximate 450 stream meters from the mouth, as the mouth of the creek is too deep and wide to traverse. The entire surveyed area was classified into one reach and is shown in Figure 10. Photos representing Inlet Creek may be found in Appendix E (Photos 31-33). The classification was a moderate width floodplain, indicative of a low gradient channel. The upper extent of fish habitat was not determined in the stream habitat survey, as sockeye salmon are known to spawn above the crossing of the Klawock-Hollis Highway (Figure 8). Table 20 summarizes the habitat survey data for Reach 1. The extended stream survey reach data from the 2015 stream survey may be found in Appendix D.

Table 21. Reach data for Inlet Creek sub-basin in the Klawock Lake Watershed on Prince of Wales Island, Alaska

Reach	Length (m)	Average Channel Bed Width (m)	Channel Type*	Bank Composition	Substrate**		
					Dominant	Sub Dominant	Next Sub Dominant
1	907	10.2	FPM	Organic	CGR	VGR	SC

**FPM = Moderate Floodplain*
*** CGR = Coarse Gravel; VCG = Very Coarse Gravel; SC = Small Cobble*

As with Reaches 1 and 2 in the Threemile Creek sub-basin, not all data for metrics comparison in this assessment were taken. Metrics were calculated from survey data with the exception of width-to-depth ratio (Table 21).

Table 22. Metrics calculated from data taken during stream surveys in Threemile Creek, Klawock Lake Watershed on Prince of Wales Island, Alaska.

Reach	Width to Depth	Large Wood/Meter	Key Large Wood/Meter	Pools/ kilometer	Pool Spacing
1	-	0.20	0.11	29	3.4

The metric were then compared to established metrics for other streams in Southeast Alaska (USFS, 2007). Table 22 represents the metric comparison and calculates a final score which is an average of the four qualitative descriptors.

Table 23. Qualitative summary of Inlet Creek Reach 1 based on comparison to established metrics (Tucker and Caouette, 2008; USFS, 2007). Numerical scores are shown in parentheses and correspond to the qualitative score, the final column shows the average of the four individual scores.

Reach	Width to Depth	Large Wood/Meter	Key Large Wood/Meter	Pools/ kilometer	Pool Spacing	Score
1	N/A	Fair (1)	Good (2)	Fair (1)	Excellent (3)	1.75

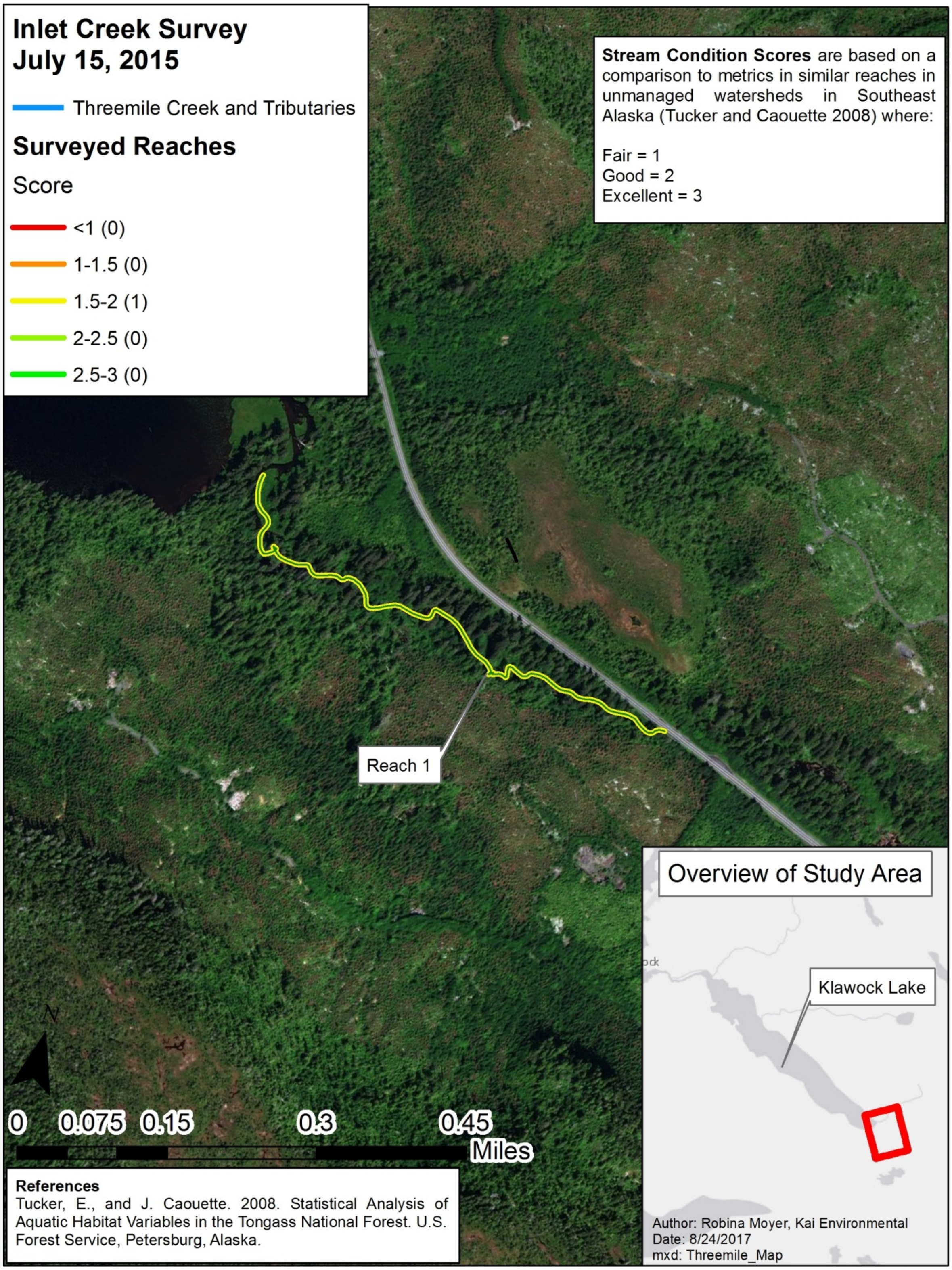

Figure 10. Inlet Creek Survey Area in Klawock Lake Watershed, Klawock, Alaska. Map shows surveyed reach and habitat condition scores based on an analysis of the survey data and a comparison to known metrics for Southeast Alaska streams.

4.3.3.1 Channel Substrate and Geometry
The width-to-depth ratio for Inlet Creek was not available. The bank composition in the surveyed reach of Inlet Creek is organic material. The dominant substrate type was coarse gravel with very coarse gravels and small cobbles being sub-dominant substrate. The moderate width floodplain (FPM) channel type provides high value sockeye salmon spawning habitat, however becomes negligible for sockeye salmon rearing habitat.

4.3.3.2 Instream Wood and Riparian Vegetation
For the surveyed section of Inlet Creek, the large wood per meter metric received a "fair" value, meaning it fell below the 25th percentile. Key large wood per meter was rated as "good" (Table 22). No riparian vegetation data was collected on Inlet Creek, however riparian buffers were noted in the aerial image analysis (Figure 9).

