Fishery Data Series No. 21-01

Fish Passage Assessment, Inventory, and Prioritization of Culverts on the Ketchikan, Petersburg, and Wrangell Road Systems, 2013–2016

by

Gillian O'Doherty

and

Mark Eisenman

June 2021

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

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	E
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	′
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	″
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

FISHERY DATA SERIES NO. 21-01

FISH PASSAGE ASSESSMENT, INVENTORY, AND PRIORITIZATION OF CULVERTS ON THE KETCHIKAN, PETERSBURG, AND WRANGELL ROAD SYSTEMS, 2013–2016

By
Gillian O'Doherty
Alaska Department of Fish and Game, Sport Fish, Research and Technical Services, Anchorage
And
Mark Eisenman
Alaska Department of Fish and Game, Sport Fish, Research and Technical Services, Anchorage

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

June 2021

This report was prepared by the authors under Alaska Sustainable Salmon Fund award #44635 from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, administered by the Alaska Department of Fish and Game.

ADF&G Fishery Data Series was established in 1987 for the publication of Division of Sport Fish technically oriented results for a single project or group of closely rewlated projects, and in 2004 became a joint divisional series with the Division of Commercial Fisheries. Fishery Data Series reports are intended for fishery and other technical professionals and are available through the Alaska State Library and on the Internet: http://www.adfg.alaska.gov/sf/publications/. This publication has undergone editorial and peer review.

Gillian O'Doherty
Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services
333 Raspberry Road
Anchorage, AK 99518, USA

and

Mark Eisenman
Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services
333 Raspberry Road
Anchorage, AK 99518, USA

This document should be cited as follows:
O'Doherty, G., and M. Eisenman. 2021. Fish passage assessment, inventory, and prioritization of culverts on the Ketchikan, Petersburg, and Wrangell road systems, 2013–2016. Alaska Department of Fish and Game, Fishery Data Series No. 21-01, Anchorage.

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF APPENDICES

ABSTRACT

Between 2013 and 2016, Alaska Department of Fish and Game's Fish Passage Assessment Project assessed 197 stream crossing sites on over 183 miles of road in the communities of Petersburg, Ketchikan, and Wrangell. The project rated 129 sites Red, or crossings assumed inadequate for juvenile fish passage; 43 sites Gray, or crossings that may be inadequate for juvenile fish passage; 20 sites Green, or crossings likely to provide adequate juvenile fish passage; and 5 sites Black, or sites that could not be rated. The project also found 57 sites considered to be potential adult barriers that had either an outfall height over 1 ft, an average culvert gradient exceeding 4% while not being embedded, or both.

Keywords: Fish passage, culvert, assessment, prioritization, fish, salmon, Southeast, Petersburg, Ketchikan, Wrangell

INTRODUCTION

Culvert crossings under roadways often delay, impede, or block fish movement into and out of stream systems, resulting in habitat fragmentation with the potential to affect fish populations. Culvert assessments throughout the Pacific Northwest (Botkin et al. 1995; Kahler and Quinn 1998; Mirati 1999) and Southeast and Southcentral Alaska (Flanders and Cariello 2000; O'Doherty 2014) suggest that a majority of existing culverts obstruct fish movements to some degree.

Culverts may be barriers to fish immediately upon installation or develop into barriers over time due to alterations in stream flow and channel morphology up and downstream or poor maintenance and debris jams. Types of barriers include over-steepened reaches, excessive water velocities, impassable jumps at the entry into the culvert, physical blockage due to damaged pipes or debris, inadequate water depth or subsurface flow at damaged structures. Free and efficient movement through culverts is necessary for anadromous and resident fishes of all age classes and life stages to allow unobstructed access to important habitats (Kahler and Quinn 1998). Adult fish, including salmon, lamprey, flounder, eulachon, and other anadromous and resident species, must access spawning areas. Juvenile salmon such as Chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), and sockeye (*O. nerka*) salmon spend up to two years in fresh water as juveniles, moving to exploit diverse habitats for feeding and overwintering. Fish passage barriers affect resident species such as Arctic grayling (*Thymallus arcticus*), which use specific streams for spawning, juvenile rearing, summer feeding, and overwintering. Culverts are most likely to have a negative effect on the movements of fish with limited swimming and leaping abilities, such as juvenile salmonids, and species such as coho salmon, that rely on small streams for spawning and rearing habitat.

OBJECTIVES

1. Locate, inventory, and assess for fish passage at stream crossings (culverts) associated with roads, trails, and driveways within the communities and road systems of Ketchikan, Petersburg, and Wrangell.
2. Determine if crossing structures impede the movements of juvenile salmonids, other anadromous fish, or resident fish.
3. Prioritize barriers with respect to replacement or removal.
4. Add all inventoried culvert crossing sites to the Alaska Department of Fish and Game (ADF&G) Fish Passage Improvement Database and make publicly available with

mapped information on fish presence through the department's online interactive Fish Resource Monitor.[1]

STUDY AREA

The study area consisted of the communities and connecting road systems of Ketchikan, Petersburg, and Wrangell, and encompassed over 183 miles of roads and 180 predicted road stream crossings. Ketchikan was assessed in 2013, Petersburg in 2013 and 2014, and Wrangell in 2014 and 2016 (Table 1, Figures 1–3).

METHODS

FISH PASSAGE RATING OVERVIEW

To rate sites for effects on the passage of juvenile and weak-swimming fish, ADF&G follows a standardized method that was developed through coordination with other state and federal agencies specifically for use in Alaska. Culverts (crossings) are categorized by type and size, three Critical Values are calculated (gradient, outfall height, and constriction ratio), and results are compared to a decision matrix called the Level 1 Assessment Matrix (Figure 4). After categorization, the crossings are rated as Green, Gray, Red, or Black (Eisenman and O'Doherty 2014; Clarkin et al. 2005; Gordon et al. 2004; Karle 2005). Culvert ratings are described in more detail below:

- Green: likely to provide adequate juvenile fish passage
- Gray: may be inadequate for juvenile fish passage
- Red: assumed to be inadequate for juvenile fish passage
- Black: unable to assign fish passage rating

The Level 1 Assessment Matrix (Figure 4) uses the best available information to predict the ability of a young-of-year juvenile coho salmon (55 mm) to pass through a variety of culvert types. A 55 mm coho salmon was chosen as the model fish because they are believed to be the weakest swimming juvenile salmonid, and therefore, culverts that are passable by 55 mm coho salmon should be passable by other juvenile salmonids.

Where structures were damaged or there were other factors affecting fish passage, those factors were also considered and were noted in the site comments. For example, if a culvert was damaged to the point it was judged that fish could not swim through it, a Red rating would be assigned, and a note made in the comments section.

SITE SELECTION AND NAMING

Prior to beginning fieldwork, all known and potential road-stream crossing locations were identified and mapped using ArcGIS. The National Hydrography Dataset (NHD)[2] was overlaid on the most up to date road layer available and all places where the two intersect were marked as potential crossing locations. Satellite and aerial imagery were used locate other potential road

[1] The Fish Resource Monitor is available on the ADF&G Fish Passage Inventory Database (FPID) website at: http://extra.sf.adfg.state.ak.us/FishResourceMonitor/guide.html (accessed June 7, 2021).

[2] U.S. Geological Survey. 2019. National Hydrography Dataset. Available at https://www.usgs.gov/core-science-systems/ngp/national-hydrography/national-hydrography-dataset (accessed March 4, 2021).

crossings. These locations were downloaded to a handheld Garmin GPS unit used to locate sites in the field. The survey crew also visually located and recorded additional stream crossings on public roads as well as unmapped roads (such as driveways and bike trails).

Once in the field, only sites known or reasonably expected to be fish bearing were included in the assessment project. Sites that were typically assumed to be non-fish bearing include: ephemeral drainages that do not contain a defined channel; disconnected ponds; extremely steep channels; and crossings located above known natural barriers such as waterfalls, drainage swales, drainage ditches, cross drainage culverts, or other artificial water features. Crossings that are located above manufactured barriers were treated as if the manufactured barriers did not exist.

All surveys received a Survey ID at the time data is collected. This Survey ID is composed of the project ID, the year, the survey ID (assigned by field staff) and follows the previously used alphanumeric conventions for project name and location (e.g., SEA12-GLH01, where SEA12 refers to the project and year, Southeast Alaska 2012, and GLH01 refers to the road the survey was conducted on and survey number on that road, Glacier Highway survey 01) (Eisenman and O'Doherty 2014). After fieldwork was completed, each new survey was assigned to a Site, which is a permanent location with a unique ID number and a fixed location. Each site may have multiple surveys (Figure 5) which allows us to track change at the site over time. In the remainder of this report we will discuss the most current data for each site and will use the Site ID only.

ASSESSMENT PROTOCOL

A standard assessment protocol was used to collect data on culverts/crossings throughout the project. A summary of the assessment protocol is presented here, a detailed description can be found in the *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* (Eisenman and O'Doherty 2014). All data was recorded on project data forms (Appendix A) and in survey notebooks and later entered into the project database.

Site and Assessment Information

Information was collected on the location of each crossing (coordinates), the date and time of survey, and the identities of the crew.

Description of the Crossing Structure

Information was collected on culvert length, dimensions, shape, and the type of material used for construction. The type of inlet and outlet (projecting, mitered, or flared) was noted as was the presence of a headwall, wingwalls, or an apron. Where a crossing structure consisted of multiple culverts, each individual culvert was numbered according to its position sequentially from left to right as the observer faces downstream.

Each culvert outfall was categorized as either set at stream grade (AG), a free fall into the outlet pool (F), a free fall onto riprap (FR), a cascade over riprap (C), a fish passage structure (PS), smooth flow over an apron (SF), an overflow pipe (OP), or a hydraulic jump (HJ) at the time of survey. If an inlet or outlet apron existed, the construction material was noted, and the length measured.

Culverts that contained substrate were inspected to determine whether they were considered embedded by measuring the depth of the substrate at the inlet and outlet to the nearest 0.10 ft. For a culvert to be considered embedded, both inverts must be lower than the streambed elevation; the

barrel must contain streambed material throughout its length; circular culverts must be buried at least 20 percent of their diameter; pipe-arch culverts must be embedded so that the mean depth of the substrate within the pipe is equal to or greater than the vertical distance from the bottom of the culvert to the point of maximum horizontal dimension or 20 percent of the height, whichever is greater. Where substrate is greater than approximately 0.5 feet deep, substrate depth was estimated by driving a steel rod of known length into the material and subtracting the height of the rod projecting above the substrate from the total length.

The condition of each culvert was ranked 1 through 5 according to the following definitions:

1. Defective: Culvert is in dire need of prompt repair or replacement, flaws threaten to disrupt or are hindering traffic.
2. Poor: Culvert is in need of repair and shows potential for further deterioration.
3. Fair: Culvert is operational but may need maintenance to restore function to its full potential (e.g., when distinct rust lines, abraded bottom, or both are present, and adverse conditions could lead to major problems).
4. Good: Culvert shows minor deficiencies, beginning of rust line formation may be visible, but with continued maintenance should be trouble free.
5. Excellent: Culvert shows no signs of problems or rust and could allow flow at full capacity without disrupting fish passage.

Longitudinal Profile

A longitudinal profile is a survey of the stream down the length of the thalweg; in this case, the longitudinal profile encompassed the reach of the stream containing the culvert(s). The purpose was to collect relative elevations of the stream, water surface, and culvert structure to calculate water depth at outlet, outfall height, and pipe gradient. Occasionally when a longitudinal profile could not be carried out, the water depth at outlet and outfall heights were measured using had held-tape measures and documented in the survey notes.

Stream Measurements

The average width of the stream at ordinary high water (OHW) above the culvert was measured along three straight runs or heads of riffles at locations upstream of any obvious influence of the crossing structure. All channel widths were measured perpendicular to stream flow and to the nearest 0.10 ft using a fiberglass tape. If the upstream channel was a lake, wide slough or braided channel, channel widths of the downstream channel is recorded instead. If both up and downstream water bodies were ponds, lakes, or sloughs, average width was not recorded.

The alignment of the inlet with the upstream channel was determined to the nearest one degree using a sighting compass. The approach angle was calculated by subtracting the back azimuth of the line looking downstream through the culvert, from the azimuth of the channel looking upstream from the culvert inlet.

The dominant and subdominant substrate type at the inlet and outlet and in the up and downstream channels outside of the culvert influence were determined visually and recorded.

In 2011, it became standard protocol to collect the gradient of the stream. This is measured as the change in elevation of the water surface over a curvilinear distance of at least 10 times the OHW width. The stream gradient is calculated outside the influence of the culvert.

Site Observation Codes

Site Observation codes refer to circumstances that affect fish passage at a site and are used to clarify the reasons a site was placed into the Gray or Red categories as well as to note problems that are not part of the Red–Gray–Green classification system, but potentially affect fish passage or the prioritization of the culvert for replacement or repair. These include poor alignment, significant sedimentation, beaver activity, deliberate blockage by means of a screen or grill, debris blockage, or various types of structural damage. The complete list of codes and detailed descriptions can be found in the *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* (Eisenman and O'Doherty, 2014).

Site Sketch

The site sketch includes the culvert, road, direction of flow, location of fish traps, and any significant features observed at the site.

Photographs

A series of photographs were taken at each site with a digital camera. The order of photographs and a description of each are recorded in the survey notebook. At minimum photographs included the following:

- A site marker with the Site ID, road, and date written on a dry erase board at the site.
- A view of the road surface at the crossing site.
- A view from the culvert looking downstream at the tail crest and beyond.
- A view from below the tail crest looking upstream showing the culvert outlet type, condition, and road embankment. This photograph should show channel roughness (substrate, debris, vegetation, etc.) and culvert outlet height above the tailwater.
- A view from an upstream location (looking downstream) showing the culvert inlet type, condition, and road embankment. This photograph should show channel roughness (substrate, debris, vegetation, etc.) and culvert inlet conditions.
- A view from the culvert looking upstream.
- A photograph, when possible, of typical stream substrate and other channel roughness elements upstream of the culvert's influence.
- Additional photographs of conditions, if any, that may be negatively affecting fish passage (e.g., damage, debris, undesirable bed load deposition).

Fish Trapping

Traps were set on site to establish fish presence. Traps were baited with cured salmon roe and set near the bank far enough up and downstream of the culvert to minimize disturbance from assessment activities. Traps soaked approximately 1–2 hours at most sites. Any captured fish were identified to species and measured then released in pools at or adjacent to capture site.

Fish observed at the site, but not trapped or handled, were also noted as visual observations.

All fish-capture information was submitted as additional or backup information to the Anadromous Waters Catalog (AWC).

CALCULATING THE CRITICAL VALUES

Gradient

Culvert gradient was calculated as the difference in elevations between inlet invert and outlet invert, divided by the length of the culvert and multiplied by 100. In the case of an embedded culvert, or a culvert with sediment at the inlet, outlet, or both, the tops of culvert elevations were used instead of invert elevations:

$$\frac{(inlet\ elevation - outlet\ elevation)}{culvert\ length} \times 100 = pipe\ gradient\ .$$

During the project, some structures were found to contain sections that were considerably steeper than the average. The gradient of these sections was calculated separately and referred to as "maximum gradients" and were used to rate the culvert. Maximum gradients may also be calculated for aprons where they were significantly steeper than the culvert itself and may impede fish passage. If a maximum gradient was used it was noted in the comments for that site.

Outfall height

Outfall height (OH) was calculated from longitudinal survey elevation data and is the distance from the water surface at outlet (OWS) to the outlet pool surface or tailwater surface (TWS).

$$OH = OWS - TWS$$

The outfall height for a free fall into pool outfall type is the outlet water surface elevation subtracted from the outlet pool surface elevation (Figure 6).

Where the outfall falls onto riprap, cascades over riprap, or consists of a fish passage structure, the outfall height was measured from the water surface at the outlet invert to the water surface at the end of cascade or fish passage structure (Figure 7; Eisenman and O'Doherty 2014).

Constriction Ratio

The constriction ratio (CR) for one culvert was calculated as the culvert width (CW) divided by the average channel width at ordinary high water (OHW). Culvert width is the widest point at the inlet invert.

$$(CW/OHW):1$$

The constriction ratio for sites that had more than one circular culvert was calculated by the following formula:

$$CR = \sqrt{(r_1^2 + r_2^2 + r_{x,\ldots}^2)} \times 2 / \mathrm{OHW},$$

where r is the radius of each culvert.

DETERMINING FISH PRESENCE

During culvert assessments, crews set minnow traps, usually one upstream and one downstream from the culvert(s) when water levels allowed, to sample for fish presence. At sites where salmon were captured or observed, an AWC nomination was submitted.

A stream was considered fish-bearing if it was previously cataloged in the AWC, if there was fisheries data in the Alaska Freshwater Fish Inventory[3], if fish were trapped or observed during culvert assessments, or if a crossing has been documented by the U.S. Forest Service and marked with a Forest Service Stream Crossing placard (Figure 8). Additional streams were surveyed if the field crew judged them to have suitable fish habitat at time of assessment.

DATA MANAGEMENT AND QUALITY CONTROL

Data was collected on paper data sheets (Appendix A1) and entered into the Fish Passage Inventory Database[4] throughout the field season. At the end of the field season, all data was printed out and compared to the original field sheets manually by two project staff to catch data entry errors. Then a series of automated data checks was used to identify any outlying values or inconsistent entries such as sites with a high outfall that were not rated as Red. Locations of sites were checked individually using GIS, and photographs and comments were reviewed for accuracy at each site by at least two project personnel. Where site locations were inconsistent with the mapped locations of creeks and roads, it was found that the mapped locations of creeks and roads were typically in error and therefore, sites were not moved to existing GIS features. Instead, locations of culverts were accurately on the mapper and the latitude and longitudes in the database were those collected at the site at the time of survey.

A final review of all ratings was independently done by a Habitat Biologist II and IV before each season's data was released as draft, and an additional review took place at the end of the project.

PRIORITIZATION

The goal of prioritization was to identify the barriers where replacement or removal has the greatest potential to benefit fish populations. Fish passage prioritizations often attempt to consider factors such as potential cost and road ownership when prioritizing culverts (Taylor et al. 2003; WDFW 2009; CRWP 2011). For our prioritization, we chose to look solely at the potential ecological benefit using upstream habitat extent, species usage, and severity of barrier. Further prioritization using species of interest, road ownership or estimated cost can be overlaid on this prioritization and used to make final selections of projects for replacement.

The prioritization assigns each site a score based on the following:

1. The amount of stream habitat available upstream up to the next barrier, the end of the stream or a gradient of approximately 10%, as determined from maps or other available data (60%).
2. Lakes and ponds are given a lake acres rating based on sized. Waterbodies over 150 acres are given a rating of 3, between 75 and 150 acres are given a 2, and any pond of lake smaller than 75 acres is given a rating of 1 (20%).
3. The number of anadromous species documented to occur in the stream the crossing is located on (15%).

---

[3] ADF&G Alaska Freshwater Fish Inventory is available at http://www.adfg.alaska.gov/index.cfm?adfg=ffinventory.interactive (accessed March 4, 2021).

[4] ADF&G Fish Passage Inventory Database is available at http://www.adfg.alaska.gov/index.cfm?adfg=fishpassage.database (accessed March 4, 2021).

4. The number of resident species documented to occur in the stream the crossing is located on (5%).
5. The barrier multiplier (R) as described above is a multiplier applied to the weighting.

The prioritization score (PS) was calculated as follows:

$$PS = R[(\text{upstream miles} * 0.6) + (\text{lake acres} * 0.2) + (\text{number of anadromous species} * 0.15) + (\text{number of resident species} * 0.05)].$$

The higher the score, the more potential impact the culvert has on fisheries resources and the more it should be prioritized for replacement.

Stream Habitat: The number of miles of habitat upstream of each culvert were measured or estimated using ArcGIS and topographical maps, the National Hydrography Database (NHD), the Anadromous Waters Catalog (AWC), aerial photography, or all of these, for all sites where data was available using the most accurate information for each stream. Cataloged anadromous stream miles and total stream miles, including potential habitat above documented anadromy, were measured or estimated separately. Stream miles were included upstream until another barrier was encountered, or the extent of known fish use was reached, or if a 10–12% gradient was sustained over a 100 ft reach. Where extent of upstream habitat could not be determined, sites were assigned an arbitrary upstream minimum value of 0.01 miles of potential stream habitat. Due to the number of unmapped streams and the various methods used to calculate the upstream miles, these figures should be treated as low quality estimates and used for comparison purposes only. Habitat quality was not addressed due to limited availability of information. All stream miles were assumed capable of being used as habitat by fish that can access them.

Lakes and Ponds: The size of all lakes and ponds was estimated using the same methods for stream miles. Each site was assigned a ranking based on the amount of potential lake habitat.

Anadromous Species: The number of anadromous species using the stream was based on AWC data and nominations, and our own trapping efforts. It is likely there are many additional streams that are not cataloged in the AWC but do contain salmonids or resident fish.

Resident Species: The number of resident fish species was based on the Alaska Freshwater Fish dataset, our own fish trapping efforts, and by information posted by U.S. Forest Service on Forest Service Stream Crossing placards at certain sites. It is likely there are many additional streams that are not cataloged in the AWC but do contain salmonids or resident fish.

The Barrier Multiplier: Additionally, culverts were also given a barrier multiplier (R). Red culverts were given a multiplier of 1, Gray culverts a multiplier of 0.5, and Green culverts received a multiplier of 0 so that their prioritization score would also be 0. Culverts found with an outfall greater than 1 ft were given a multiplier of 1.5 (Red rating + Outfall greater than 1 ft) to reflect their potential to restrict adult fish movement as well as juvenile fish movement (NMFWS 2001). Culverts with a low condition rating, 1 or 2, were also given an additional 0.5 to its barrier multiplier to reflect the impact of damaged structures and deferred maintenance on fish movement.

For this prioritization, upstream habitat was given a weight of 0.60 in the prioritization formula, lake acres rating was given a weight of 0.20, anadromous fish were given a weight of 0.15, and resident fish a weight of 0.05. These weightings are based on the best professional judgement of the authors and were chosen for use statewide based on a larger data set. They are intended to give

a general prioritization that can be refined by the user for more local use, or in the event a prioritization is desired that focuses on one species or one road owner.

RESULTS

Over the course of this multi-year project, over 183 miles of roads were surveyed, and 197 sites were assessed for fish passage: 102 in Petersburg, 57 in Ketchikan, and 38 in Wrangell (Table 1). Of the sites assessed, 153 were on known fish bearing streams (Table 2). Assessments showed that fish passage is widely impacted throughout the assessed areas on small to medium sized streams with 129 sites rated Red (crossings assumed to be inadequate for juvenile salmonid passage), 43 sites Gray (crossings may be inadequate for juvenile salmonid passage), and only 20 sites Green (crossings likely to provide adequate juvenile salmonid passage). There were 5 sites rated Black, meaning the project was unable to assign a Red, Gray, or Green fish passage rating due to either safety concerns, site access, or site conditions (Table 3).

Culverts having an outfall over 1 ft or a gradient exceeding 4% while not embedded are considered potential barriers to adult salmon passage (NMFS 2001). Of the 197 sites assessed, 57 were considered likely adult barriers due to an outfall over 1 ft, 58 sites were considered a potential adult barrier due to a culvert gradient exceeding 4%, and 27 sites had both an outfall greater than 1 ft and a culvert gradient exceeding 4% (Table 4).

FISH PASSAGE RATINGS

The Fish Passage Assessment Project uses three main criteria, or Critical Values, for rating a culvert as Red, Gray, or Green in the Level 1 Assessment Matrix (Figure 4). These criteria are the culvert gradient, culvert outfall height or perch, and culvert(s) constriction ratio. Most sites were rated based on the three Critical Values in the Level 1 Assessment Matrix (Figure 4). Outfall heights and gradients were measured at most sites, but constriction ratio was only measured at sites where it was possible to collect standard stream widths. Culverts connecting two sloughs or ponds or an artificial channel to a lake were not assessed for constriction ratio.

Ketchikan

In 2013, 57 sites were assessed on 87 miles of roads (Figure 9, Table 1). The major factors affecting fish passage at sites assessed in Ketchikan were steep culvert gradients, culvert outfall height, sediment accumulation at the inlet, and constriction (Table 5). Thirty sites were rated Red (52.6%), 14 sites Gray (24.5%), 11 sites Green (19.3%), and 2 sites Black (3.5%) (Table 3). Among these sites, there were 26 Red (55.3%), 11 Gray (23.4%), 9 Green (19.2%), and 1 Black (2%) located on known fish-bearing streams (Table 2); the rest were located on streams the survey crew judged to have habitat potential to bear fish. Twenty-three sites were potential adult barriers of which 18 sites had an outfall height greater than 1 ft, 13 sites had an overall gradient greater than 4%, and 8 sites had both an outfall height greater than 1 ft and a gradient greater than 4% (Table 4).

Petersburg

In 2013 and 2014, 102 fish passage sites were assessed on over 75 miles of roads in the Petersburg area (Figure 10, Table 1). The major factors affecting fish passage at sites assessed in Petersburg were Red culvert gradients, Red outfall heights, and Gray constriction ratios (Table 5). Sixty-nine sites were rated Red (67.6%), 24 sites Gray (23.5%), 8 sites Green (7.8%), and 1 site Black (1%) (Table 3). Sixty-nine Red sites, 19 Gray sites, and 8 Green sites were on streams known to be fish bearing (Table 2). Thirty-eight sites were potential adult barriers of which 22 sites had outfall

heights greater than 1 ft, 26 sites had culvert gradients greater than 4%, and 10 of the 38 sites sites had both an outfall height greater than 1 ft and a gradient greater than 4% (Table 4).

Wrangell

In 2014 and 2016, fish passage assessment crews assessed 38 sites in the Wrangell area on over 24 miles of roads (Figure 11, Table 1). The major factors affecting fish passage at sites assessed in the Wrangell area were Red culvert gradient, Red outfall height, and Gray constriction ratio (Table 5). Thirty sites were rated Red (78.9%), 5 sites Gray (13.2%), 1 site Green (2.6%), and 2 sites Black (5.3%) (Table 3). Of those, 15 Red sites (78.9%), 3 Gray sites (15.8%), and 1 Green site (5.3%) were located on streams known to be fish bearing (Table 2). The project found 27 potential adult barriers of which 17 sites had an outfall height greater than 1 ft, 19 sites had a culvert gradient greater than 4%, and 9 of the 27 sites had both an outfall height greater than 1 ft and a gradient greater than 4% (Table 4).

CRITICAL VALUES

OUTFALL HEIGHT AND OUTFALL TYPE

Ketchikan

Twenty-five culverts (44.6%) in the Ketchikan area had no drop at the outfall, 2 culverts (3.6%) had an outfall height of less than 4 inches (Gray), 29 culverts (51.8%) had an outfall over 4 inches (Red). Twenty-two culverts (39.3%) had an outfall over 1 ft and are considered a potential barrier to adult salmon (Table 6). The most common types of outfalls were free fall into pool and free fall onto riprap (Table 7).

Petersburg

Fifty-three culverts (50%) in the Petersburg area had no drop at the outfall, 12 culverts (11.3%) had an outfall height of less than 4 inches (Gray), and 41 culverts (38.7%) had an outfall over 4 inches (Red). Twenty-three culverts (21.7%) had an outfall over 1 ft and are considered a potential barrier to adult salmon (Table 6). The most common outfall types were free fall into pool, free fall onto riprap, and cascade over riprap (Table 7).

Wrangell

Eight culverts (17.8%) in the Wrangell area had no drop at the outfall, 5 culverts (11.1%) had an outfall height of less than 4 inches (Gray), and 26 culverts (71.1%) had an outfall over 4 inches (Red). Nineteen culverts (42.2%) had an outfall over 1 ft and are considered a potential barrier to adult salmon (Table 6). The most common outfall types were free fall into pool and free fall onto riprap (Table 7).

GRADIENT

Gradient represents the overall gradient or slope of the culvert and could not be determined at all sites, typically due to damage or accessibility issues.

Ketchikan

Gradient could be determined at 54 culverts of which 11 (18.5%) had a gradient 0–1%, 8 culverts (14.8%) had a gradient 1–2%, and 35 culverts (64.8%) had a gradient over 2%. Twenty-two culverts (40.7%) had a gradient over 4% and are potential barriers to adult salmon (Table 8).

Petersburg

Sixteen culverts (15%) had a gradient <0–1% gradient, 23 culverts (22%) had a gradient 1–2% gradient, and 64 culverts had gradients >2% (63%). The project found 30 culverts (29%) with a gradient greater than 4% and these are potential barriers to adult salmon passage (Table 8).

Wrangell

Gradient could be determined at 37 culverts of which 4 culverts, (10.8%) had a gradient 1–2%, and 33 culverts (89.2%) had a gradient greater than 2%. Twenty-one culverts (56.8%) had a gradient exceeding 4% and are potential barriers to adult salmon passage (Table 8).

CONSTRICTION RATIO

CR was not measured where the where stream width could not be determined, for example between two lakes or in a slough or artificial channel.

Ketchikan

Seven sites (14.6%) had a CR between 0 and 0.50 (Red rating), 13 sites (27.1%) had a CR between 0.50 and 0.75 (Gray), and 28 sites (58.3%) had a CR greater than 0.75 (Green) (Table 9).

Petersburg

Thirty sites (32%) had a CR between 0 and 0.50 (Red), 38 sites (40.4%) had a CR between 0.50 and 0.75 (Gray), and 26 sites (27.6%) had a CR greater than 0.75 (Green) (Table 9).

Wrangell

Two sites (8.0%) had a CR between 0.25 and 0.50 (Red), 10 sites (40.0%) had a CR between 0.50 and 0.75 (Gray), and 15 sites (52%) had a CR greater than 0.75 (Green) (Table 9).

CROSSING STRUCTURE CHARACTERISTICS

Ketchikan

Most assessed sites in the Ketchikan area were single, circular culverts 40–50 ft in length, 2.5–4.5 ft in width, and made of corrugated steel (Tables 10–14).

The project found 7 culverts (11.5%) in the Ketchikan area to be embedded, 3 sites (5%) were found to be backwatered, 6 sites (10.5%) had tidal influence, and 6 culverts (9.8%) had baffles (Table 15–18).

Petersburg

Most assessed sites in the Petersburg area were single, circular culverts 60–90 feet in length, 2–4 ft wide, and made of corrugated steel (Tables 10–14).

The project found 4 culverts (3.6%) to be embedded, 4 sites (3.9%) were determined to be backwatered, 8 sites (7.8%) of sites were found to be tidally influenced with an additional 3 sites (2.9%) that might have tidal influence, and 4 sites (3.6%) were found to have baffles (Tables 15–18).

Wrangell

Most assessed sites in Wrangell were single, circular culverts 50–90 ft in length, 2–4 ft in width, and made of corrugated steel (Tables 10–14).

The project found no culverts to be embedded or have baffles, 1 site (2.6%) met the criteria for being backwatered, 4 sites (10.5%) of sites were found to have tidal influence with an additional 2 sites (5%) that might have tidally influenced (Tables 15–18).

STREAM CHARACTERISTICS

Ketchikan

At time of assessment most streams were at medium stream stage and culverts had a water depth at outlet under 0.25 ft (Tables 19 and 20). Stream widths ranged from 2–4 ft to 22–24 ft wide, and 48% of streams were 4–8 ft at OHW (Table 21). Stream slope was measured at 15 sites and ranged from under 1% to over 5%. Forty percent of streams had a gradient between 3% and 4% (Table 22).

Petersburg

At time of assessment most streams were at medium stream stage and most culverts had a water depth at outlet under 0.25 ft (Tables 19 and 20). Streams at assessed sites had an average stream width between 2 and 10 ft at OHW and a gradient between 2–3% (Tables 21 and 22).

Wrangell

Most streams were at medium stream stage and most culverts had a water depth at outlet less than 0.25 feet (Tables 19 and 20). Streams had an average stream width at OHW between 2–4 ft (Table 21). Measured stream gradients ranged from 1–2% to over 10% (Table 22).

FISH COLLECTION DATA

Ketchikan

Crew members set minnow traps at 51 sites (89.5%) in the Ketchikan area. They caught or observed fish at 39 sites (68.4%). Thirty-eight nominations to the AWC were made with data from 30 sites (Table 23). Of the 38 AWC nominations, 28 (73.7%) were new additions to the catalog, and 10 (26.3%) were back-up nominations (Table 24).

Petersburg

Crew members set minnow traps at 87 sites (85.3%) in the Petersburg area and caught or observed fish at 75 sites (86.2%). Eighty-five nominations were made to the AWC representing 63 sites (Table 23). Of the 85 AWC nominations, 50 were new additions (58.8%), 34 were back-up nominations (40.0%), and 1 was a correction (1.2%) (Table 24).

Wrangell

Crew members set minnow traps at 26 sites (68.4%) and caught or observed fish at 14 sites (53.8%). Eight nominations were made to the AWC (Table 23). All nominations were new additions to the catalog (Tables 24).

PRIORITIZATION

The goal of prioritization was to identify the barriers where replacement or removal has the greatest potential to benefit fish populations, but this is intended as a "first cut" effort at prioritization and is not definitive. The highest prioritization scores reflect those culverts with the most diversity of fish species and the greatest potential to block fish movement, and these culverts should be

considered first for replacement (Tables 25–27). Green and Black culverts were not assigned a prioritization score.