4.3.3.3 Pool Habitat
The pools per kilometer also fell below the 25th percentile, giving Inlet Creek a qualitative rating of "fair" (Table 22). Pool spacing was given a rating of "excellent", falling above the 75th percentile (Table 22).

5.0 Discussion

Sockeye salmon spawning surveys were conducted in Hatchery Creek, Threemile Creek and Inlet Creek over three years (2014-2016). Weekly surveys were conducted in Threemile and Inlet Creeks, while spot surveys were conducted in Hatchery Creek as conditions allowed. Spawning surveys help determine if sockeye salmon are spawning within each sub-basin, as well as give a relative amount of spawning habitat available. Further, the spawning surveys record habitat descriptors such as what dominant habitat features are present in areas that sockeye salmon are using. While the Hatchery Creek spawning survey data is not all inclusive, it does provide insight as to whether the system continues to support spawning sockeye salmon, and whether or not sockeye salmon are present upstream and downstream of a legacy beaver dam system on the first major tributary.

Spawning sockeye salmon were predominantly found in Threemile and Inlet Creeks, with slightly more sockeye salmon observed in Threemile Creek than in Inlet Creek (Tables 11 and 18, respectively). In Threemile Creek, during the peak week for each year, there were 320 live sockeye with 168 spawning in 2014, 629 live sockeye salmon with 350 spawning in 2015, and 399 live sockeye salmon with 358 spawning in 2016. In Inlet Creek, during the peak week for each year, there were 84 live sockeye salmon with 30 spawning in 2014, 388 live sockeye salmon with 268 spawning in 2015 and 575 live sockeye salmon with 531 spawning in 2016. This is consistent with historical information, where Threemile Creek and Inlet Creek have been identified as the most important spawning systems in Klawock Lake (Cartwright and Lewis, 2014; Cartwright and Conitz, 2006).

For Threemile and Inlet Creeks, Figures 5 and 8 respectively, depict lower sockeye spawning area observed in 2014, than in 2015 and 2016. This corresponds to spawning area data in Tables 11 and 18. Sockeye salmon weir counts for 2014-2016 were 6,196 in 2014, 8,804 in 2015 and

6,905 in 2016 (Jeff Lundberg, personal communication). Therefore, it does not appear that lower sockeye spawning areas in 2014 correlate with lower sockeye salmon returns. While the same protocols were implemented by the field crew across the peak return time, the trend may be a result of pooled data across surveys or water clarity affecting visual observations.

The historical aerial imagery analysis conducted on each sub-basin provides information regarding larger scale land use changes over time. Aerial imagery is provided from 1948, prior to any development in the watershed, including the Klawock Hollis Highway. This imagery gives a birds eye view of each sub-basin intact, and lends towards interpretation on how these changes may be influencing the functions of the current system. The imagery provided from 1972 is post construction of the Klawock-Hollis Highway, and prior to any lower section sub-basin timber harvest activities. Current aerial imagery for all three sub-basins is post timber harvest and road construction associated with timber harvest. Further, as is the case in the Threemile Creek sub-basin, urban development is also evident.

Stream habitat survey data, and associated analyzed metrics, are commonly used because they can provide information about both fish habitat and overall stream functionality. Width-to-Depth Ratio can indicate channel stability, often increasing in floodplain channels after disturbances which alter the normal sediment load of the system (Rosgen, 1996, Tucker and Caouette, 2008). Large woody debris is crucial to the creation of fish habitat and aids in maintaining normal channel function by dispelling stream energy. In areas where there has been riparian vegetation harvest, the in-stream woody debris can decay faster than the young growth can produce wood substantial enough to contribute to maintaining stream structure (Tucker and Caouette, 2008). A highly productive stream, in terms of quality fish habitat, has alternating pools and riffles of roughly the same size; the pools/kilometer metric can be used to estimate this relationship without counting riffles (Groot and Margolis, 1991; Tucker and Caouette, 2008). Pool metrics can also help evaluate channel complexity and stability.

All three sub-basins in this assessment have previously been assessed using Proper Functioning Conditions (PFC) survey methods in 1999 and/or 2000 (CCTHITA and USFS, 2002). While not directly comparable to current survey data, the PFC data focused on general overall instream restoration opportunities throughout the Klawock Lake Watershed. In general, a comparison of stream habitat survey data collected herein to the PFC data collected in 1999/2000 can lend towards better understanding of whether major restoration actions have improved stream conditions over time.

The Hatchery Creek, Threemile Creek and Inlet Creek sub-basins in the Klawock Lake Watershed are discussed in further detail in the following sections. Understanding current spawning habitat, identifying larger scale changes over time, and assessing current habitat conditions are tools used to identify potential next steps for key features assessed in each sub-basin.

5.1 Hatchery Creek

The Hatchery Creek spawning surveys were not all inclusive of the sub-basin due to access, time and available resources. Survey work for both spawning and stream habitat concentrated around an accessible tributary in the lower portion of Hatchery Creek, designated Tributary 2, with a known beaver dam structure that has been in place for a number of years. Spawning sockeye salmon were observed in one main location depicted on Figure 2. The largest spawning area observed was during the 2015 spawning survey, with an area of 124 m^2. Spawning sockeye salmon were observed all three survey years, which corresponds to Cartwright and Conitz (2002) findings of providing data for having Hatchery Creek listed in the AWC for sockeye salmon spawning. The geographical extent of which sockeye salmon utilize Hatchery Creek is not known. The mainstem of Hatchery Creek provides approximately 8.69 kilometers of floodplain and palustrine habitat accessible to fish (CCTHITA and USFS, 2002), which would be considered high value spawning habitat for sockeye salmon (Table 1). It was noted in spawning surveys in 2015 that adult sockeye salmon were not present in upper tributaries to Hatchery Creek during the spawning season, despite Tributary 2 providing the potential for quality fish habitat (CCTHITA and USFS, 2002).

Historical imagery comparisons show the most dramatic changes in the watershed being from timber harvest and the roads constructed to accommodate timber harvest. Harvest occurred in the early 1980s. Riparian buffers after timber harvest are not evident in aerial imagery, supported by CCTHITA and USFS (2002) documenting that at least five tributaries were harvested to the streambanks. Given that the lower sections of Hatchery Creek are largely floodplain and palustrine channel types (CCHTITA and USFS, 2002), a fair amount of backwater ponding may be observed in aerial imagery. This may be due to timber removal, as well as beaver activity which was noted in past and current stream survey work.

Floodplain channels, which comprise the stream habitat surveyed reaches of Hatchery Creek and Tributary 2 of Hatchery Creek, facilitate sediment storage in the form of pool and point bar deposition of sediments transported from upstream. These sediments typically remain until a high flow event. Woody debris plays a significant role in providing structure to floodplain channels, creating pools and providing cover for rearing fish (Paustian et al., 2010). Overall, the stream habitat surveyed reaches of Hatchery Creek are functioning relatively well and provide high potential as sockeye salmon spawning habitat. In 2002, CCTHITA and USFS gave the lower mainstem of Hatchery Creek a Proper Functioning Condition rating and the lower section of Tributary 2 a Functional at Risk rating due to the lack of large woody debris recruitment. This continues to be supported by data in current stream habitat surveys, where the large wood metrics scored a “fair” value and key wood per meter values were “good”, suggesting a healthier quantity of key wood than total large wood. This indicates that larger, pre-timber harvest legacy wood has not yet decayed instream and is still in place, while smaller woody debris is decaying and not being replaced. Although some riparian thinning was done throughout the watershed, as recommended (CCHTITA and USFS, 2002), no assessment of the impacts of this on riparian vegetation has been done.