Prioritization scores are grouped by road network to facilitate review and site selection (Tables 25–27). To use the prioritization, first identify the geographic area of interest and locate the highest-scoring culverts in that area. Scores are calculated in the same way for each site, so it is possible to compare sites across tables as well as within a table. Using the scores in the tables below, additional information in the appendices, and the ADF&G Fish Resource Monitor[5] (an interactive mapper with full survey data and numerous photographs of each site as well as information on fish species and life stages from both the AWC and AFFI datasets), it is possible to target a small subset of barriers for priority replacement based on various criteria such as species of interest, stream size, watershed, and road ownership. Extent of upstream habitat and fish diversity are important components of the prioritization score and sites with less existing data may have lower scores. Therefore we recommend that prior to final site selection a site visit should be conducted to inspect each site for upstream habitat and fish presence, to ensure the culvert remains in the same condition and to identify any non-ecological factors that may impact replacement.

In this study area, we observed a relatively small number of culverts with high prioritization scores, meaning they present a significant barrier to fish passage and have a significant amount of upstream habitat. We recommend those are the first structures considered for replacement when funds are available (Figures 12–37). Where there are many culverts with similar scores, replacement of many structures may be required to see a large improvement in fish passage throughout the watershed or region, and it is recommended that a comprehensive plan for improvement is developed locally to consider issues such as barriers per watershed, road ownership, scheduled road maintenance, seasonal traffic loads, and cost. An example of this includes the results for the Blind Slough and Blind River in Petersburg (Table 26).

Overall, the percentage of culverts that may impair passage of juvenile fish was high in the study area at 87.6%. The percentage of culverts with potential to impair the passage of adult salmon was also high at 45%, although those sites may not all be located on streams with spawning habitat. The Petersburg road network contained the largest number of culverts as well as the second highest percentage of Red and Gray culverts (90.8%), and is considered the highest-priority road network in the region. Although it is difficult to directly compare benefits between watersheds, it is suggested that the Petersburg area be regarded as the most impacted by barriers to fish passage at this time. Wrangell has the second largest percentage of Red and Gray sites, but these represent fewer overall sites, 18 compared to 79 on the Petersburg road system, and a much smaller amount of overall habitat with an estimated total of 1.47 upstream miles compared to 23.05 upstream miles in Petersburg. Ketchikan represents an intermediate priority with 9.57 miles of potential habitat above 37 Red and Gray sites. It should be noted that not all streams are mapped or have aerial imagery of sufficient quality to estimate their length, and therefore, are underestimated in the prioritization scores. This occurred most commonly in Wrangell where 24 out of 38 streams could not be accurately estimated in length.

Factors such as habitat quality, presence of invasive species, road maintenance, and species of concern are not included in this prioritization but should be considered before any project is

[5] ADF&G Fish Resource Monitor available at http://extra.sf.adfg.state.ak.us/FishResourceMonitor/guide.html (accessed June 7, 2021).

undertaken. In addition, due to the number of unmapped streams and the various methods used to calculate the upstream miles or lake size habitat extent, figures presented herein should be treated as low-quality estimates and used for comparison purposes only or replaced if more accurate information is available. ADF&G hopes to update this prioritization in the future when better stream mapping data become available.

DISCUSSION

The results indicate that fish passage for juvenile salmonids and other weak swimming fish is widely impacted throughout Petersburg, Ketchikan, and Wrangell. During this project, 197 sites were assessed. Sixty-five percent of sites were rated Red, or assumed to be inadequate for juvenile fish passage; and 22% were rated Gray, or may be inadequate for juvenile fish passage (Table 2). The project also found that 29% of sites had an outfall greater than 1 ft, 29% of sites had a culvert gradient greater than 4%, and 14% of sites had both, making them potential barriers to adult salmon passage (Table 4). Road systems in Southeast Alaska tend to be built close to shorelines or run along the edge of major river valleys due to topography that is dominated by large, steep mountains; as a result, one road may cross numerous small tidal systems or tributaries to a large river. Often this means that the majority of habitat for crossed streams lies upstream from the assessed culvert(s), and that the stream empties into saltwater or a large river close to the culvert outlet. A minimum of 34.09 miles of stream habitat is currently located above a Red or Gray culvert in the study area.

Small and medium sized streams are important to juvenile salmonids that will utilize nonnatal streams for rearing for up to two years (Kahler and Quinn 1998). Additionally, many of the small streams in Southeast Alaska have resident populations of Dolly Varden char and cutthroat trout, and it has been observed that these fish utilize the entire length of usable habitat in their streams when flows allow; therefore, passable road crossings are critical for maintaining habitat connectivity (Bryant et al. 2009). Due to the same topography, small and medium sized streams very often have only one crossing along their entire length, meaning that replacing a single crossing will allow access to all potential habitat for both resident and anadromous fishes (Figures 9–11).

The Level 1 Assessment method assigns culverts to categories based on physical characteristics of the structure and assigns a rating based on what we know about fish passage through that type of structure. It is particularly useful for identifying culverts that are not barriers or of low concern and identifying significant or total barriers. However, it should be noted that the Level 1 Assessment was designed as a rapid assessment for large geographical areas focused on juvenile salmonid passage; it does not focus on barriers to adult salmon or other species such as trout, and is limited in its assessment of partial or temporal barriers.

Similarly, the prioritization is intended to be a guide to identifying and selecting sites with above or below average potential ecological significance and impacts to salmonid passage; it is not meant to be a prescriptive order of replacement. There is an abundance of sites within the study area that lack accurate mapping of the stream course and are not in the *Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes* (commonly known as the Anadromous Waters Catalog), or any other dataset of fish presence, and are therefore underscored in the prioritization tables. Prior to final selection of restoration sites, the restoration practitioner should review the available information and consider factors such as species and life stage of interest, channel type, and flow conditions at the site. Additional assessment including hydrologic modeling may be appropriate prior to final site selection. Finally, conditions at any site are subject to change

without notice to the Fish Passage Improvement Program. Ground truthing conditions at sites is recommended early on in any kind of replacement selection process.

RECOMMENDATIONS

We recommend the following for fish passage replacement projects:

1. Projects should be considered as part of all road upgrades and incorporated wherever possible.
2. When carried out solely for fish passage benefit, replacement projects should be prioritized based on predicted ecological benefit as much as possible, with the understanding that they are often carried out in an opportunistic manner and not in the order of prioritization.
3. Projects should be concentrated within watersheds for maximum benefit. In practice, this may mean replacing one or more lower priority culverts concurrently with the replacement of a high priority culvert in order to improve fish passage throughout the watershed.
4. If multiple barrier culverts exist on a stream, replacing all of the culverts should be considered to open as much upstream habitat as possible, concentrating on the culverts lower in the watershed first.
5. Projects should not be concentrated in the best studied and best-known watersheds to the detriment of potentially more productive watersheds elsewhere in Southeast Alaska.

We also recommend that the existing prioritization is recalculated when additional habitat or fisheries data is available.

ACKNOWLEDGEMENTS

The authors would like to thank all personnel and organizations that contributed and assisted with this project. They include Neil Durco, John Hudson, Skip Repetto, Ryan Snow, Neil Stichert, Holly Zafian, the U.S. Forest Service, the U.S. Fish and Wildlife Service, and the Alaska Sustainable Salmon Fund. This report was prepared by the authors under Alaska Sustainable Salmon Fund award #44635 from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, administered by the Alaska Department of Fish and Game.

REFERENCES CITED

Botkin, D., K. Cummins, T. Dunne, H. Reiger, M. Sobel, L. Talbot, and L. Simpson. 1995. Status and future of salmon of Western Oregon and Northern California: findings and options. Center for the Study of the Environment, Report No. 8. Santa Barbara, CA.

Bryant, M. D, M. D. Lukey, J. P. McDonell, R. A. Gubernick, and R. S. Aho. 2009. Seasonal movement of Dolly Varden and cutthroat trout with respect to stream discharge in a second-order stream in Southeast Alaska. North American Journal of Fisheries Management 29:1728–1742.

Clarkin, K., A. Connor, M. J. Furniss, B. Gubernick, M. Love, K. Moynan, and S. WilsonMusser. 2005. National inventory and assessment procedure for identifying barriers to aquatic organism passage at road-stream crossings. USDA Forest Service National Technology and Development Program. San Dimas, CA.

CRWP (Copper River Watershed Project). 2011. Prioritizing fish passage improvement projects in the Copper River Watershed. Copper River Watershed Project, Cordova, AK.

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

Flanders, L. S., and J. Cariello. 2000. Tongass road condition survey report. Alaska Department of Fish and Game, Habitat and Restoration Division. Technical Report No. 00-7.

Gordon, N. D., T. A. McMahon, B. L. Finlayson, C. J. Gippel, and R. J. Nathan. 2004. Stream hydrology: An introduction for ecologists. 2nd Edition. John Wiley and Sons, England.

Kahler, T. H., and T. P. Quinn. 1998. Juvenile and resident salmonid movement and passage through culverts. Research Project T9903, Task 96. Washington State Transportation Center (TRAC). University of Washington, Seattle, WA.

Karle, K. F. 2005. Analysis of an efficient fish barrier assessment protocol for highway culverts. Hydraulic Mapping and Modeling report FHWA-AK-RD-05-02 prepared for Alaska Department of Transportation, Juneau, AK.

Mirati, A. 1999. Assessment of road culverts for fish passage problems on state- and county-owned roads. Statewide Summary Report. Oregon Department of Fish and Wildlife.

NMFS (National Marine Fisheries Service). 2001. Guidelines for salmonid passage at stream crossings. National Oceanic and Atmospheric Administration, NMFS–Southwest Region. Santa Rosa, CA.

O'Doherty, G. M. 2014. Fish passage assessments of culverted road crossings in King Salmon, Naknek, and Dillingham: 2012-2013. Alaska Department of Fish and Game, Fishery Data Series No. 14-45, Anchorage.

O'Doherty, G., and M. Eisenman. *In Prep*. Fish Passage at Culverts in the Matanuska-Susitna Borough, Alaska. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Taylor, R. N., T. D. Grey, A. L. Knoche, and M. Love. 2003. Russian River stream crossing inventory and fish passage evaluation final report. Ross Taylor and Associates, McKinleyville, CA.

WDFW (Washington Department of Fish and Wildlife). 2009. Fish passage and surface water diversion screening assessment and prioritization manual. Washington Department of Fish and Wildlife. Olympia, WA.

TABLES AND FIGURES

Table 1.–Total road miles surveyed, predicted number of crossings, and total number of sites assessed during this project.

Road system	Total road miles assessed	Predicted number of crossings	Number of crossings assessed
Ketchikan	87	53	57
Petersburg	72	103	102
Wrangell	24.5	24	38
Total	183.5	180	197

Table 2.–Fish passage site ratings for sites known to be fish bearing in Petersburg, Ketchikan, and Wrangell.

Site rating	Ketchikan	% of Sites	Petersburg	% of Sites	Wrangell	% of Sites	Total	% of Total sites
Red	26	55.3	60	69.0	15	78.9	101	66.0
Gray	11	23.4	19	21.8	3	15.8	33	21.6
Green	9	19.1	8	9.2	1	5.3	18	11.8
Black	1	2.1	0	0.0	0	0.0	1	0.7
Total	47	100.0	87	100.0	19	100.0	153	100.0

Table 3.–Fish passage site ratings for all sites assessed, including known fish bearing streams and waterbodies not known to be fish-bearing but judged to have suitable habitat during the site visit, in Petersburg, Ketchikan, and Wrangell.

Site rating	Ketchikan	% of Sites	Petersburg	% of Sites	Wrangell	% of Sites	Total	% of Total sites
Red	30	52.6	69	67.6	30	78.9	129	65.5
Gray	14	24.6	24	23.5	5	13.2	43	21.8
Green	11	19.3	8	7.8	1	2.6	20	10.2
Black	2	3.5	1	1.0	2	5.3	5	2.5
Total	57	100.0	102	100.0	38	100.0	197	100.0

Table 4.–Sites having an outfall over 1 ft, a gradient greater than 4%, or both for culverts assessed in Petersburg, Ketchikan, and Wrangell.

Adult barrier	Ketchikan	Petersburg	Wrangell	Total	% of Total sites
Outfall height >1 ft	18	22	17	57	28.9
Culvert gradient >4%	13	26	19	58	29.4
Both	8	10	9	27	13.7

Table 5.–Site conditions affecting fish passage for Red and Gray culverts on the Ketchikan, Petersburg, and Wrangell road systems. Critical values are underlined.

Factors affecting fish passage	Ketchikan	% of Sites Ketchikan	Petersburg	% of Sites Petersburg	Wrangell	% of Sites Wrangell
Beaver activity	0	0.0	3	2.9	2	5.3
Compound gradient	3	5.3	7	6.9	5	13.2
Constriction ratio Gray	12	21.1	33	32.4	9	23.7
Constriction ratio Red	6	10.5	23	22.5	3	7.9
Culvert gradient Gray	6	10.5	12	11.8	2	5.3
Culvert gradient Red	28	49.1	69	67.6	29	76.3
Culvert is poorly aligned	11	19.3	26	25.5	3	7.9
Debris flow	0	0.0	0	0.0	2	5.3
Hydraulic flow exceed capacity	6	10.5	0	0.0	7	18.4
Inlet perch	13	22.8	22	21.6	6	15.8
Mechanical problem or joints parting	5	8.8	14	13.7	2	5.3
Other	0	0.0	0	0.0	1	2.6
Outfall height Gray	1	1.8	13	12.7	2	5.3
Outfall height Red	27	47.4	40	39.2	25	65.8
Road bank erosion	0	0.0	0	0.0	2	5.3
Road fill (pushed off road by grader)	2	3.5	0	0.0	0	0.0
Shallow fill above culvert	0	0.0	0	0.0	1	2.6
Structural problem	8	14.0	18	17.6	1	2.6
Subsidence	0	0.0	0	0.0	1	2.6

Table 6.–Outfall heights for culverts assessed on the Ketchikan, Petersburg, and Wrangell road systems.

Outfall height (in)	Ketchikan	% of Culverts	Petersburg	% of Culverts	Wrangell	% of Culverts	Total	% of Total culverts	Culvert rating
At Grade	25	44.6	53	50.0	8	17.8	86	41.5	Green
>0–4	2	3.6	12	11.3	5	11.1	19	9.2	Gray
4–12	7	12.5	18	17.0	7	15.6	32	15.5	Red
12–24	6	10.7	6	5.7	5	11.1	17	8.2	Red
24–36	3	5.4	7	6.6	4	8.9	14	6.8	Red
36–48	5	8.9	6	5.7	4	8.9	15	7.2	Red
48–60	2	3.6	0	0.0	3	6.7	5	2.4	Red
60–72	3	5.4	2	1.9	7	15.6	12	5.8	Red
72–84	1	1.8	0	0.0	2	4.4	3	1.4	Red
84–96	1	1.8	0	0.0	0	0.0	1	0.5	Red
>96	1	1.8	2	1.9	0	0.0	3	1.4	Red
Total	56	100.0	106	100.0	45	100.0	207	100.0	

Table 7.–Outfall types for culverts assessed on the Ketchikan, Petersburg, and Wrangell road systems.

Outfall type	Ketchikan	% of Culverts	Petersburg	% of Culverts	Wrangell	% of Culverts	Total	% of Total culverts
At grade	27	44.3	53	48.2	8	20.5	88	41.9
Cascade	0	0.0	0	0.0	1	2.6	1	0.5
Cascade over riprap	1	1.6	2	1.8	0	0.0	3	1.4
Fish passage structure	1	1.6	0	0.0	0	0.0	1	0.5
Free fall into pool	15	24.6	33	30.0	18	46.2	66	31.4
Free fall onto riprap	15	24.6	20	18.2	10	25.6	45	21.4
Hydraulic jump	1	1.6	0	0.0	0	0.0	1	0.5
Overflow pipe	1	1.6	2	1.8	2	5.1	5	2.4
Total	61	100.0	110	100.0	39	100.0	210	100.0

Table 8.–Culvert gradients for culverts assessed on the Ketchikan, Petersburg, and Wrangell road systems.

Gradient (%)	Ketchikan	% of Culverts	Petersburg	% of Culverts	Wrangell	% of Culverts	Total	% of Total Culverts
-1–0	1	1.9	1	1.0	0	0.0	2	1.0
0–1	10	18.5	15	14.6	0	0.0	25	12.9
1–2	8	14.8	23	22.3	4	10.8	35	18.0
2–3	8	14.8	16	15.5	9	24.3	33	17.0
3–4	5	9.3	18	17.5	3	8.1	26	13.4
4–5	4	7.4	5	4.9	6	16.2	15	7.7
5–6	5	9.3	13	12.6	3	8.1	21	10.8
6–7	5	9.3	2	1.9	4	10.8	11	5.7
7–8	4	7.4	5	4.9	3	8.1	12	6.2
8–9	2	3.7	2	1.9	1	2.7	5	2.6
9–10	0	0.0	0	0.0	2	5.4	2	1.0
>10	2	3.7	3	2.9	2	5.4	7	3.6
Total	54	100.0	103	100.0	37	100.0	194	100.0

Table 9.–Constriction ratio for sites assessed on the Ketchikan, Petersburg, and Wrangell road systems.

Constriction ratio (CR)	Ketchikan	% of Sites	Petersburg	% of Sites	Wrangell	% of Sites	Total	Total % of Sites	Site rating
0–0.25	0	0.0	1	1.1	0	0.0	1	0.6	Red
0.25–0.5	7	14.6	29	30.9	2	8.0	38	22.8	Red
0.5–0.75	13	27.1	38	40.4	10	40.0	61	36.5	Gray
0.75–1	10	20.8	13	13.8	8	32.0	31	18.6	Green
1–1.25	10	20.8	8	8.5	2	8.0	20	12.0	Green
1.25–1.5	1	2.1	2	2.1	2	8.0	5	3.0	Green
1.5–1.75	1	2.1	2	2.1	0	0.0	3	1.8	Green
1.75–2	4	8.3	0	0.0	0	0.0	4	2.4	Green
2–2.25	1	2.1	0	0.0	1	4.0	2	1.2	Green
>2.25	1	2.1	1	1.1	0	0.0	2	1.2	Green
Total	48	100.0	94	100.0	25	100.0	167	100.0	

Table 10.–Culvert lengths for culverts assessed on the Ketchikan, Petersburg, and Wrangell road systems.

Culvert length (ft)	Ketchikan	% of Culverts	Petersburg	% of Culverts	Wrangell	% of Culverts	Total	Total % of culverts
10–20	1	1.7	5	4.7	0	0.0	6	3.0
20–30	1	1.7	3	2.8	1	2.6	5	2.5
30–40	1	1.7	0	0.0	2	5.3	3	1.5
40–50	9	15.3	10	9.4	1	2.6	20	9.9
50–60	3	5.1	11	10.4	6	15.8	20	9.9
60–70	2	3.4	23	21.7	7	18.4	32	15.8
70–80	5	8.5	21	19.8	8	21.1	34	16.7
80–90	7	11.9	13	12.3	9	23.7	29	14.3
90–100	2	3.4	9	8.5	3	7.9	14	6.9
100–110	4	6.8	7	6.6	1	2.6	12	5.9
110–120	6	10.2	2	1.9	0	0.0	8	3.9
120–130	2	3.4	1	0.9	0	0.0	3	1.5
130–140	3	5.1	1	0.9	0	0.0	4	2.0
140–150	4	6.8	0	0.0	0	0.0	4	2.0
150–160	2	3.4	0	0.0	0	0.0	2	1.0
160–170	1	1.7	0	0.0	0	0.0	1	0.5
170–180	1	1.7	0	0.0	0	0.0	1	0.5
180–190	1	1.7	0	0.0	0	0.0	1	0.5
190–200	0	0.0	0	0.0	0	0.0	0	0.0
>200	4	6.8	0	0.0	0	0.0	4	2.0
Total	59	100.0	106	100.0	38	100.0	203	100.0

Table 11.–Culvert widths for culverts assessed on the Ketchikan, Petersburg, and Wrangell road systems.

Culvert inlet widths (ft)	Ketchikan	% of Culverts	Petersburg	% of Culverts	Wrangell	% of Culverts	Total	Total % of Culverts
1–2	0	0.0	1	0.9	2	5.0	3	1.4
2–3	7	11.7	33	30.0	11	27.5	51	24.3
3–4	11	18.3	33	30.0	12	30.0	56	26.7
4–5	7	11.7	13	11.8	4	10.0	24	11.4
5–6	3	5.0	6	5.5	2	5.0	11	5.2
6–7	5	8.3	5	4.5	7	17.5	17	8.1
7–8	4	6.7	4	3.6	2	5.0	10	4.8
8–9	8	13.3	2	1.8	0	0.0	10	4.8
9–10	2	3.3	2	1.8	0	0.0	4	1.9
10–11	4	6.7	3	2.7	0	0.0	7	3.3
11–12	1	1.7	1	0.9	0	0.0	2	1.0
12–13	5	8.3	3	2.7	0	0.0	8	3.8
13–14	2	3.3	0	0.0	0	0.0	2	1.0
14–15	0	0.0	1	0.9	0	0.0	1	0.5
15–16	0	0.0	0	0.0	0	0.0	0	0.0
16–17	0	0.0	0	0.0	0	0.0	0	0.0
17–18	0	0.0	0	0.0	0	0.0	0	0.0
18–19	0	0.0	1	0.9	0	0.0	1	0.5
19–20	0	0.0	1	0.9	0	0.0	1	0.5
>20	1	1.7	1	0.9	0	0.0	2	1.0
Total	60	100.0	110	100.0	40	100.0	210	100.0

Table 12.–Culvert types (shapes) for culverts assessed on the Ketchikan, Petersburg, and Wrangell road systems.

Culvert types (shape)	Ketchikan	% of Culverts	Petersburg	% of Culverts	Wrangell	% of Culverts	Total	Total % of Culvert
Box culvert	2	3.3	2	1.8	0	0.0	4	1.9
Circular pipe	41	67.2	92	82.9	36	85.7	169	79.0
Open-bottom arch	3	4.9	3	2.7	0	0.0	6	2.8
Oval	6	9.8	1	0.9	0	0.0	7	3.3
Pipe-arch	9	14.8	13	11.7	6	14.3	28	13.1
Total	61	100.0	111	100.0	42	100.0	214	100.0

Table 13.–Culvert construction material for culverts assessed on the Ketchikan, Petersburg, and Wrangell road systems.

Culvert construction material	Ketchikan	% of Culverts	Petersburg	% of Culverts	Wrangell	% of Culverts	Total	Total % of Culvert
Corrugated aluminum	12	20.0	11	9.9	3	7.1	26	12.2
Corrugated steel	24	40.0	79	71.2	32	76.2	135	63.4
Plastic	4	6.7	6	5.4	1	2.4	11	5.2
Reinforced concrete	1	1.7	0	0.0	0	0.0	1	0.5
Structural aluminum plate	5	8.3	5	4.5	0	0.0	10	4.7
Structural steel plate	13	21.7	10	9.0	6	14.3	29	13.6
Wood	1	1.7	0	0.0	0	0.0	1	0.5
Total	60	100.0	111	100.0	42	100.0	213	100.0

Table 14.–Number of culverts at site for sites assessed on the Petersburg road system.

No. of culverts at site	Ketchikan	% of Sites	Petersburg	% of Sites	Wrangell	% of Sites	Total	Total % of sites
1	53	93.0	92	90.2	34	89.5	179	90.9
2	3	5.3	8	7.8	4	10.5	15	7.6
3	1	1.8	1	1.0	0	0.0	2	1.0
Unknown	0	0.0	1[a]	1.0	0	0.0	1	0.5
Total	57	100.0	102	100.0	38	100.0	197	100.0

[a] It could not be determined how many culverts, if any, were at site 10203216 in Petersburg.

Table 15.–Culverts that meet project standards for embeddedness on the Petersburg road system.

Embedded culverts	Ketchikan	% of Culverts	Petersburg	% of Culverts	Wrangell	% of Culverts	Total	Total % of Culverts
No	54	88.5	107	96.4	40	100.0	201	94.8
Yes	7	11.5	4	3.6	0	0.0	11	5.2
Total	61	100.0	111	100.0	40	100.0	212	100.0

Table 16.–Culverts that meet project standards for being backwatered on the Petersburg road system.

Backwatered Sites	Ketchikan	% of Sites	Petersburg	% of Sites	Wrangell	% of Sites	Total	Total % of Sites
No	53	93.0	98	96.1	37	97.4	188	95.4
Yes	3	5.3	4	3.9	1	2.6	8	4.1
Maybe	1	1.8	0	0.00	0	0.0	1	0.5
Total	57	100.0	102	100.0	38	100.0	197	100.0

Table 17.–Sites found to be tidally influenced on the Petersburg road system.

Tidal influence	Ketchikan	% of Sites	Petersburg	% of Sites	Wrangell	% of Sites	Total	Total % of Sites
No	51	89.5	91	89.2	32	84.2	174	88.3
Yes	6	10.5	8	7.8	4	10.5	18	9.1
Maybe	0	0.0	3	2.9	2	5.3	5	2.5
Total	57	100.0	102	100.0	38	100.0	197	100.0

Table 18.–Culverts found to have baffles on the Petersburg road system.

Baffles?	Ketchikan	% of Culverts	Petersburg	% of Culverts	Wrangell	% of Culverts	Total	Total % of Culverts
No	54	88.5	106	96.4	41	100.0	201	94.8
Yes	6	9.8	4	3.6	0	0.0	10	4.7
Maybe	1	1.6	0	0.0	0	0.0	1	0.5
Total	61	100.0	110	100.0	41	100.0	212	100.0

Table 19.–Water depth at outlet for culverts assessed on the Petersburg road system.

Culvert water depth at outlet (ft)	Ketchikan	% of Culverts	Petersburg	% of Culverts	Wrangell	% of Culverts	Total	Total % of Culverts
Dry	4	6.8	6	5.8	2	5.3	12	8.4
>0–0.25	28	47.5	60	57.7	25	65.8	113	79.0
0.25–0.5	12	20.3	20	19.2	7	18.4	39	27.3
0.5–0.75	5	8.5	9	8.7	1	2.6	15	10.5
0.75–1	4	6.8	6	5.8	0	0.0	10	7.0
1–1.25	3	5.1	1	1.0	1	2.6	5	3.5
1.25–1.5	2	3.4	1	1.0	0	0.0	3	2.1
1.5–1.75	0	0.0	1	1.0	2	5.3	3	2.1
>1.75	1	1.7	0	0.0	0	0.0	1	0.7
Total	59	100.0	104	100.0	38	100.0	143	140.6

Table 20.–Stream stage at time of survey for sites assessed on the Petersburg road system.

Stream Stage	Ketchikan	% of Sites	Petersburg	% of Sites	Wrangell	% of Sites	Total	Total % of Sites
Low	6	10.7	40	39.6	8	21.1	54	27.7
Medium	26	46.4	57	56.4	22	57.9	105	53.8
High	24	42.9	4	4.0	8	21.1	36	18.5
Total	56	100.0	101	100.0	38	100.0	195	100.0

Table 21.–Average stream widths at ordinary high water (OHW) for sites assessed on the Petersburg road system.

Average stream width at OHW (ft)	Ketchikan	% of Sites	Petersburg	% of Sites	Wrangell	% of Sites	Total	Total % of Sites
0–2	0	0.0	2	2.2	0	0.0	2	1.2
2–4	5	10.6	14	15.4	11	47.8	30	18.6
4–6	11	23.4	26	28.6	5	21.7	42	26.1
6–8	11	23.4	18	19.8	4	17.4	33	20.5
8–10	7	14.9	11	12.1	0	0.0	18	11.2
10–12	2	4.3	6	6.6	2	8.7	10	6.2
12–14	2	4.3	3	3.3	0	0.0	5	3.1
14–16	3	6.4	1	1.1	1	4.3	5	3.1
16–18	1	2.1	2	2.2	0	0.0	3	1.9
18–20	2	4.3	2	2.2	0	0.0	4	2.5
20–22	2	4.3	1	1.1	0	0.0	3	1.9
22–24	1	2.1	1	1.1	0	0.0	2	1.2
>24	0	0.0	4	4.4	0	0.0	4	2.5
Total	47	100.0	91	100.0	23	100.0	161	100.0

Note: OHW = ordinary high water.

Table 22.–Stream gradient for sites assessed on the Petersburg road system.

Stream gradients (%)	Ketchikan	% of Sites	Petersburg	% of Sites	Wrangell	% of Sites	Total	Total % of Sites
0–1	4	26.7	9	18.4	0	0.0	13	18.6
1–2	1	6.7	8	16.3	1	16.7	10	14.3
2–3	2	13.3	11	22.4	2	33.3	15	21.4
3–4	6	40.0	2	4.1	0	0.0	8	11.4
4–5	1	6.7	5	10.2	0	0.0	6	8.6
5–6	1	6.7	2	4.1	0	0.0	3	4.3
6–7	0	0.0	4	8.2	0	0.0	4	5.7
7–8	0	0.0	2	4.1	0	0.0	2	2.9
8–9	0	0.0	3	6.1	1	16.7	4	5.7
9–10	0	0.0	1	2.0	0	0.0	1	1.4
>10	0	0.0	2	4.1	2	33.3	4	5.7
Total	15	100.0	49	100.0	6	100.0	70	100.0

Table 23.–Fish collection effort, information, and AWC nominations for sites assessed in Ketchikan, Petersburg, and Wrangell.

Fish collection effort	Ketchikan	% of Sites	Petersburg	% of Sites	Wrangell	% of Sites	Total	Total % of Sties
No. of sites trapped	51	89.5	87	85.3	26	68.4	164	83.2
No. of sites trapped where fish captured or observed	39	76.5	75	86.2	14	53.8	128	78.0
No. of sites nominated to AWC	30	58.8	63	72.4	8	30.7	101	61.6

Table 24.–AWC nomination types for sites were AWC nominations were submitted in Ketchikan, Petersburg, and Wrangell.

AWC nomination type	Ketchikan	% of Nominations	Petersburg	% of Nominations	Wrangell	% of Nominations	Total	Total % of nominations
Addition	28	73.7	50	58.8	8	100.0	86	65.6
Back-up	10	26.3	34	40.0	0	0.0	44	33.6
Correction	0	0.0	1	1.2	0	0.0	1	0.8
Total	38	100.0	85	100.0	8	100.0	131	100.0

Table 25.–Prioritization of all Red and Gray rated sites in the Ketchikan area.

Site	Road name	Stream name	Prioritization score	Stream miles above culvert	AWC miles above culvert	Lake acres above culvert	Anadromous fish species	Resident fish species
10103229	North Tongass Highway	Trollers Creek	2.600	1.25	0	2.65	2	1
10103208	South Tongass Highway	Unnamed	1.696	0.83	0	0	2	1
10103174	Ward Lake Road	Unnamed	1.155	1.20	0	0	0	1
10103230	North Tongass Highway	1st Waterfall Creek	0.651	0.14	0.14	0	2	1
10103199	Schoenbar Road	Schoenbar Creek	0.622	1.49	1.49	0	2	1
10103140	Driveway off North Tongass Hwy	Unnamed	0.612	0.01	0	0	2	0
10103241	Baranof Avenue	Hoadly Creek	0.570	0.05	0	0	2	1
10103170	Ward Lake Road	Unnamed	0.556	0.38	0	0	0	1
10103151	Gravina Island Highway	Unnamed	0.538	0.23	0.23	3.74	1	1
10103237	Wood Road	Unnamed	0.522	0.08	0.08	0	2	0
10103243	Hospital Parking Lot	Hoadly Creek	0.470	0.20	0.17	0	2	1
10103211	D1 Loop Road	Unnamed	0.435	0.15	0	0	1	1
10103227	Scheonbar Road	Scheonbar Creek	0.416	0.11	0.11	0	2	1
10103205	North Tongass Highway	Unnamed	0.384	0.07	0.07	0	1	0
10103213	North Point Higgins Road	Unnamed	0.283	0.86	0	0	0	1
10103231	South Tongass Highway	Adams Creek	0.274	0.08	0.08	0	3	1
10103167	Ward Lake Road	Unnamed	0.267	0.13	0	0	0	2
10103239	Shoreline Drive	Unnamed	0.252	0.03	0.03	0	1	0
10103147	Abandoned Road Pullout	Unnamed	0.234	0.01	0	0	1	0
10103165	Ward Lake Road	Unnamed	0.210	0.10	0	0	1	0
10103204	Revella Road	Unnamed	0.186	0.31	0	0	0	0
10103149	Lewis Reef Road	Unnamed	0.168	0.06	0	0	2	0
10103175	Ward Lake Road	Unnamed	0.165	0.10	0	0	0	1
10103242	Jackson Street	Hoadly Creek	0.165	0.10	0	0	0	1
10103210	North Tongass Highway	Unnamed	0.164	0.13	0.13	0	1	2
10103141	North Tongass Highway	Unnamed	0.162	0.04	0.04	0	2	0
10103146	North Tongass Highway	Unnamed	0.156	0.01	0	0	1	0

-continued-

Table 25.–Page 2 of 2.