Because floodplains already store a high amount of sediment, they are sensitive to the introduction of additional sediment. As a result, the USFS Best Management Practices (BMP) state that any riparian management activities in a floodplain should emphasize stream bank protection and erosion control (USFS, 2006). The most common restoration projects undertaken in floodplains are large wood projects, where additional wood is placed in the channel to create rearing habitat for juvenile fish (Paustian et al., 2010). Given the distance of the surveyed reaches from the nearest road (from 160 – 805 meters) and the forested habitat, it is likely that the access necessary to place additional large wood into the stream would create considerable riparian disturbance and sedimentation. While the stream could have better metrics values for wood, it is still considered to be functioning in the "good" to "excellent" range and FPM and FPS channel types are of high value as sockeye salmon spawning and rearing habitat (Tucker and Cauoette, 2008; Paustian et al., 2010). It is debatable whether or not the amount of riparian disturbance associated with such a large wood project would justify the potential habitat restoration treatment.

One key feature assessed in the Hatchery Creek sub-basin was a large beaver dam located approximately 290 meters up Tributary 2 (see Figure 4 for location). The structure measured 1.35 meters (4.4 feet) high with a 1 meter (3.2 feet) deep pool in front of it. An adult salmon's ability to jump and overcome upstream barriers is dependent on their physical condition. Given that adult sockeye salmon will have navigated the Klawock River and Klawock Lake to arrive in Hatchery or Threemile Creeks, it is likely that fish condition becomes poorer as they migrate up the creeks. Given the pool depth requirements in Table 4, the beaver dam is considered a barrier to the adult migration of sockeye salmon. There are several small side channels that have developed around the dam that may allow sockeye the opportunity to move upstream during moderate or high water events; several sockeye were observed above the dam in 2017 (M. Kampnich, personal observation).

Tributary 2 of Hatchery Creek is the largest tributary in the sub-basin, and could provide up to 2.9 kilometers of anadromous fish habitat (CCTHITA and USFS, 2002), most of which is currently inaccessible due to the adult fish pass blockage of the assessed beaver dam. Based on current data and the analysis of the survey data and metrics, it seems likely that, if accessible, this area would provide suitable sockeye salmon spawning habitat in the immediate future. Reach 3, above the steel girder bridge (Figure 4) contains intact riparian vegetation (C. Woll, personal observation; CCTHITA and USFS, 2002), and was previously rated as Proper Functioning Condition. This reach is approximately 1,046 meters long, and survey data indicate it would provide high value spawning habitat for sockeye salmon.

The downstream implications of removing the beaver dam on Tributary 2 also need to be considered. The dam appears to have been in place for some time and its removal would likely lead to the removal of pools and an initial release of sediment and silt, disrupting downstream habitat on the Hatchery Creek mainstem currently used by coho, pink, and potentially sockeye salmon (CCTHITA and USFS, 2002). Deep pools, such as those created by beaver dams, provide overwintering habitat for juvenile salmon, especially coho salmon; dam removal could be detrimental to the winter survival of juveniles (Paustian et al., 2010). Although beaver activity will likely continue in the area even with the removal of the dam, it is thought that the logs used in the dam were from previous logging activities, and a dam of this scale may not be likely to be built. Any removal should be done in a manner to mimimize a pulse of sediment, especially during salmon spawning times.

5.2 Threemile Creek

Sockeye salmon spawning surveys showed relatively high use of the mainstem of Threemile Creek downstream of the crossing with the Klawock-Hollis Highway at mile marker 12 (Figure 5). While a few adult sockeye salmon were observed above the double culverts at the highway crossing in 2015, only six were observed to be spawning during surveys. CCTHITA and USFS (2002) identified up to 4.8 kilometers of Class I anadromous fish habitat on the mainstem of Threemile Creek, and the current AWC documents sockeye salmon present to the same extent. While spawning habitat may be available to sockeye salmon upstream of the highway crossing, spawning surveys and anecdotal observations indicate that a relatively low number, if any, adult sockeye salmon are utilizing it. This conflicts with historical information about high use of habitat far up the stream by sockeye salmon (Moser, 1898).

As seen in Figure 6, by 1972 the Klawock-Hollis Highway was constructed and some development within the Threemile sub-basin had begun. In 1991, the Klawock Lake Subdivision was recorded, and individual lots were given to shareholders of KHC (M. Edenshaw, personal communication). By the current aerial imagery most lots within the subdivision have had fill and residential houses constructed. In addition, the landowner immediately downstream of the Klawock-Hollis Highway crossing has restricted floodplain flow with the installation of a rip rap rock dyke (see Section 4.2.3.1). Aerial imagery also shows extensive timber harvest and associated road building along Threemile Creek and within the sub-basin. These developments within the lower reaches of the sub-basin impact fish habitat and can complicate planning efforts for potential restoration opportunities.

Reaches 1, 2 and 7 assessed on the mainstem of Threemile Creek are classified as small and moderate floodplain, the characteristics of which are discussed above for Hatchery Creek (see Section 5.1). These segments tend to facilitate sediment storage and large wood and pools can play a significant role for rearing salmon (Paustain et al., 2010). These three reaches received the lowest overall scores during the stream habitat surveys conducted in 2015 and 2016 (Table 15). While large wood per kilometer in the lower reaches were considered “good”, the remaining metrics only scored “fair”. Reach 3 received the highest overall rating of 2.4, making it the best functioning reach on Threemile Creek in this current assessment.

As mentioned in Section 4.2.3, Reach 1 was treated as a floodplain for this analysis. While there are multiple braided channels in the section with alluvial deposition, it was not clear at the time of the survey how many of the channels are active or remnants. Further, the stream has been manipulated by landowners to protect property, which has changed the hydrology and over function of the reach. Therefore, the channel type has likely changed over time, or the transition makes it difficult to determine one channel type over the other. With respect to alluvial fans, and how they function for spawning and rearing salmon, they are not addressed in Tucker and Caoulette (2008). It is difficult to quantify alluvial fan dynamics in systems with timber harvest (Emil Tucker, personal communication).

Reaches 4-6 and 8 are all classified as reaches that can both provide valuable spawning and rearing habitat when enough woody debris is available, however their scores for large wood per meter and pools per kilometer were "fair" (Table 15). Limited enhancement is possible through the anchoring of large wood into channels (Paustain et al., 2010).

While the channel type and substrate of Reaches 3-6 and 8 are not the most ideal for sockeye salmon spawning, they can provide suitable spawning habitat when sufficient wood is present. The large wood and pool metrics of all the surveyed reaches are below average, indicating that there is less wood present than would be in an unmanaged stream of the same channel type. Similar to Hatchery Creek, key wood metrics ranked higher than large wood. Again, this could indicate that smaller woody debris is eroding before it can be replaced, while legacy key wood remains from pre- or immediately post-timber harvest. The bedrock chute observed at the upper end of the survey is likely a barrier to fish passage, meaning there is approximately one mile of potential habitat available upstream from where the stream flows under the Klawock-Hollis Highway.

The presence of a significant number of conifers in the riparian vegetation is encouraging, however, their small size means that they are less likely to contribute to in-stream large and key wood for several years. This was also noted in the Proper Functioning Condition survey, which rated the mainstem of Threemile Creek as Functional at Risk with a downward trend (CCTHITA and USFS, 2002). Given the nature of the surveyed channel types, it is likely they never provided excellent sockeye salmon habitat. Undercutting, erosion, and excessive sediment deposition were all phenomenon observed in current stream habitat surveys and the 1999 PFC surveys (CCTHITA and USFS, 2002). The combination of these challenges with the limited large wood recruitment indicates that what little habitat potentially exists is in a degraded condition post-timber harvest. Although some riparian thinning was done throughout the watershed, as recommended (CCHTITA and USFS, 2002), no assessment of the impacts of this on riparian vegetation has been done.

The double culverts, located where Threemile Creek crosses the Klawock-Hollis Highway at mile marker 12, were assessed and both culverts were categorized as red. CCTHITA and USFS (2002) also noted that the highway crossing, as well as the subdivision, which may be limiting fish passage into available habitat above the road crossing due to the altered hydrology and morphology of the downstream habitat by impairing floodplain connectivity. These developments deny the stream access to the overflow channels observed in historical aerial imagery during high streamflow events. These factors may be contributing to why more sockeye salmon are not accessing available habitat above the Klawock-Hollis Highway.

Given that Threemile Creek has been identified as one of the largest sockeye salmon producing streams in the Klawock Lake system, this conclusion may partially explain declines seen in Klawock Lake sockeye salmon returns in recent decades. Knowing that small and medium moderate gradient mixed control, medium low gradient contained and small channels all require adequate wood inputs to provide the limited amount of fish habitat they can offer, it is logical that these reaches continue to function below potential. Timber harvest in the Threemile Creek watershed has undoubtedly impacted in-stream wood deposition, as well as affected sediment routing.

The channel types surveyed are likely to respond positively to the addition of large wood and there is potential for habitat enhancement in Threemile Creek. However, given the amount of bedrock present, any project would need to be well planned and engineered to ensure that placed wood does not get blown out in a high water event; efforts on examining previous riparian thinning or new treatments may be considered to ensure future recruitment of large wood. Considerations to landowners should also be given when considering the addition of large wood in Reach 1 of Threemile Creek. Added wood has a high potential for flooding in the subdivision, which is already seen as an issue previously discussed. The two culverts at the Klawock-Hollis Highway were recently classified as red culverts, which will likely continue to degrade fish passage over time. A fish passage improvement project at this location would need to be well planned, as to not have downstream effects in the Klawock Lake Subdivision. Similar to Hatchery Creek, access for restoration may be an issue on Threemile Creek. There are logging roads parallel to the creek on both sides, but they are decommissioned and in many places the slope between the creek and roads is higher than 30 degrees.

5.3 Inlet Creek

The mainstem of Inlet Creek has previously been classified as a Class I anadromous fish stream up to the point where current sockeye salmon spawning surveys ended, and Inlet Creek was given a proper functioning condition rating (CCTHITA and USFS, 2002). In CCTHITA and USFS (2002), improvement to the culvert outlet pools and/or culvert replacement at the Klawock-Hollis Highway crossing was recommended as a restoration opportunity to improve fish passage, which occurred in 2012/2013 (Klawock Watershed Council, 2008; Woll and Prussian, 2016). Current sockeye salmon spawning surveys show active spawning above the culvert (Figure 8), indicating that the culvert is not a problem for adult fish passage.

Historical aerial imagery comparisons for Inlet Creek show the two primary changes within the sub-basin, the addition of the Klawock-Hollis Highway, and timber harvest with roads constructed to accommodate timber harvest. The logging road system in the Inlet Creek sub-basin is largely unknown, and no formal Road Condition Survey work has taken place (CCTHITA and USFS, 2002). Aerial imagery shows most logging roads run adjacent and cross tributaries of Inlet Creek rather than the mainstem. According to aerial imagery, the mainstem of Inlet Creek has not been significantly altered over time, and current imagery shows intact riparian buffers. This correlates with the average 66 foot riparian buffer observed during the Proper Functioning Conditions survey in 2000 (CCTHITA and USFS, 2002). Other than timber harvest and associated activities, the historical aerial imagery analysis did not highlight any other large changes on the mainstem of Inlet Creek.

Much like Tributary 1 in Hatchery Creek (see section 5.1), Inlet Creek is classified as a floodplain channel, which facilitates sediment storage in the form of pool and point bar deposition. Further, woody debris plays a significant role in providing instream structure important for rearing fish (Paustian et al., 2010). The survey team conducting the Proper Functioning Conditions survey in 2000 determined the intact riparian buffers would allow for adequate future large woody debris recruitment. However, the large wood per meter metric in the 2015 survey was classified as “fair”, as was the pools per kilometer metric, suggesting that decaying smaller woody debris is not being replaced, which may in turn be reducing the number of pools. The key wood per meter metric scored better with a value of "good", and pool spacing scored "excellent". Therefore the overall condition of the mainstem of Inlet Creek will likely continue to have high value as sockeye salmon spawning habitat. While no immediate restoration opportunities were identified for the mainstem of Inlet Creek, future surveys should include an assessment of the large wood recruitment to assure that the system continues to function as best it can. Failure to see improvement in large woody debris recruitment in the future may lead potentially placing larger wood in the stream to maintain its functions.

5.4 Conclusions

Hatchery Creek is a large sub-basin, much of which has not been recently assessed. Sockeye salmon, which were not previously listed in the State of Alaska Anadromous Waters Catalog, were actively spawning in the sub-basin for all three years of survey work. A complete assessment of the sub-basin would be a valuable resource tool for future management of sockeye salmon. The focus in this study was to concentrate on evaluating one tributary where a legacy beaver dam has been in place and impeding adult fish passage to approximately 2.9 kilometers of potential upstream habitat. While the upstream habitat was rated "good" habitat, it was limited in large wood both instream and for future recruitment, and access to upstream habitat to conduct restoration activities to improve those conditions would be challenging. It is not recommended to remove the legacy beaver dam located on Tributary 1, without conducting further analysis of downstream impacts of the release of stored sediments, as floodplain channel types are particularly sensitive to sediment loading.