Site	Road name	Stream name	Prioritization score	Stream miles above culvert	AWC miles above culvert	Lake acres above culvert	Anadromous fish species	Resident fish species
10103172	Ward Lake Road	Ward Creek	0.156	0.13	0	0	0	0
10103164	North Tongass Highway	Unnamed	0.135	0.15	0	0	0	0
10103236	South Tongass Highway	Homestead Creek	0.108	0.11	0	0	1	0
10103212	D2 Loop Road	Unnamed	0.104	0.09	0	0	0	1
10103209	North Tongass Highway	Unnamed	0.103	0.01	0	0	1	1
10103226	Revilla Road	Unnamed Creek	0.090	0.30	0	0	0	0
10103240	Abandoned Road Grade	Hoadly Creek tributary	0.084	0.01	0	0	0	1
10103244	D1 Loop Road	Unnamed Creek	0.084	0.01	0	0	0	1
10103234	Unnamed	Unnamed	0.081	0.27	0	0	0	0
10103169	Ward Lake Road	Ward Creek tributary	0.060	0.10	0	0	0	0
10103143	Gravina Island Highway	Unnamed	0.056	0.01	0	0	0	1
10103238	Shoreline Drive	Unnamed	0.048	0.04	0	0	0	0
10103202	Ward Lake Road	Ward Creek tributary	0.045	0.15	0	0	0	0
10103162	North Tongass Highway	Unnamed	0.012	0.01	0	0	0	0
10103145	South Tongass Highway	Unnamed	0.006	0.01	0	0	0	0
10103232	Unnamed	Unnamed	0.006	0.01	0	0	0	0
10103153	Gravina Island Highway	Unnamed	0.003	0.01	0	0	0	0

Table 26.–Prioritization of all Red and Gray rated sites in the Petersburg area.

Site ID	Road name	Stream name	Prioritization score	Stream miles above culvert	AWC miles above culvert	Lake acres above culvert	Anadromous fish species	Resident fish species
10203301	Mitkof Highway	Unnamed	1.960	1.30	0	0	1	1
10203171	Sandy Beach Road	Unnamed	1.328	0.69	0	0	1	2
10203133	Mitkof Highway	Unnamed	1.226	1.46	1.46	0	2	1
10203155	Driveway	Unnamed	1.107	0.73	0.48	0	2	0
10203136	Greens Camp Rec Site	Unnamed	0.990	2.80	2.80	0	2	0
10203282	Mitkof Highway	Big Gulch	0.940	2.30	2.30	0	3	1
10203138	Banana Point Boat Launch	Unnamed	0.801	0.14	0	0	2	3
10203139	Mitkof Highway	Unnamed	0.760	0.30	0	0	1	1
10203294	Mitkof Highway	Unnamed	0.736	0.28	0.07	0	1	1
10203152	Sandy Beach Road	Unnamed	0.720	0.70	0.45	0	2	0
10203173	Noseeum Road	Milk Creek	0.705	0.45	0.18	0	1	1
10203325	Mitkof Highway	Unnamed	0.660	0.40	0	0	1	1
10203220	Mitkof Highway	Blind Slough tributary	0.618	0.27	0.11	0	1	2
10203214	Mitkof Highway	Unnamed	0.615	0.35	0	0	1	1
10203272	Mitkof Highway	Fur Farm Creek	0.615	0.10	0.02	0	2	1
10203159	Sandy Beach Road	Unnamed	0.579	0.06	0.06	0	2	1
10203318	Abandoned Road Grade	Unnamed	0.556	0.13	0	0	1	1
10203163	Sandy Beach Road	Unnamed	0.552	0.42	0.22	0	2	0
10203317	Mitkof Highway	DelMar Creek	0.512	0.52	0.52	0	1	1
10203295	Mitkof Highway	Taain Creek	0.508	0.09	0.09	0	1	1
10203192	Mitkof Highway	Strange Creek	0.490	0.40	0.21	0	1	2
10203316	Mitkof Highway	Unnamed	0.446	0.41	0.41	0	1	1
10203225	Mitkof Highway	Blind River tributary	0.444	0.16	0	0	1	1
10203217	Mitkof Highway	Unnamed	0.430	0.30	0	0	1	2
10203290	Mitkof Highway	Unnamed	0.426	0.14	0.06	0	1	1

-continued-

Table 26.–Page 2 of 4.

Site ID	Road name	Stream name	Prioritization score	Stream miles above culvert	AWC miles above culvert	Lake acres above culvert	Anadromous fish species	Resident fish species
10203193	Mitkof Highway	Unnamed	0.411	0.04	0.04	0	1	2
10203283	Mitkof Hwy	Luna Creek	0.387	0.18	0.08	0	1	0
10203276	Mitkof Highway	Unnamed	0.369	0.16	0	0	1	0
10203286	Frederick Drive	Unnamed	0.350	0.50	0	0	0	1
10203188	Mitkof Highway	Blind River	0.349	0.08	0.08	0	4	1
10203296	Abandoned Road	Unnamed	0.345	0.05	0.05	0	1	1
10203144	Mitkof Highway -Pullout	Unnamed	0.324	0.11	0.11	0	1	0
10203306	Scow Bay Waterline Access Road	Unnamed	0.322	0.37	0	0	0	2
10203189	Mitkof Highway	Unnamed	0.315	0.10	0.10	0	1	0
10203322	Mitkof Highway	Unnamed	0.312	0.01	0	0	1	0
10203182	Mitkof Highway	Lee's Cabin Creek	0.304	0.09	0.05	0	1	2
10203298	Mitkof Highway	Unnamed	0.300	0.25	0	0	0	1
10203166	Sandy Beach Park Access Road	Unnamed	0.297	0.08	0	0	1	0
10203284	Mitkof Highway	Unnamed	0.296	0.16	0	0	1	1
10203183	Mitkof Highway	Powerline Creek	0.290	0.55	0.55	0	1	2
10203302	Mitkof Highway	Blowdown Creek	0.286	0.06	0.06	0	1	2
10203304	Mitkof Highway	Unnamed	0.28	0.05	0.05	0	1	2
10203319	Mitkof Highway	Unnamed	0.270	0.30	0	0	0	0
10203321	Mitkof Highway	Unnamed	0.270	0.30	0	0	0	0
10203224	Mitkof Highway	Blind Slough tributary	0.268	0.03	0.03	0	1	2
10203303	Mitkof Highway	Mabel Creek	0.261	0.04	0.04	0	1	0
10203194	Mitkof Highway	Unnamed	0.260	0.10	0.05	0	1	1
10203191	Mitkof Highway	Unnamed	0.248	0.08	0	0	1	1
10203150	Mitkof Highway	Unnamed	0.243	0.56	0.56	0	1	0
10203195	Mitkof Highway	Unnamed	0.242	0.07	0	0	1	1

-continued-

Table 26.–Page 3 of 4.

Site ID	Road name	Stream name	Prioritization score	Stream miles above culvert	AWC miles above culvert	Lake acres above culvert	Anadromous fish species	Resident fish species
10203320	Private Drive	Unnamed	0.240	0.20	0	0	0	0
10203305	Mitkof Highway	Unnamed	0.236	0.06	0.06	0	1	1
10203307	Mitkof Highway	Baxter Creek	0.234	0.01	0	0	1	0
10203187	Mitkof Highway	Unnamed	0.224	0.04	0	0	1	1
10203134	Mitkof Highway	Unnamed	0.222	0.12	0	0	1	0
10203221	Mitkof Highway	Unnamed	0.221	0.07	0.07	0	2	2
10203176	Mitkof Highway	Unnamed	0.206	0.01	0.01	0	1	1
10203179	Noseeum Road	Milk Creek tributary	0.206	0.01	0	0	1	1
10203180	Noseeum Road	Milk Creek tributary	0.206	0.01	0	0	1	1
10203299	Mitkof Highway	Unnamed	0.206	0.01	0	0	1	1
10203300	Mitkof Highway	Unnamed	0.200	0.25	0	0	0	1
10203135	Mitkof Highway	Unnamed	0.199	0.33	0.33	0	1	1
10203181	South Nordic Drive	Unnamed	0.199	0.33	0.50	0	1	1
10203215	Mitkof Highway	Unnamed	0.193	0.06	0.03	0	2	1
10203331	Mitkof Hwy	Unnamed	0.188	0.23	0	0	0	1
10203309	Abandoned Road Grade	Unnamed	0.180	0.20	0	0	0	0
10203313	Mitkof Highway	Unnamed	0.175	0.25	0.25	0	1	1
10203291	Frederick Drive	Unnamed	0.165	0.10	0	0	0	1
10203185	Mitkof Highway	Unnamed	0.156	0.01	0.01	0	1	0
10203196	Mitkof Highway	Unnamed	0.13	0.10	0.01	0	1	1
10203142	Mitkof Highway	Unnamed	0.120	0.05	0	0	0	1
10203206	Mitkof Highway	Unnamed	0.120	0.05	0	0	0	1
10203148	Mitkof Highway	Unnamed	0.108	0.11	0.11	0	1	0
10203323	Private Driveway	Unnamed	0.108	0.12	0	0	0	0
10203218	Mitkof Highway	Blind River tributary	0.105	0.10	0	0	1	0

-continued-

Table 26.–Page 4 of 4.

Site ID	Road name	Stream name	Prioritization score	Stream miles above culvert	AWC miles above culvert	Lake acres above culvert	Anadromous fish species	Resident fish species
10203219	Mitkof Highway	Blind River tributary	0.105	0.10	0	0	1	0
10203326	Scow Bay Waterline Access Road	Unnamed	0.094	0.23	0	0	0	1
10203275	Mitkof Highway	Unnamed	0.084	0.01	0	0	0	1
10203137	Mitkof Highway	Unnamed	0.075	0	0	0	0	1
10203178	Wrangell Avenue	McCabe Creek	0.069	0.23	0	0	0	0
10203223	Mitkof Highway	Blind Slough tributary	0.056	0.01	0	0	0	1
10203156	Mikof Highway	Unnamed	0.055	0.10	0	0	0	1
10203314	Mitkof Highway	Unnamed	0.045	0.05	0.05	0	0	0
10203168	Nordic Avenue	Unnamed	0.042	0.07	0	0	0	0
10203297	Private Driveway	Unnamed	0.031	0.02	0.02	0	0	1
10203271	Mitkof Highway	Unnamed	0.030	0.10	0	0	0	0
10203177	Eighth Street	Unnamed	0.012	0.01	0.01	0	0	0
10203292	Mitkof Highway	Unnamed	0.012	0.01	0	0	0	0
10203324	Mitkof Highway	Unnamed	0.009	0.01	0	0	0	0
10203197	Mitkof Highway	Unnamed	0.006	0.01	0	0	0	0
10203329	Mitkof Highway	Unnamed	0.006	0.02	0	0	0	0
10203184	Mitkof Highway	Unnamed	0.003	0.01	0	0	0	0
10203308	Mitkof Highway	Unnamed	0.003	0.01	0	0	0	0

Table 27.–Prioritization of all Red and Gray rated sites in the Wrangell area.

Site	Road name	Stream name	Prioritization score	Stream miles above culvert	AWC miles above culvert	Lake acres above culvert	Anadromous fish species	Resident fish species
10203312	Zimovia Highway	Playground Creek	0.396	0.16	0	0	1	3
10203315	Zimovia Highway	Unnamed	0.354	0.06	0	0	1	1
10203506	Zimovia Highway	Unnamed	0.350	0.50	0	0	0	1
10203310	Park Road	Playground Creek	0.348	0.08	0.08	0	1	3
10203333	Zimovia Highway	Unnamed	0.309	0.01	0	0	1	1
10203293	Stikine/Evergreen Ave	Unnamed	0.280	0.05	0	0	1	2
10203334	Zimovia Highway	Unnamed	0.206	0.01	0	0	1	1
10203499	Shoemaker Bay Loop	Unnamed	0.192	0.13	0	0	0	1
10203509	Zimovia Highway	Unnamed	0.186	0.06	0.04	0	1	0
10203503	Zimovia Highway	Unnamed	0.138	0.07	0	0	0	1
10203498	Shoemaker Bay Loop	Unnamed	0.120	0.05	0	0	0	1
10203508	Zimovia Highway	Unnamed	0.084	0.01	0	0	0	1
10203504	Access road off Zimovia Hwy	Unnamed	0.080	0.05	0	0	0	1
10203279	Zimovia Highway	Unnamed	0.056	0.01	0	0	0	1
10203281	Zimovia Highway	Unnamed	0.056	0.01	0	0	0	1
10203332	Zimovia Highway	Unnamed	0.056	0.01	0	0	0	1
10203335	Zimovia Highway	Unnamed	0.056	0.01	0	0	0	1
10203507	Zimovia Highway	Unnamed	0.056	0.01	0	0	0	1
10203277	Zimovia Highway	Unnamed	0.009	0.01	0	0	0	0
10203285	Private Drive	Unnamed	0.009	0.01	0	0	0	0
10203288	Zimovia Highway	Unnamed`	0.009	0.01	0	0	0	0
10203330	Zimovia Highway	Unnamed	0.009	0.01	0	0	0	0
10203497	Old Road Grade	Unnamed	0.009	0.01	0	0	0	0
10203512	Zimovia Highway	Unnamed	0.009	0.01	0	0	0	0
10203513	Zimovia Highway	Unnamed	0.009	0.01	0	0	0	0

-continued-

Table 27.–Page 2 of 2.

Site	Road name	Stream name	Prioritization score	Stream miles above culvert	AWC miles above culvert	Lake acres above culvert	Anadromous fish species	Resident fish species
10203278	Zimovia Highway	Unnamed	0.006	0.01	0	0	0	0
10203280	Private Drive	Unnamed	0.006	0.01	0	0	0	0
10203287	Zimovia Highway	Unnamed	0.006	0.01	0	0	0	0
10203289	Zimovia Highway	Unnamed	0.006	0.01	0	0	0	0
10203327	Zimovia Highway	Unnamed	0.006	0.01	0	0	0	0
10203328	Zimovia Highway	Unnamed	0.006	0.01	0	0	0	0
10203496	Driveway off Zimovia Highway	Unnamed Stream	0.006	0.01	0	0	0	0
10203502	Zimovia Highway	Unnamed	0.006	0.01	0	0	0	0
10203505	Zimovia Highway	Unnamed	0.006	0.01	0	0	0	0
10203510	Zimovia Highway	Unnamed	0.003	0.01	0	0	0	0
10203511	Zimovia Highway	Unnamed	0.003	0.01	0	0	0	0

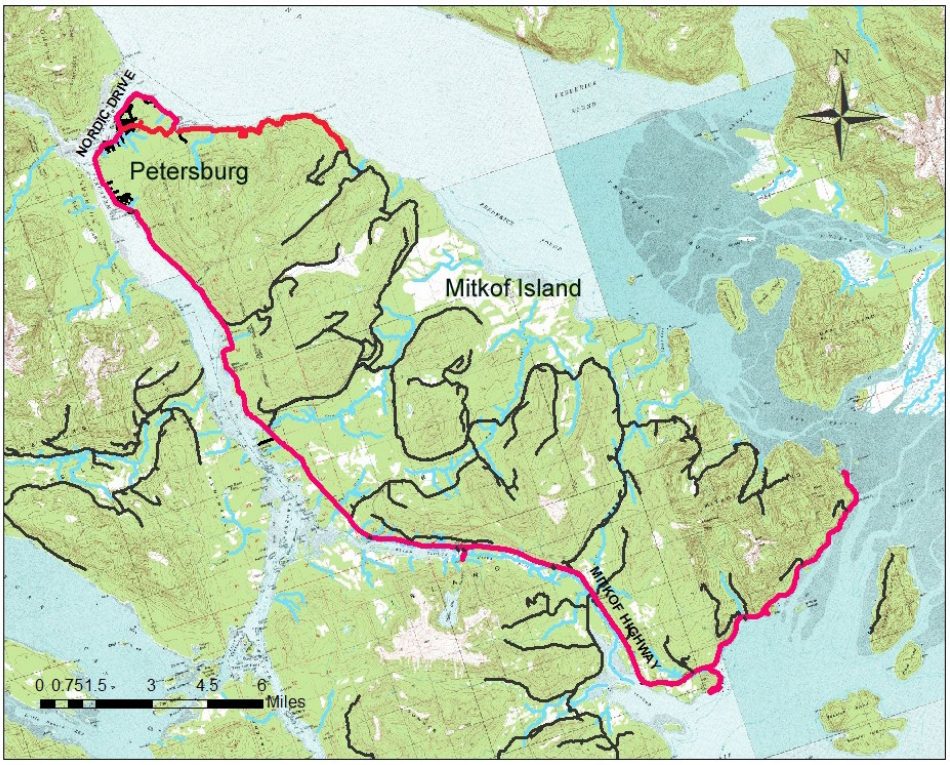

Figure 1.–Map showing the road network in the Petersburg area. Sites were assessed on roads marked in red.