Threemile Creek continues to be an important sockeye spawning system despite challenges from dramatic landscape changes. The sub-basin has the potential to provide improved spawning and rearing habitat with the addition of large woody debris or improved large wood recruitme; however in-stream work may be limited by access and risk to personal property as well as funding for proper design for successful wood placement. The culverts at the Klawock-Hollis Highway likely hinder fish passage into upstream spawning habitat. Further data collection to support a more stringent analysis of fish passage constraint may lead to the potential for fish crossing improvements. Such an effort would need to seriously consider the downstream implication on private landowners. Finally, a significant amount of restoration work has occurred in the Threemile Creek sub-basin, however there has not been an assessment to determine whether those efforts are working. Examples would include determining if road closures and erosion control efforts have improved sedimentation issues, as well as knowing if riparian thinning prescriptions were applied and if they are working.

Inlet Creek currently provides valuable spawning and rearing habitat for sockeye salmon. Sockeye salmon habitat functions well in present time, however there is low availability of large wood recruitment that may pose future issues. Inlet Creek would benefit from regular monitoring for potential degradation of habitat.

Future sockeye salmon spawning and habitat assessment work is needed on Halfmile Creek, which was not included in this study but has been identified as an important sockeye salmon stream. Further, the lakeshore of Klawock Lake may also be a contributing habitat for sockeye salmon spawning success, but little to no data is available. This information would help to round out the overall status of sockeye spawning habitat available in the Klawock Lake watershed.

6.0 References

Alaska Department of Environmental Conservation, Drinking Water Protection Program. Accessed August 10, 2016: http://dec.alaska.gov/eh/dw/dwp/protection_areas_map.html.

Alaska Department of Natural Resources. 2016a. Division of Forestry, Alaska Forest Resources and Practices Act. Accessed August 10, 2016: http://forestry.alaska.gov/forestpractices.

Alaska Department of Natural Resources. 2016b. Land Records Search Portal. Accessed August 10, 2016: http://dnr.alaska.gov/projects/las/#filenumber/22890/filetype/LAS/landflag/y/searchtype/casefile/reporttype/abstract.

Cartwright and Conitz, 2006. Klawock Lake sockeye salmon (Oncorhynchus nerka) stock assessment project: 2003 annual report and 2001-2003 final report. Alaska Department of Fish and Game, Fishery Data Series No. 06-64, Anchorage.

Cartwright, M. A., and B. A. Lewis. 2004. Klawock Lake sockeye salmon (Oncorhynchus nerka) stock assessment project: 2002 annual report. Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services, Juneau, Alaska.

Central Council Tlingit and Haida Tribes of Alaska (CCTHITA), and US Forest Service (USFS). 2002. Klawock Watershed Condition Assessment, Klawock, Alaska.

Eisenman, M., and G. O'Doherty. 2014. Culvert inventory and assessment manual for fish passage in the State of Alaska: A guide to the procedures and techniques used to inventory and assess stream crossings 2009-2014. Alaska Department of Fish and Game, Special Publication No. 14-08, Anchorage

Edgington, J. and R. Larson. 1979. Revised anadromous stream catalog of southeastern Alaska. Appendix C – District 3, Volume II. West Coast of Prince of Wales Island. Alaska Department of Fish and Game Technical Data Report Series.

Groot, C. and L. Margolis. 1991. Pacific salmon life histories. Vancouver, BC: University of British Columbia Press.

Keta Engineering. 2003. Klawock Watershed Restoration Master Plan. Prepared for the Klawock Watershed Council, Klawock, Alaska

Klawock Watershed Council. 2008. Klawock Watershed Restoration Master Plan Update – 2008, Klawock, Alaska.

Moser, J. F. 1898. The salmon and salmon fisheries of Alaska: Report of the operations of the United States Fish Commission Steamer Albatross for the year ending June 30, 1898. US Government Printing Office.

Nichols, J., K. Schroeder, B. Frenette, J. Williams, A. Crupi, and K. Smikrud. 2013. A user guide for performing stream habitat surveys in Southeast Alaska. Alaska Department of Fish and Game, Special Publication No. 13-04, Anchorage.

Paustian, S. J. E., K. Anderson, D. Blanchet, S. Brady, M. Cropley, J. Edgington, J. Fryxell, G. Johnejack, D. Kelliher, M. Kuehn, S. Maki, R. Olson, J. Seesz, and M. Wolanek. 2010. A Channel Type Users Guide for the Tongass National Forest, Southeast Alaska. Page 179 in A. R. USDA Forest Service, editor. US Department of Agriculture, Forest Service, Alaska Region. Accessed at https://dspace.nmc.edu/handle/11045/20008.

Powers, Patrick and John Orsborn. 1985. Analysis of Barriers to Upstream Fish Migration: An Investigation of the Physical and Biological Conditions Affecting Fish Passage Success at Culverts and Waterfalls. Albrook Hydraulics Laboratory. Department of Civil and Environmental Engineering, Washington State University. Pullman, Washington.

Ratner, N. C., P. Brown, J. Rowan, D. Yates, M. Smith, J. A. Dizard, A. Paige, and M. F. Turek 2006. Local knowledge, customary practices, and harvest of sockeye salmon from the Klawock and Sarkar Rivers, Prince of Wales Island, Alaska. Alaska Department of Fish and Game, Division of Subsistence.

Rosgen, D.L., 1996. Applied River Morphology. Western Hydrology, Lakewood, Colorado.

Southeast Alaska Hydrography Database. 2016. GIS data downloaded from: http://seakgis.alaska.edu/index.html.

Strahler, A. 1964. Quantitative geomorphology of drainage basins and channel networks. Pages 39-76 in V. T. Chow, editor. Handbook of Applied Hydrology. McGraw-Hill, New York.

Tucker, Emil and John Caouette. 2008. Statistical Analyses of Aquatic Habitat Variables in the Tongass National Forest. Unpublished report. U.S. Forest Service, Petersburg, Alaska.

United States Forest Service. 2001. Alaska region aquatic habitat management handbook. Chapter 20. USDA Forest Service. FSH 2090.21. R-10 Amendment 2090.21-2001-1.

United States Forest Service. 2006. Forest Service Handbook Alaska Region (Region 10), Juneau, Alaska. Amendment Number: R-10 2509.22-2006-2. FSH 2509.22 – Soil and Water Conservation Handbook.

United States Forest Service. 2007. Habitat Management Objectives – Statistical Update. Forest Service Handbook, Juneau, Alaska.

United States Forest Service. 2015. Fish-Stream Identification and Stream Classification on the Tongass National Forest

Viereck, L. A., C. T. Dyrness, A. R. Batten, and K. J. Wenzlick. 1992. The Alaska Vegetation Classification. USDA Forest Service, Pacific Northwest Research Station, Oregon. PNW-GTR-286.

Woll, Christine and Aaron Prussian. 2016. Klawock Lake Sockeye Salmon Retrospective Analysis. The Nature Conservancy and Alaska Watershed Consultants.

APPENDIX A

VEGETATION CLASS CODES (adopted from Viereck, et al. 1992)

I. Trees > 3m tall with canopy cover of ≥ 10%. If not, got to II.

IA. >75% of tree cover contributed by coniferous species. If not, go to IB.

IA1. Tree canopy of 60-100%. If not, go to IA2.

IA1a. Sitka Spruce dominates overstory and regeneration. Occupies wet sites in SE AK, primarily in alluvial flood plains.

IA1b. Western Hemlock dominates overstory; other species <25% of overstory.

IA1c. Sitka Spruce and Western Hemlock each contribute >30% cover. Sitka Spruce constitutes most of overstory, Western Hemlock usually provides most of understory. Occurs on moist sites throughout SE AK.

IA1d. Western Hemlock dominates. Sitka Spruce >25% cover but < Western Hemlock.

IA1e. Western Hemlock and Alaska Cedar dominate (each contributes 25-75% of canopy cover) Occurs on a variety of upland sites from sea level to subalpine.

IA1f. Mountain Hemlock dominates canopy cover. Occurs near treeline, normally on saturated soil throughout SE AK.

IA1g. Western Hemlock and Western Red cedar dominate (each contribute 25-75% of canopy). Alaska Cedar and Mountain Hemlock may also be significant. Occurs on low-producing, poorly drained sites in southern SE AK.

IA1h. Silver Fir and Western Hemlock dominate (each contributes 25 - 75% of canopy cover). Sitka Spruce and Western Red cedar may also be important. Limited distribution in southernmost SE AK.

IA1i. Subalpine Fir dominates canopy cover. Other important species include Sitka Spruce, Mountain Hemlock, and Alaska-cedar. Occurs I scattered locations near treeline in SE AK.

IA2. Tree canopy of 25 - 60% cover. If not, go to IA3.

IA2a. Sitka Spruce dominates overstory. Other species <25% of canopy cover. Often occurs in alluvial deposits and glacial moraines and outwash in SE AK.

IA2b. Western Hemlock and Sitka Spruce dominate overstory (each contribute 25-75% of canopy cover). Occurs from low to mid-elevations in SE AK.

IA2c. Mountain Hemlock dominates overstory. Other trees <25% of canopy cover. Primarily on high mountain slopes in SC and SE AK.

IA2d. Dominated by various combinations of cedar, Western Hemlock, Mountain Hemlock, Sitka Spruce, Lodgepole pine, Western Red cedar, and Pacific Yew. Stands with 3-5 overstory conifer species common on level or gently sloping wet sites in SE AK.

IA3. Tree canopy of 10-25% cover.

IA3a. Lodgepole Pine dominates overstory. Other species <25% of canopy cover. Generally on boggy, poorly-drained sites in SE AK.

IA3b. Sitka Spruce dominates overstory. Other species <25% of canopy cover. On poorly-drained sedge peat in SE and coastal SC AK.

IB. >75% of tree cover contributed by broadleaf species. If not, go to IC.

IB1. Tree canopy of 60-100% cover. If not, go to IB2.

IB1a. Red Alder dominates overstory. Other species <25% of canopy cover.

IB1b. Black Cottonwood dominates overstory. Other species <25% of canopy over. Generally along streams in SE and SC AK.

IB2. Tree canopy of 25-60% cover. If not, go to IB3.

IB3. Tree canopy of 10-25% cover.

IC. Broadleaf or coniferous species both contribute 25-75% of tree cover.

IC1. Tree canopy of 60-100% cover. If not, go to IC2.

IC2. Tree canopy of 25-60% cover. If not, go to IC3.

IC3. Tree canopy of 10-25% cover.

II. Erect to decumbent (reclining or laying on the ground with the tip ascending) woody shrubs with cover ≥25% OR dwarf trees (<3m tall) with cover ≥ 10% cover. If not, go to III.

IIA. Dwarf trees (<3m tall) with cover ≥ 10% cover. If not, go to IIB.

IIA1. Dwarf tree canopy of 60-100% cover. If not, go to IIA2.

IIA1a. Mountain Hemlock dominates overstory. Sitka Spruce may be present. Occurs at treeline in SE AK.

IIA1b. Subalpine Fir dominates overstory. Mountain Hemlock and Sitka Spruce may be present. Forms dense stands at elevational treeline in SE AK.

IIA2. Dwarf canopy of 25-59% cover. If not, go to IIA3.

IIA2b. Mountain Hemlock dominates overstory. Sitka Mountain-ash may be present. Common on peatlands and sometimes on exposed ridges in SE AK.

IIA3. Dwarf tree canopy of 10-25% cover.

IIB. Shrubs >1.5m tall and ≥25% cover dominate. If not, go to IIC.

IIB1. Shrub canopy cover >75%. If not, go to IIB2.

IIB1a. Willow species dominate overstory (<25% other canopy species). Characteristic of floodplains.

IIB1b. Alder species dominate overstory (<25% other canopy species). Common on steep slopes, floodplains and stream banks.

IIB1d. Alder and Willow co-dominate overstory. (each contributes 25-75% of canopy cover). Occurs on floodplains terraces and drainages on slopes.

IIB1f. Standing water present most or all of growin season Alder & Willow typically dominate. Common in Interior, SC, and SE Alaska on sites with poorly drained soil and hummocky micro-relief with depressions containing standing water.

IIB2. Shrub canopy cover 25-74% OR ≥ 2% IF little or no other vegetation cover resent.

IIB2a. Willow species dominate overstory (<25% other canopy species). Occupies a variety of sites, from dunes to river banks. Most common in Interior, W, SC and Arctic AK.

IIB2b. Alder species dominate overstory (<25% other canopy species). Found throughout state, but not as abundant as closed alder communities.

IIB2d. Alder and Willow co-dominate overstory. (each contributes 25-75% of canopy cover). On floodplain terraces and steep slopes near treeline in Interior and N. AK

IIB2f. Standing water present most or all of growing season. Alder (usually) and Willow typically dominate. Occurs on floodplains and drainages in Interior and SC AK.

IIC. Shrubs 0.2-1.5m tall and ≥25% cover dominate. If not, go to IID.

IIC1. Shrub canopy cover >75%. If not, go to IIC2.

IIC1b. Willow species dominate overstory (<25% other canopy species). Common in Interior, W and N AK along streams and lakes.

IIC1d. Ericaceous (e.g. Copperbush Cladothamnus pyrolaeflorus) species dominate. Near treeline in SE AK (Copperbush Cladothamnus pyrolaeflorus).

IIC1e. Alder and Willow co-dominate overstory. (each contributes 25-75% of canopy cover). Reported from SE AK on poorly drained soils.

IIC2. Shrub canopy cover 25-74% OR ≥ 2% IF little or no other vegetation cover present.

IIC2e. Ericaceous species dominate (<25% other canopy species). Wet peal soils. Common in maritime climates of SE and SC Alaska and Aleutian Is. Hydrophytic sedges and Sphagnum mosses generally present.

IIC2i. Willow species dominate overstory (<25% other canopy species); graminoids dominate understory on peat soils (in subarctic and subalpine regions within treeline). Occurs in wet stream bottoms and depressions in Interior, SW, SC and SE AK.

IIC2j. Sweetgale and graminoids dominate on extremely wet (often standing water) on peat soils. Occupies poorly drained lowlands and pond margins in SE, SC and SW AK.

IID. Shrubs < 0.2 m tall and ≥ 25% cover OR ≥ 2% IF little or no other vegetation cover present.

IID1. Dryas species dominate. If not, go to IID2.

IID1a. Dryas species dominate.

IID1b. Dryas species and sedges dominate.