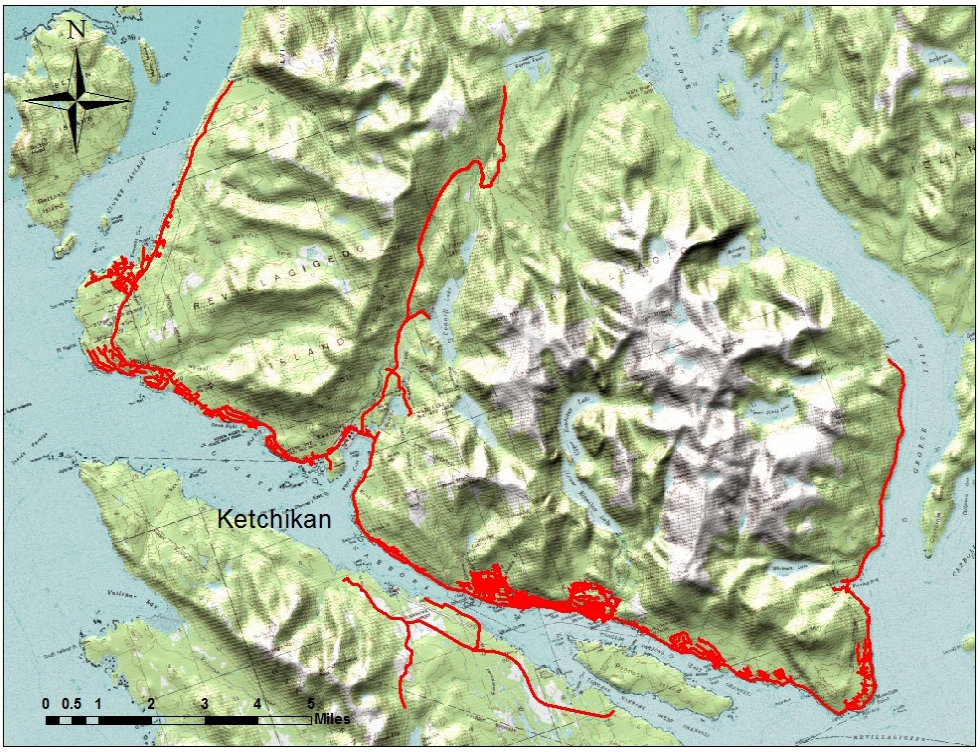

Figure 2.–Map showing the road network in the Ketchikan area. Sites were assessed on roads marked in red.

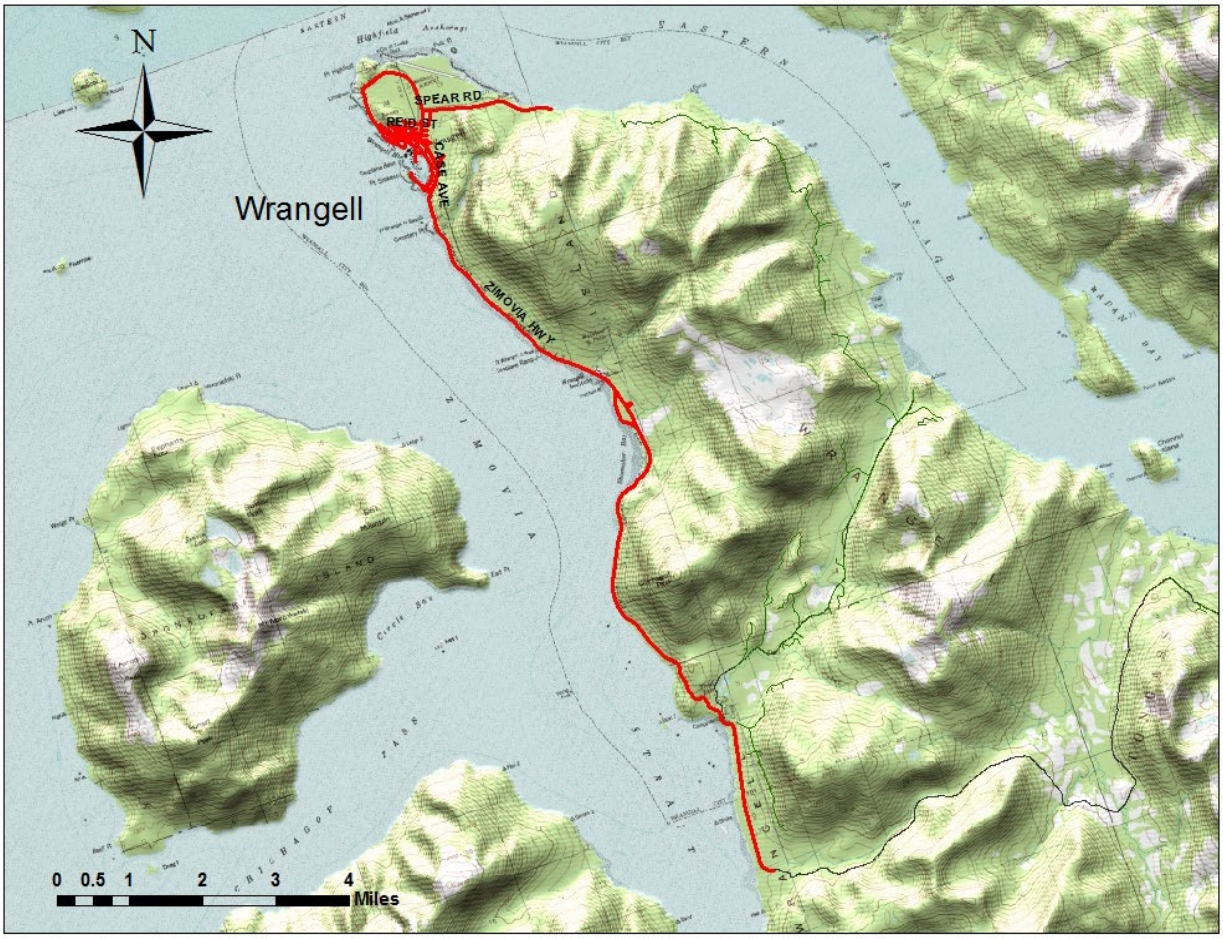

Figure 3.–Map showing the road network in the Wrangell area. Sites were assessed on roads marked in red.

	Structure Type	Green	Grey	Red
1	Bottomless pipe arch, embedded pipe arch, corrugated metal pipe, box culvert or other embedded structure that functions in a similar fashion.	Installed at channel gradient (+/–1% slope), AND constriction ratio greater than or equal to 0.75 OR fully backwatered	Structure not installed at channel gradient (+/–1%), OR constriction ratio of 0.5 to 0.75	Constriction ratio less than 0.5
2	Culverts (all span widths) with 2 X 6-inch corrugations or greater, not embedded.	Culvert gradient less than 1.0%, AND outfall height = 0, AND constriction ratio greater than 0.75 OR fully backwatered	Culvert gradient 1.0 to 2.0%, OR less than or equal to 4-inch outfall height, OR constriction ratio of 0.5 to 0.75	Culvert gradient greater than 2.0%, OR outfall hgt. greater than 4 inches, OR constriction ratio less than 0.5
3	Pipe arch or circular corrugated metal pipe (span width greater than 4 feet), less than 2 X 6-inch corrugations, not embedded	Culvert gradient less than 0.5%, AND outfall height = 0, AND constriction ratio greater than 0.75 OR fully backwatered	Culvert gradient 0.5 to 2.0%, OR less than or equal to 4-inch outfall height, OR constriction ratio of 0.5 to 0.75	Culvert gradient greater than 2.0%, OR outfall hgt. greater than 4 inches, OR constriction ratio less than 0.5
4	Pipe arch or circular corrugated metal pipe (span width less than or equal to 4 feet), less than 2 X 6-inch corrugations, not embedded	Culvert gradient less than 0.5%, AND outfall height = 0, AND constriction ratio greater than 0.75 OR fully backwatered	Culvert gradient 0.5 to 1.0%, OR less than or equal to 4-inch outfall height, OR constriction ratio of 0.5 to 0.75	Culvert gradient greater than 1.0%, OR outfall hgt. greater than 4 inches, OR constriction ratio less than 0.5.
5	Non-embedded box culverts, culverts with non-standard configurations or materials, culverts with baffles or downstream weirs or step pools, fish ladders, bridges with aprons.	Fully backwatered as described below	All others	Outfall height at downstream end of structure greater than 4 inches.
6	Multiple Structure Installations (MSI)	Individual culverts all classified as Green as above	Individual culverts all classified as Gray or as some mix of Green, Gray or Red as above.	Individual culverts all classified as Red as above.

Figure 4.–ADF&G Level 1 Assessment Matrix.

Notes: These criteria are not design standards, but rather indicate whether the structure is likely to provide fish passage for juvenile salmonids based on a one-time evaluation.

Ordinary high water (OHW) is the mean stream width measured either upstream or downstream of the culvert beyond the hydraulic influence of the culvert.

An embedded culvert must have 100% bed load coverage. Circular and box culverts must be embedded at least 20% of their height. A pipe arch must be embedded so that the mean bed load depth is greater than or equal to the vertical distance from the bottom of the pipe to the point of maximum horizontal dimension of the culvert (haunch height) or is 1 foot deep, whichever is greater.

A culvert is considered backwatered if one of the following conditions is met: 1) elevation of the tailwater control exceeds the elevation of the invert at both the outlet and inlet of the culvert and the invert of any aprons or other inlet or outlet structures; or 2) the culvert is located in a pond, slough, or other area with slow-moving or still water, the tailwater and headwater surfaces are equivalent, and water surface is continuous throughout the entire structure and at least 0.1 feet in depth at the shallowest point. Culvert gradient, span to OHW ratio, and outfall height criteria are not considered in the assessment of fish passage in backwatered culverts. A culvert is not backwatered if a hydraulic jump occurs within the barrel.

Outfall height is the difference between the water surface elevation at the outlet and in the outlet pool (or the equivalent tailwater surface).

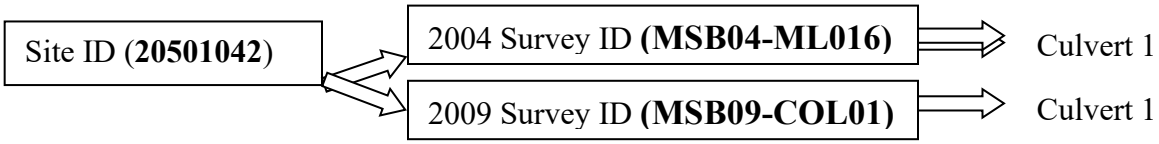

Figure 5.–Example of site/survey nomenclature for a site with more than one survey.

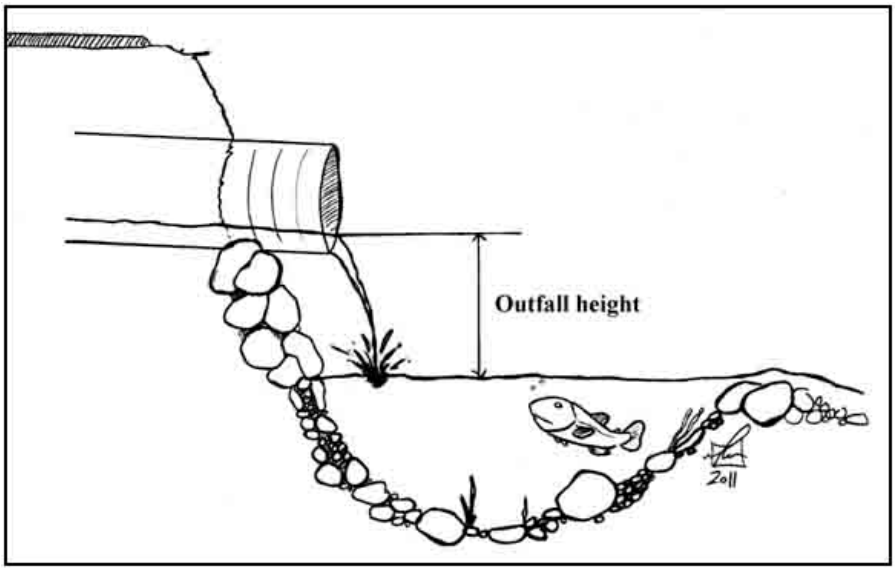

Figure 6.–Illustration showing where outfall height is measured on a free fall into pool outfall type.

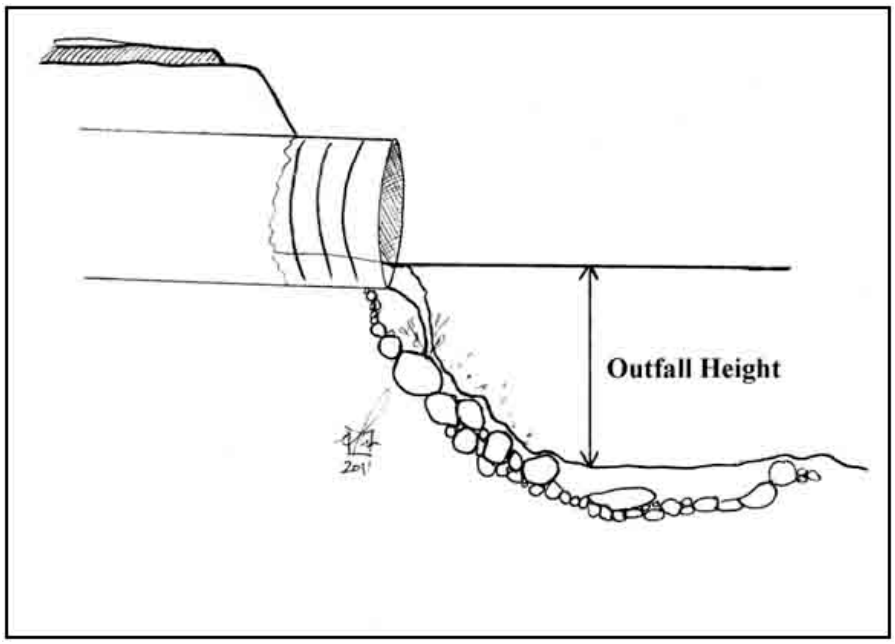

Figure 7.–Illustration showing the outfall height measurement for a free fall onto riprap and cascade over riprap.

Figure 8.–U.S. Forest Service Stream Crossing fish presence placard.

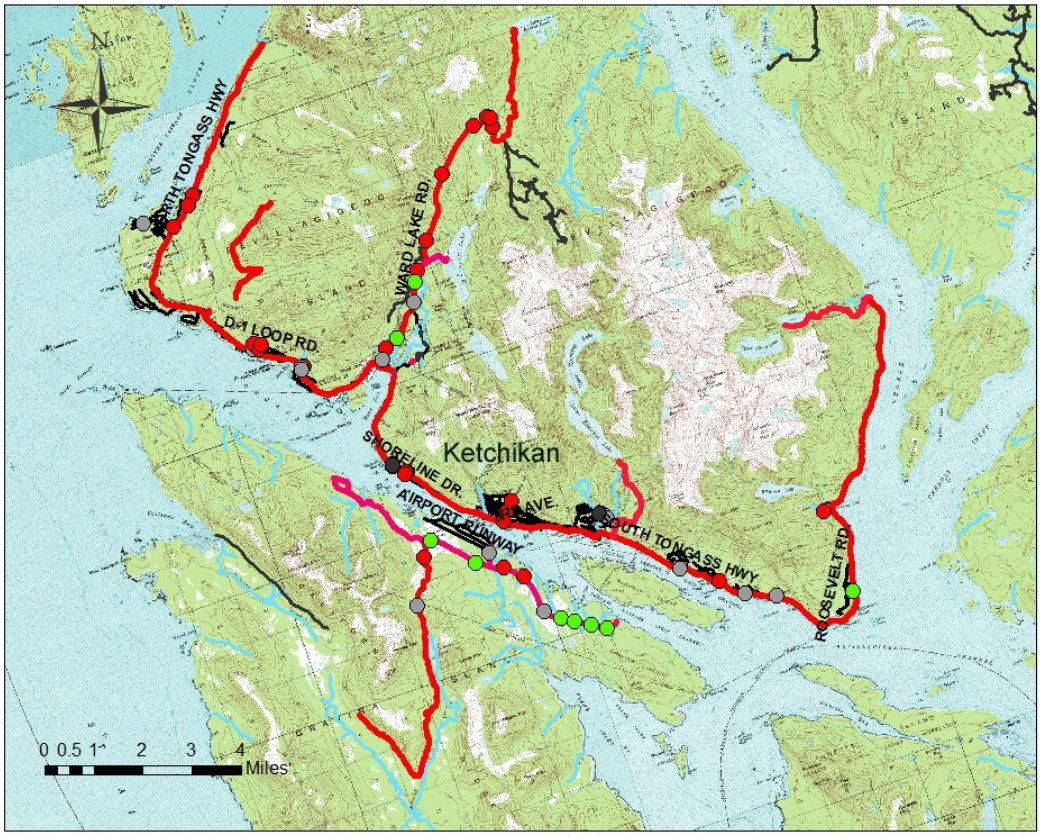

Figure 9.–Map showing assessed culvert sites on the Ketchikan road system, with color-coded ratings.