IID1c. Dryas species and fruticose lichens dominate.

IID2. Ericaceous species dominate. If not, go to IID3.

IID2c. Crowberry Empetrum nigrum dominates.

IID2d. Mountain-Heath Phyllodoce aleutica dominates. Common on alpine slopes.

IID2e. Cassiope species dominate. Widespread on moist alpine sites.

IID3. Willow species dominate.

III. Herbaceous (non-woody) vegetation dominates with < 25% scrub and < 10% forest cover. If not, go to IV.

IIIA. Grasses and Sedges dominate (Rushes and Horsetails are treated as forbs). If not, go to IIIB.

IIIA1. Graminoids dominate on well- to excessively-drained sites. If not, go to IIIA2. Grasslands of well-drained, dry sites, such as south facing bluffs, old beaches and sand dunes.

IIIA1a. Elymus species dominate. Occurs on beaches, dunes, gravel outwash flats, and dry slopes mostly in coastal areas, but occasionally in Alaska and Brooks Ranges and Interior Alaska.

IIA1d. Medium height grasses and broad-leaved herbs dominate.

IIIA1e. Hair-grasses Deschampsia species dominate. Common in Aleutian Islands and along southern coast of Alaska. Often diverse stands with small numbers of a great many species.

IIIA2. Graminoids dominate or co-dominate on mesic sites. Grasslands on moist sites, but usually not with standing water (tussocks often present).

IIIA2a. Bluejoint Calamagrostis dominates (includes lawns). 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 co-dominate. Widely distributed in southern half of state.

IIIA2c. Bluejoint Calamagrostis dominates with conspicuous shrubs providing < 25% cover. Extensive in SW AK and probably also common in SC and Interior AK.

IIIA2d. Sedges in tussock growth form dominate (in arctic and alpine regions beyond treeline). Widely distributed throughout W, N and Interior AK.

IIIA2e. Sedges and Grasses dominate in various combinations (in arctic and alpine regions beyond treeline).

IIIA2f. Sedges and broad-leaved herbs co-dominate (in arctic and alpine regions beyond treeline

IIIA2g. Grasses and broad-leaved herbs co-dominate (in arctic and alpine regions beyond treeline).

IIIA2h. Sedges dominate with conspicuous willow component providing < 25% cover (in arctic and alpine regions beyond treeline).

IIIA2i. Sedges dominate with conspicuous shrub birch component providing < 25% cover (in arctic and alpine regions beyond treeline).

IIIA2j. Sedges dominate with conspicuous dryas component providing < 25% cover (in arctic and alpine regions beyond treeline).

IIIA3. Graminoids dominate or co-dominate on wet (saturated or flooded most or all of growing season) sites.

IIIA3c. Sedges and broad-leaved herbs co-dominate (in arctic and alpine regions beyond treeline). Found on very wet, poorly drained sites with standing water, such as oxbow lakes and alpine bogs. Apparently widely distributed throughout Alaska.

IIIA3d. Tall Sedges emerging from standing water (> 0.15 m deep) dominate.

IIIA3e. Grasses emerging from standing water (>0.15 m deep) dominate. 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.

IIIA3f. Coarse, relatively tall Sedges in saturated/shallow soils dominate (in subarctic and subalpine regions within tree limit). 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). Occupies upper parts of coastal marshes in SC and SE Alaska.

IIIA3h. Salt-tolerent Grasses (e.g., Puccinellia) dominate. Commonly occupies tidal mud flats along entire AK coast.

IIIA3i. Salt-tolerent Sedges (e.g., Carex) dominate. Commonly occupies tidal mud flats along entire AK coast.

IIIA3j. Delicate, low Sedges on bog peats dominate (in subarctic and subalpine regions within tree limit). 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 co-dominant on peat soils (in subarctic and subalpine regions within tree limit). 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.

IIIB1. Forbs dominate on dry sites (often sparsely vegetated pioneer communities). On dry sites, usually rocky and well-drained; mostly tundra sites. If not, go to IIIB2.

IIIB1a. Open Herb communities colonizing previously un-vegetated non-alpine sites. Found throughout AK on floodplains, river banks and eroding bluffs.

IIIB1b. Wide variety of herbs and sedges dominate on sites covered by late melting snow beds.

IIIB1c. Sparse herb communities on alpine rock outcrops, talus and blockfields.

IIIB2. Forbs dominate in mesic soils.

IIIB2a. Mixture of herbs dominate.

IIIB2b. Fireweed Epilobium angustifolium dominates.

IIIB2c. Tall (0.5-1.5 m) Umbilliferae (e.g., Heracleum and Angelica) dominate.

IIIB2d. Ferns (e.g., Athyrium and Dryopteris) dominate.

IIIB3. Forbs dominate on wet (saturated or flooded most or all of growing season) sites.

IIIB3a. Herbs (e.g., Equisetum, Menyanthes trifoliata, and Potentilla palustris) emerging from standing water (> 0.15 m) – found in ponds and sloughs

IIIB3b. Herbs on saturated or shallow flooded (≤ 0.15 m deep) non-peat soils dominate (in subarctic and subalpine regions within tree limit).

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).

IIIB3d. Halophytic Herbs dominate on tidal areas inundated ≥ a few times/month by salt water.

IIIC. Bryophytes (mosses and liverworts) and/or Lichens dominate. If not, go to IIID.

IIIC1. Bryophytes (mosses and liverworts) dominate. If not, go to IIIC2.

IIIC1a. Bryophytes (e.g., Gymnocolea, Scapania, and Nardia) dominate on non-wet sites. Vascular plants are virtually absent.

IIIC1b. Bryophytes (e.g., Rhacomitrium, Grimmia, and Andreaea) dominate on non-wet sites. Vascular plants are virtually absent. Occurs on gravelly slopes, sand dunes and mounds. Cover is usually sparse.

IIIC2. Lichens dominate.

IIIC2a. Crustose Lichen species dominate. 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. Occurs on dry fellfields and exposed ridges.

IIID. Plants with floating or submerged leaves dominate. Plants may also have emergent leaves and flowers.

IIID1. Aquatic communities in fresh water.

IIID1a. Pond lilies Nuphar and Nymphaea dominate.

IIID1b. Common Marestail Hippuris vulgaris dominates. Standing water may dry up for several weeks during growing season. Emergents are absent or nearly so.

IIID1c. Aquatic Buttercup Ranunculus species dominate or co-dominate.

IIID1d. Berreed Sparganium species dominate.

IIID1e. Water Milfoil Myriophyllum spicatum dominate.

IIID1f. Pondweeds Potamogeton species dominate.

IIID1g. Water Star-Wort Callitriche species dominate.

IIID1h. Aquatic Cryptogams (e.g., mosses Fontinalis, liverwort Scapania, lichen Siphula, and quillwort Isoetes) dominate.

IIID2. Aquatic communities in brackish water.

IIID2a. Four-Leaf Marestail Hippuris tetraphylla dominates.

IIID2b. Brackish water-tolerent Pondweed Potamogeton, Wigeongrass Ruppia spiralis, or Horned Pondweed Zannichellia palustris dominate.

IIID3. Aquatic communities in marine water

IIID3a. Eelgrass Zostera marina dominates.