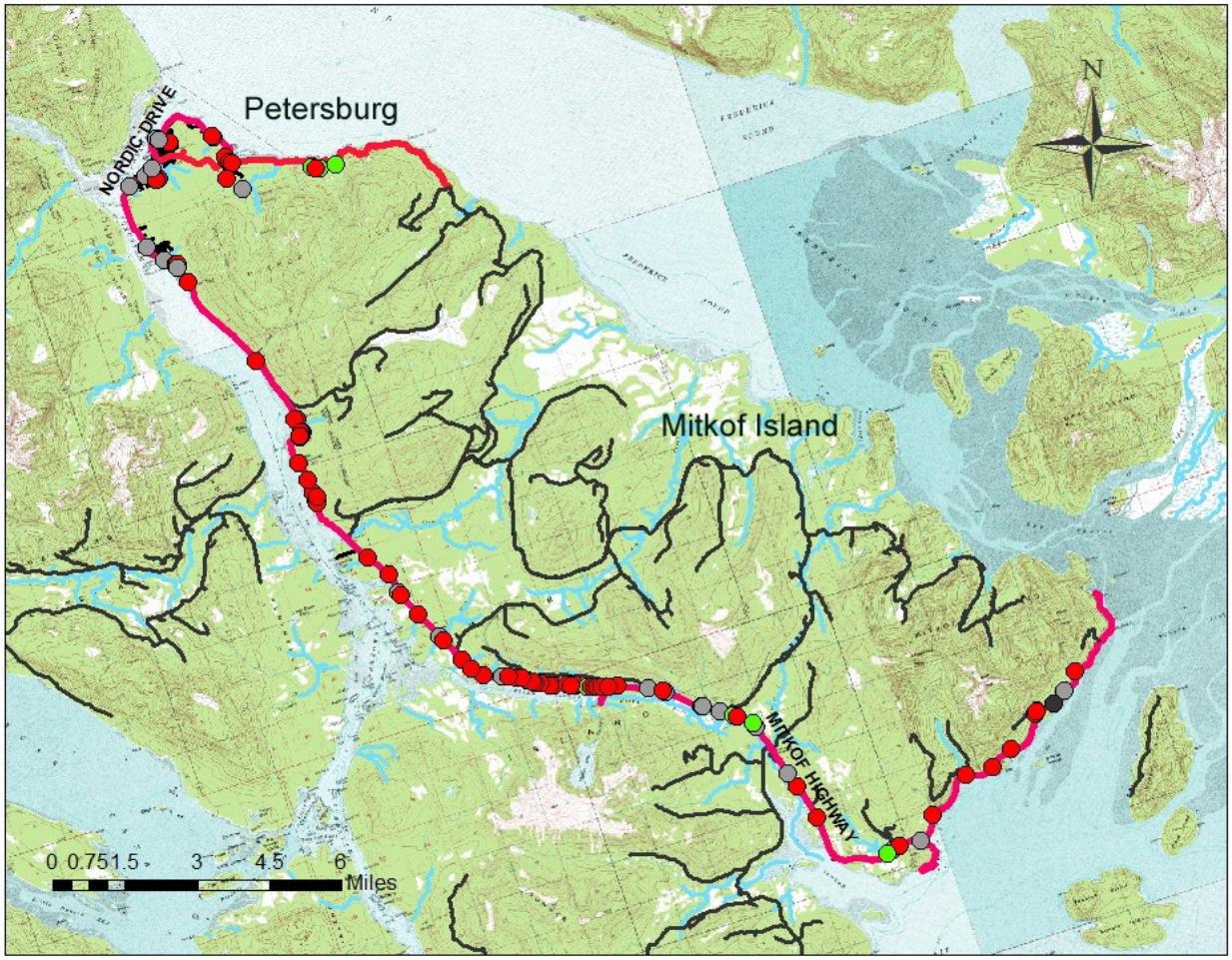

Figure 10.–Map of the sites assessed for fish passage on the Petersburg road system, with color-coded ratings.

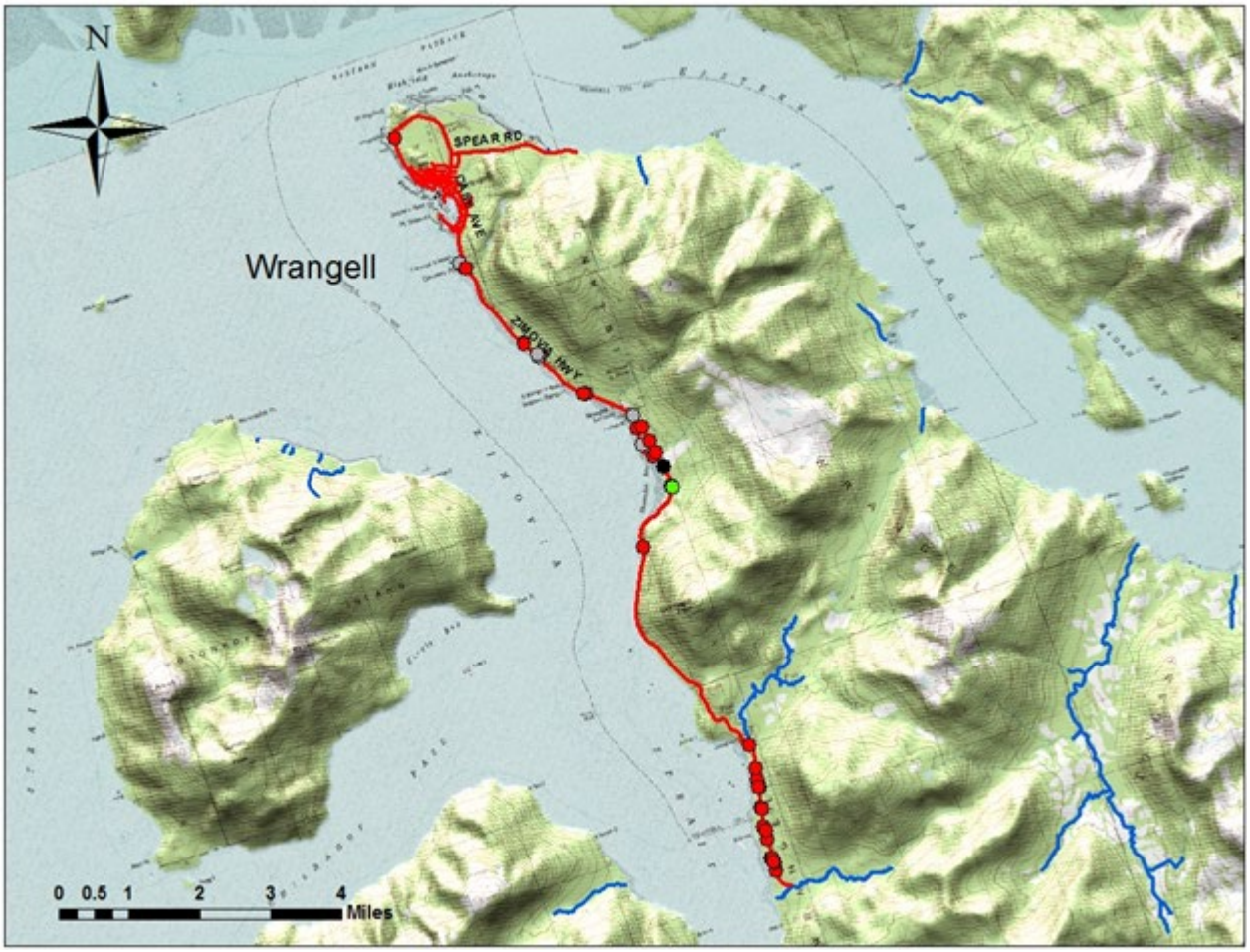

Figure 11.–Map showing sites assessed for fish passage on the Wrangell road system, with color-coded ratings.

Figure 12.–Site 10103229, North Tongass Highway, Trollers Creek (AWC# 101-90-10705), Ketchikan, culvert outlet.

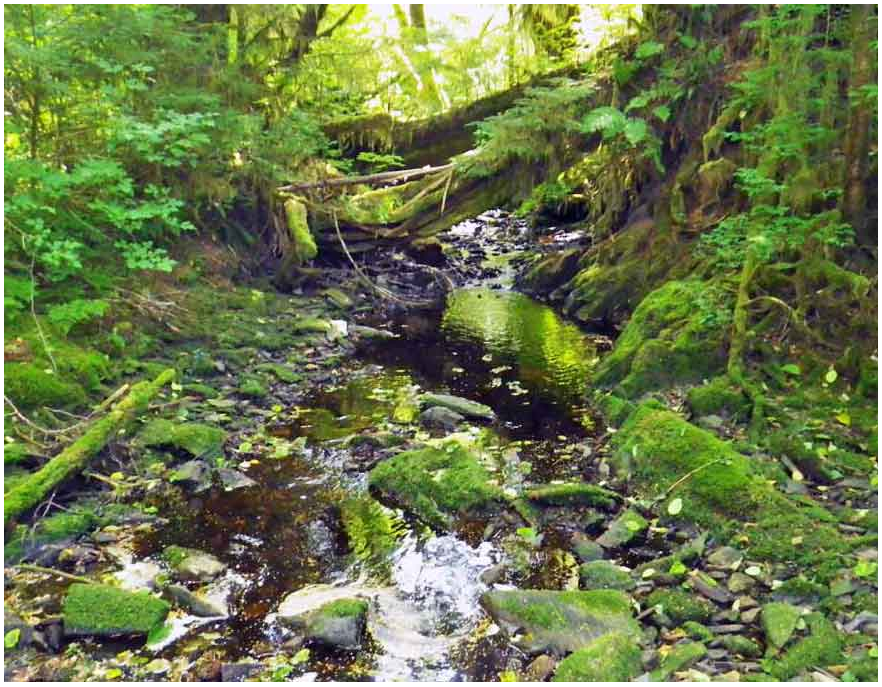

Figure 13.–Site 10103229, North Tongass Highway, Trollers Creek (AWC# 101-90-10705), Ketchikan, upstream habitat above culvert.

Figure 14.–Site 10103208, South Tongass Highway, unnamed creek (AWC# 101-47-10300), Ketchikan, culvert outlet.

Figure 15.–Site 10103208, South Tongass Highway, unnamed creek (AWC# 101-47-10300), Ketchikan, culvert inlet.

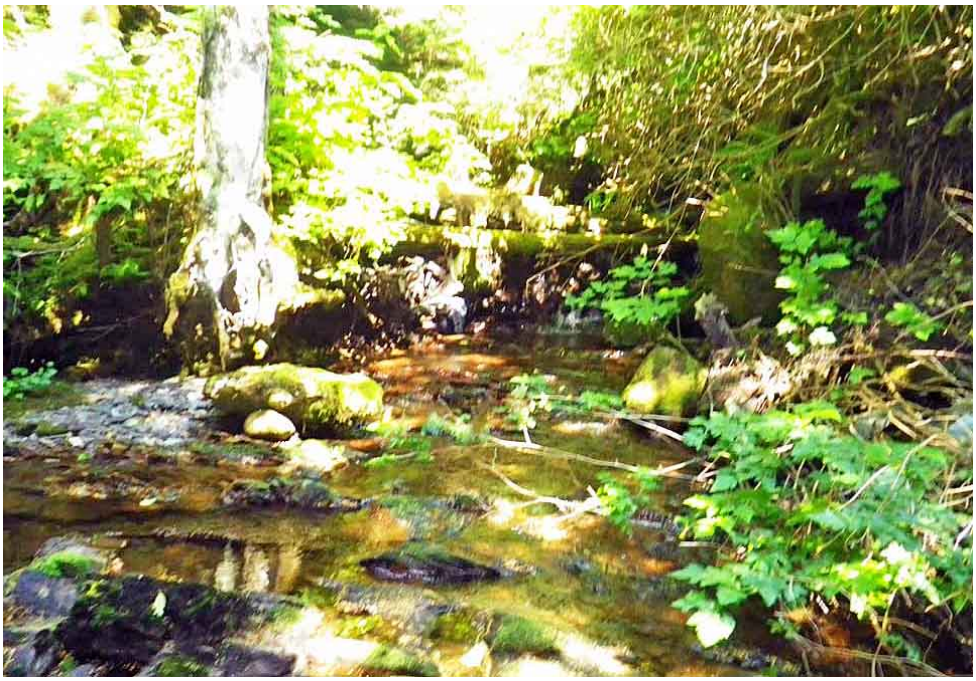

Figure 16.–Site 10103208, South Tongass Highway, unnamed creek (AWC# 101-47-10300), Ketchikan, upstream habitat above culvert.

Figure 17.–Site 10103174, Ward Lake Road, unnamed creek, Ketchikan, culvert outlet.

Figure 18.–Site 10103174, Ward Lake Road, unnamed creek, Ketchikan, culvert inlet.

Figure 19.–Site 10103174, Ward Lake Road, unnamed creek, Ketchikan, upstream habitat above culvert.

Figure 20.–Site 10203301, Mitkof Highway, Letti Creek (AWC# 106-44-10070), Petersburg, outlet showing outfall onto riprap barrier.

Figure 21.–Site 10203301, Mitkof Highway, Letti Creek (AWC# 106-44-10070), Petersburg, upstream habitat above culvert.

Figure 22.–Site 10203133, Mitkof Highway, unnamed creek (AWC Stream #108-40-10600), Petersburg, culvert inlets.

Figure 23.–Site 10203133, Mitkof Highway, unnamed creek (AWC Stream #108-40-10600), Petersburg, culvert outlets.

Figure 24.–Site 10203133, Mitkof Highway, unnamed creek (AWC Stream #108-40-10600), Petersburg, upstream habitat above culverts.

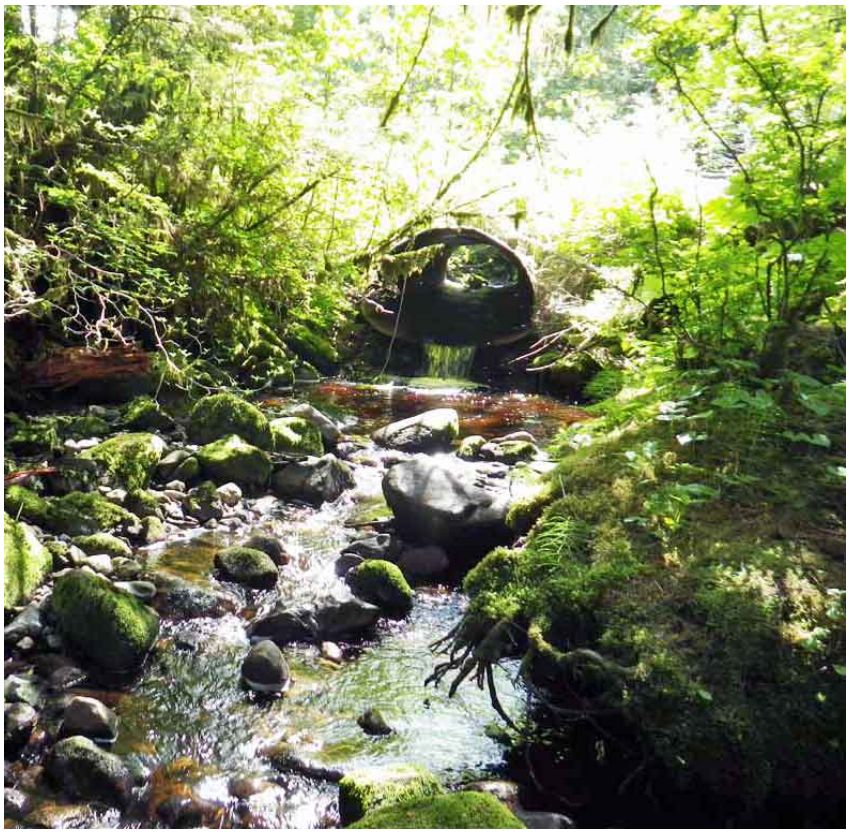

Figure 25.–Site 10203171, Sandy Beach Road, unnamed creek (AWC Stream #108-60-10051), Petersburg, culvert outlet.

Figure 26.–Site 10203171, Sandy Beach Road, unnamed creek (AWC Stream #108-60-10051), Petersburg, culvert interior.