IIID3b. Marine Algae dominates.

IV. <2% vegetative cover.

DISTURBANCE CLASS CODES (RDB)

- **I.** Anthropogenic Disturbance
  - **IA.** Unique
    - **IA1.** Timber Harvest
      - **IA1a.** 0-1 year post-harvest
      - **IA1b.** 1-5 year post-harvest
      - **IA1c.** 10-20 year post-harvest
      - **IA1d.** 20+ year post-harvest
    - **IA2.** Construction
      - **IA2a.** 0-1 year post-construction

7.0 **IA2b.** 1-5 year post-construction

      - **IA2c.** 10-20 year post-construction
      - **IA2d.** 20+ year post-construction
    - **IA3.** Enhancement/Restoration
      - **IA3a.** Bank stabilization
      - **IA3b.** Riparian thinning
      - **IA3c.** Fisheries related
      - **IA3d.** Rip-rap
  - **IB.** Repeated Seasonal
    - **IB1.** Foot traffic
      - **IB1a.** Anglers
      - **IB1b.** Non-anglers
    - **IB2.** Vehicle traffic
      - **IB2a.** Non-recreational (road vehicle)
      - **IB2b.** Recreational (atv, snowmachine, etc)
  - **IC.** Permanent
    - **IC1.** Pervious Surfaces
      - **IC1a.** Urban/commercial landscaping
      - **1C1b. Agricultural**
      - **IC1c.** Gravel
      - **IC1d.** Other
    - **IC2.** Impervious surfaces
      - **IC2a.** Parking area
      - **IC2b.** Paved trail/walkway
      - **IC2c.** Concrete wall/abutment
- **II.** Natural Disturbance
  - **IIA.** Water/flood
    - **IIA1.** Bank disturbance (slumping/undercutting/erosion)
      - **IIA1a.** Wood inputs
      - **IIA1b.** Sediment inputs
    - **IIA2.** Chronic sediment deposition from tributary
  - **IIB.** Windthrow
  - **IIC.** Glacial retreat
  - **IID.** Fire
  - **IIE.** Mass wasting
    - **IIE1.** Avalanche
    - **IIE2.** Creep/solifluction
    - **IIE3.** Landslide
    - **IIE4.** Debris torrent
  - **IIF.** Natural tree mortality

APPENDIX B

Photo log for Hatchery Creek

Photo 1. Starting point of stream survey on Hatchery Creek, in the Klawock Lake Watershed, Klawock, Alaska. Photo taken from bridge, looking downstream.

Photo 2: Beaver dam at the downstream extent of Reach 1 (Figure 2) in Hatchery Creek, Klawock Lake Watershed, Klawock,

Alaska. Photo taken from below the dam, looking upstream with a crew member on dam for scale.

Photo 3: Photo of Reach 1 in Hatchery Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is

taken looking upstream from the channel type verification point.

Photo 4. Photo of Reach 1 in Hatchery Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is taken looking downstream from the channel type

verification point.

Photo 5. Photo of Reach 2 in Hatchery Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is

taken looking upstream from the channel type verification point.

Photo 6. Photo of Reach 2 in Hatchery Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is

taken looking downstream from the channel type verification point.

Photo 7. Photo of Reach 3 in Hatchery Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is

taken looking upstream from the channel type verification point.

Photo 8. Photo of Reach 3 in Hatchery Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is taken looking downstream from the channel type verification point

APPENDIX C

Photo log for Threemile Creek

surveyed reaches of Threemile Creek in the Klawock Lake Watershed, Klawock, Alaska.

Photo 9: Bedrock chute, a potential barrier to fish passage, at the upper extent of the

Photo 10: Photo of Reach 1 in Threemile Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is taken looking downstream from the channel type verification point.

Photo 91: Photo of Reach 1 in Threemile Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is taken looking upstream from the channel type verification point.

Photo 12: Photo of Reach 2 in Threemile Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is taken looking downstream from the channel type verification point

Photo 13: Photo of Reach 2 in Threemile Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is taken looking upstream from the channel type verification point

Photo 14: Photo of Reach 3 in Threemile Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is taken looking downstream

Photo 15: Photo of Reach 4 in Threemile Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is taken looking downstream from the channel type verification point

Photo 16: Photo of Reach 4 in Threemile Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is taken looking upstream from the channel type verification point

Photo 17: Photo of Reach 5 in Threemile Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is taken looking downstream from the channel type verification point

Photo 18: Photo of Reach 5 in Threemile Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is taken looking upstream from the channel type verification point

Photo 19: Photo of Reach in Threemile Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is taken looking downstream from the channel type verification point

Photo 100: Photo of Reach 6 in Threemile Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is taken looking upstream from the channel type verification point

Photo 21: Photo of Reach 7 in Threemile Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is taken looking downstream from the channel type verification point

Photo 22: Photo of Reach 7 in Threemile Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is taken looking upstream from the channel type verification point

Photo 23: Photo of Reach 8 in Threemile Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is taken looking downstream from the channel type verification point

Photo 24: Photo of Reach 8 in Threemile Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is taken looking upstream from the channel type verification point

Photo 25: Example of undercut bank seen throughout the reaches surveyed in Threemile Creek in the Klawock Lake Watershed, Klawock, Alaska.

Photo 26: Example of undercut bank and erosion seen throughout the surveyed reaches of Threemile Creek in the Klawock Lake Watershed, Klawock, Alaska.

APPENDIX D

Reach data collected in 2015 for Threemile Creek and Inlet Creek drainages in Klawock Lake Watershed in Klawock, Alaska. All measurement are in meters (m).

Metric	Threemile Creek Reach 1	Threemile Creek Reach 2	Inlet Creek Reach 1
% Slope	-	-	
Reach length	326.75 m	432.97 m	907.08 m
Average channel bed width	13.25 m	19.44 m	10.16 m
Number of pools	10 m	9 m	26 m
Mean residual pool depth	0.60 m	0.61 m	0.48 m
RPD/CBW*	0.04 m	0.03 m	0.05 m
Pool size	-	-	-
Pools/km	30.60 m	20.79 m	28.66 m
Pool spacing	2.47 m	2.47 m	3.43 m
Pool length/meter	0.47 m	0.40 m	0.40 m
Total large wood	126 m	130 m	180 m
Total large wood/meter	0.39 m	0.20 m	0.20 m
Total key large wood	66 m	40 m	99 m
Total key large wood/meter	0.20 m	0.09 m	0.11 m
Width/depth	-	-	-
Mean bank full width	-	-	-
D50	4.57 m	45.30 m	30.69 m
Relative submergence	-	-	-
Minimum residual pool depth	0.28 m	0.34 m	0.25 m

*RPD – Residual Pool Depth; CBW = Channel Bed Width

APPENDIX E

Photo log for Inlet Creek

Photo 31: Photo of Inlet Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is taken looking upstream from the lower portion of Reach 1

Photo 32. Photo of Inlet Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is taken looking upstream from the midpoint of Reach 1, showing large woody debris.

Photo 33. Photo of Inlet Creek, of the Klawock Lake Watershed, Klawock, Alaska. The photo is taken looking downstream from the upper portion of Reach 1.