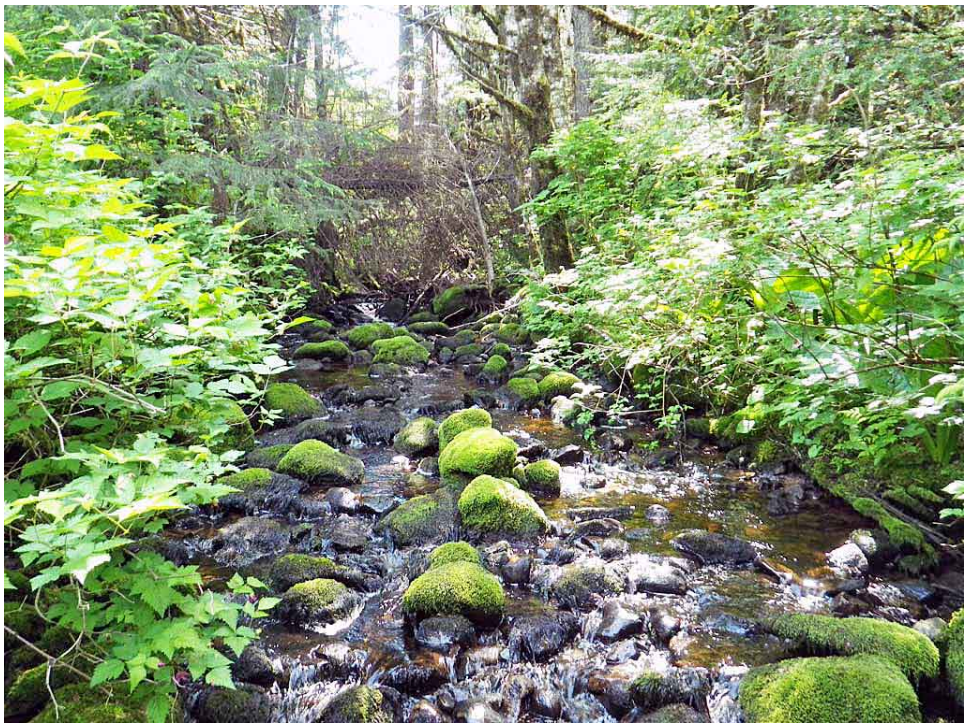

Figure 27.–Site 10203171, Sandy Beach Road, unnamed creek (AWC Stream #108-60-10051), Petersburg, upstream habitat above culvert.

Figure 28.–Site 10203312, Zimovia Highway, Playground Creek (AWC# 108-40-10282), Wrangell, culvert outlets.

Figure 29.–Site 10203312, Zimovia Highway, Playground Creek (AWC# 108-40-10282), Wrangell, culvert inlets.

Figure 30.–Site 10203312, Zimovia Highway, Playground Creek (AWC# 108-40-10282), Wrangell, upstream habitat above culverts.

Figure 31.–Site 10203315, Zimovia Highway, unnamed creek (AWC# 108-40-10290), Wrangell, culvert outlets.

Figure 32.–Site 10203315, Zimovia Highway, unnamed creek (AWC# 108-40-10290), Wrangell, culvert inlets.

Figure 33.–Site 10203315. Zimovia Highway, unnamed creek (AWC# 108-40-10290), Wrangell, upstream habitat above culverts.

Figure 34.–Site 10203506, Zimovia Highway, unnamed stream, Wrangell, culvert outlet.

Figure 35.–Site 10203506, Zimovia Highway, unnamed stream, Wrangell, culvert inlet.

Figure 36.–Site 10203506, Zimovia Highway, unnamed stream, Wrangell, upstream habitat above culvert.

APPENDIX A: FIELD FORMS

Appendix A1.–Field data form.

Survey ID		**Date**	
Site ID		**Time**	
Road Name		**Book #**	
Milepost		**Crew**	
Watershed		**Lat.**	
Stream Name		**Long.**	

Site Classification (Red/Gray/Green) _____

(Complete all applicable sections of this form before leaving survey site!)

Failure Codes	1	2	3	4	5	6
from table						

Resurvey? (Y/N)		Old Survey ID (if known)_____
Backwatered? (Y/N)		Step Pools ❑ Baffles ❑ Tidal ❑

Culvert Description: pipes numbered left to right facing downstream

	Units	1	2	3	4	5
Culvert Type (CIR, PA, etc.)						
Culvert Material (CSP, SSP, etc.)						
Structure Type (from matrix)	1 to 5					
Inlet Type (PRO, HDW, ect)						
Inlet Apron Length	ft					
Inlet Width	ft					
Inlet Height	ft					
Substrate Depth Inlet	ft					
Rust Line Height Inlet	ft					
Sedimentation at Inlet?	Y/N					
Outlet Type (PRO, HDW, ect.)						
Outlet Apron Length	ft					
Outlet Width	ft					
Outlet Height	ft					
Outfall Type (AG, F, C, etc.)						
Substrate Depth Outlet	ft					
Corrugation Depth	in					
Corrugation Width	in					
Culvert Length	ft					
Embedded?	Y/N					
Embedded Depth	ft					
Condition Rating (5=best)	1 to 5					
Outfall Height	ft					
Pipe Gradient	%					
Water Depth at Outlet	ft					
Max Gradient	%					
Length of Max Gradient	ft					
Stream Gradient	%					
Backwatered?	Y/N					
Individual Culvert Rating (Red, Gray, Green)						

Habitat Elements	**Upstream**	**Downstream**	**Inlet**	**Outlet**
Dominant substrate				
Subdominant substrate				

Stream Measurements

	Dist.	**OHW**
Upstream width		
Upstream width		
Upstream width		
Upstream width		
Downstream width		
Downstream width		
Downstream width		

Avg u/s width	
Avg d/s width	
Constriction Ratio	

Stream Stage (High, Med, or Low)	
Stream Approach Angle	

Fish data:	Sheet #		Line #s	
Trap	Loc/Dist	Time In	Time out	Soak Time
A				
B				

Notes: (Fish observations, damage, oddities, ect)

-continued-

	Structure Type	Green *Conditions may be adequate to pass juvenile fish*	Gray *Conditions unlikely to pass juvenile fish, additional analysis required*	Red *Conditions assumed inadequate to pass juvenile fish, additional analysis required*
1	Bottomless pipe arch, embedded pipe arch, CMP, box culvert or other embedded structure that functions in a similar fashion to an embedded pipe arch.	Installed at channel gradient (+/- 1% gradient), AND culvert span to OHW width ratio greater than or equal to 0.75 OR fully backwatered	Structure not installed at channel gradient (+/- 1%), OR culvert span to OHW width ratio of 0.5 to 0.75	Culvert span to OHW width ratio less than 0.5
2	Culverts (all span widths) with 2 X 6 inch corrugations or greater, not embedded.	Culvert gradient less than 1.0%, AND outfall hgt.= 0, AND culvert span to OHW width ratio greater than 0.75 OR fully backwatered	Culvert gradient 1.0 to 2.0%, OR less than or equal to 4-inch outfall hgt., OR culvert span to OHW width ratio of 0.5 to 0.75	Culvert gradient greater than 2.0%, OR outfall hgt. greater than 4 inches, OR span to OHW width ratio less than 0.5
3	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 culvert span to OHW width 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 culvert span to OHW width ratio of 0.5 to 0.75	Culvert gradient greater than 2.0%, OR outfall hgt. greater than 4 inches, OR culvert span to OHW width ratio less than 0.5
4	Pipe arch or circular CMP (span width less than or equal to 4 feet), less than 2 X 6 inch corrugations, not embedded	Culvert gradient less than 0.5%, AND outfall hgt.= 0, AND culvert span to OHW width ratio greater than 0.75 OR fully backwatered	Culvert gradient 0.5 to 1.0%, OR less than or equal to 4-inch outfall hgt., OR culvert span to OHW width ratio of 0.5 to 0.75	Culvert gradient greater than 1.0%, OR outfall hgt. greater than 4 inches, OR span to OHW width ratio less than 0.5.
5	Non-embedded box culverts, culverts with non-standard configurations or materials, culverts with baffles or downstream weirs or step pools, fish ladders, bridges with aprons.	Fully backwatered as described below.	All others	Outfall height at downstream end of structure greater than 4 inches.
6	Multiple Structure Installations	Individual culverts all classified as Green as above	Individual culverts all classified as Gray or as some mix of Green, Gray or Red as above.	Individual culverts all classified as Red as above.

1. These criteria are not design standards, but rather indicate whether the structure is likely to provide fish passage for juvenile salmonids based on a one-time evaluation.
2. Ordinary high water (OHW) is the mean stream width measured either upstream or downstream of the culvert beyond the hydraulic influence of the culvert. .
3. An embedded culvert must have 100% bedload coverage. Circular and box culverts must be embedded at least 20% of their height. A pipe-arch must be embedded so that the mean bedload depth is greater than or equal to the vertical distance from the bottom of the pipe to the point of maximum horizontal dimension of the culvert (haunch height) or is 1 foot deep, whichever is greater.
4. A culvert is considered backwatered if one of the following conditions is met: 1) elevation of the tailwater control exceeds the elevation of the invert at both the outlet and inlet of the culvert and the of any aprons or other inlet or outlet structures 2) the culvert is located in a pond, slough or other area with slow moving or still water and the tallwater and headwaters surface are equivalent and water surface is continuous throughout the entire structure and at least 0.1 feet in depth at the shallowest point. Culvert gradient, span to OHW ratio, and outfall height criteria are not considered in the assessment of fish passage in backwatered culverts. A culvert is not backwatered if a hydraulic jump occurs within the barrel.
5. Outfall height is the difference between the water surface elevation at the outlet and in the outlet pool (or the equivalent tailwater surface).

Site Observations

OHG	Outfall height gray
OHR	Outfall height red
GRDG	Culvert gradient gray
GRDR	Culvert gradient red
CRG	Constriction ratio gray
CRR	Constriction ratio red
AL	Culvert is poorly aligned
BV	Beaver Activity
CG	Compound gradient in pipe
CS	Cut-slope sliding into culvert
DF	Debris Flow
EC	Hydraulic flows exceeded capacity
IAS	Inlet apron too steep
IB	Improper bedding
IC	Damage associated with ice problems
IP	Inlet perch
MP	Mechanical damage or joints parting
MT	Material inadequate for designed use
OAS	Outlet apron too steep
OT	Other - vibrations, cavitation, etc.
RD	Road bank erosion
RF	Road Fill (pushed off road by grader)
SD	Sediment accumulation
SF	Shallow fill above culvert
SG	Culvert sagging in middle
SS	Subsidence
ST	Structural Problem
TS	Culvert is too short
WD	Woody Debris
NO	None of this type

Inlet/Outlet Type

PRO	Projecting
MIT	Mitered
HDW	Headwall
FLA	Flared
APR	Apron
WIN	Wing Wall

Culvert Material

SSP	Structural steel plate (bolted)
SAP	Structural aluminum plate (bolted)
CSP	Corrugated steel
CAP	Corrugated aluminum
WOD	Wood
RCP	Reinforced concrete
CPP	Corrugated plastic
NCP	Non-corrugated metal
UNK	Unknown/Other

Culvert Type

CIR	Circular pipe
OVL	Oval
AO	Open-bottom arch
BOX	Box culvert
PA	Pipe-arch
BR	Bridge
OT	Other
RM	Removed structure
FBO	Flat-bottom Oval

Substrate Types

Code	Descriptio	Size Guidelines
MD	Silt/ Clay	0.08mm to less than 2mm
SA	Sand	2mm to less than 5mm
GRV	Gravel	5mm to less than 80mm
CBL	Cobble	80mm to less than 250mm
BO	Boulder	250mm to less than 1 meter
BD	Bedrock	1 meter or greater
OR	Organics	n/a
NO	None	n/a

Outfall Type

AG	At Stream Grade
F	Free Fall In To Pool
C	Cascade Over Rip-Rap
SF	Smooth Flow Over Apron
OP	Overflow Pipe
HJ	Hydraulic Jump
FR	Free Fall on To Rip Rap
PS	Fish Passage Structue

Appendix A2.–Photo site field data form.

Fish Passage Survey Photo Site Only Form

(Remember to fill out a section in the Survey Notebook for this site as well)

Survey ID:	_____	Date:	_____
Site ID:	_____	Time:	_____
Road Name:	_____	Book #	_____
Milepost	_____	Crew:	_____
Watershed	_____	Latitude	_____
Stream Name	_____	Longitude:	_____

Photo Log

Comments: (Include why this is a photo site only: bridge, safty concern, ect.)

1 _____
2 _____
3 _____
4 _____
5 _____
6 _____
7 _____
8 _____
9 _____
10 _____

ALASKA DEPARTMENT OF FISH AND GAME

*All Site ID's for Photo Sites should begin with the prefix PS to denote a photosite.
(Example:PSARD01)
**This Form should only be filled out if you were unable to take any physical measurements at the site or if you are documenting a site as a bridge replacement.

Appendix A3.–Fish sampling form.

Fish Passage Culvert Assessment Sheet ____ of _____

Fish Sampling Form

Date _____ **Project** _____

	Site ID	Trap #	Distance from culvert	U/S or D/S	Species	Size category	Number	Comments
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								

APPENDIX B: COMPLETE SITE LIST ARRANGED BY AREA AND ROAD

Appendix B1.–Site list, by road, for all sites assessed on the Petersburg road system.

Site ID	Assessment date	Road name	Stream name	Latitude	Longitude	Site rating	Site condition rating	Site observations
10203296	6/21/14	Abandoned Road	Unnamed	56.72252	-132.93082	Red	1	Constriction ratio red, Compound gradient in pipe, Inlet perch, Structural Problem, Hydraulic flows exceeded capacity, Culvert sagging in middle
10203309	6/22/14	Abandoned Road Grade	Unnamed	56.7787	-132.96477	Red	2	Culvert gradient red, Constriction ratio gray
10203318	6/20/14	Abandoned Road Grade	Unnamed	56.71804	-132.92906	Red	2	Constriction ratio gray, Outfall height red
10203138	6/27/13	Banana Point Boat Launch	Unnamed	56.55459	-132.6297	Red	2	Outfall height red, Culvert gradient red, Constriction ratio red, Debris Flow, Woody Debris, Structural Problem
10203155	6/12/13	Driveway	Unnamed	56.81304	-132.92361	Red	1	Structural Problem, Constriction ratio red, Outfall height red, Culvert is too short, Culvert gradient red
10203161	6/11/13	Driveway off Sandy Beach Road	Unnamed	56.80592	-132.92039	Green	1	Mechanical damage or joints parting, Structural Problem, Constriction ratio red
10203177	6/9/13	Eighth Street	Unnamed	56.81514	-132.94757	Red	3	Culvert gradient red, Outfall height red, Structural Problem
10203273	6/10/14	Frederick Drive	Unnamed	56.79369	-132.87347	Green	4	None of this type
10203274	6/10/14	Frederick Drive	Hobo Creek	56.79443	-132.87724	Green	3	Structural Problem
10203286	6/11/14	Frederick Drive	Unnamed	56.79331	-132.86414	Red	3	Culvert gradient red
10203291	6/10/14	Frederick Drive	Unnamed	56.79381	-132.8756	Red	3	Constriction ratio gray, Culvert gradient red, Outfall height red
10203311	6/11/14	Frederick Drive	Unnamed	56.79336	-132.86449	Green	4	None of this type

-continued-

Site ID	Assessment date	Road name	Stream name	Latitude	Longitude	Site rating	Site condition rating	Site observations
10203136	6/28/13	Greens Camp Rec Site	Unnamed	56.5397	-132.67995	Gray	4	Tidal, Constriction ration gray
10203156	6/12/13	Mikof Highway	Unnamed	56.78637	-132.97729	Gray	4	Culvert gradient red, Constriction ratio gray
10203133	6/28/13	Mitkof Highway	Unnamed	56.55483	-132.64482	Red	3	Culvert gradient red, Outfall height gray, Inlet perch
10203134	6/28/13	Mitkof Highway	Unnamed	56.54638	-132.66922	Red	4	Outfall height red, Culvert gradient red, Constriction ratio gray, Inlet perch
10203135	6/13/13	Mitkof Highway	Unnamed	56.80599	-132.97585	Gray	3	Inlet perch, Outfall height gray, Structural Problem
10203137	6/27/13	Mitkof Highway	Unnamed	56.5583	-132.61682	Red	3	Culvert gradient red, Outfall height red, Constriction ratio gray
10203139	6/25/13	Mitkof Highway	Unnamed	56.57465	-132.57014	Red	2	Outfall height red, Culvert gradient red, Compound gradient in pipe, Structural Problem
10203142	6/25/13	Mitkof Highway	Unnamed	56.56591	-132.5983	Red	3	Culvert gradient red, Constriction ratio red, Inlet perch, Outfall height red, Hydraulic flows exceeded capacity
10203148	6/13/13	Mitkof Highway	Unnamed	56.80766	-132.96535	Gray	3	Constriction ratio gray
10203150	6/13/13	Mitkof Highway	Unnamed	56.78107	-132.97063	Gray	4	Culvert gradient gray
10203176	7/25/13	Mitkof Highway	Unnamed	56.61792	-132.83191	Red	3	Culvert gradient red, Outfall height red, Culvert is poorly aligned
10203182	7/17/13	Mitkof Highway	Lee's Cabin Creek	56.61398	-132.80978	Red	4	Culvert is poorly aligned, Culvert gradient red, Outfall height gray
10203183	7/17/13	Mitkof Highway	Powerline Creek	56.61007	-132.7943	Gray	4	Outfall height gray, Culvert gradient gray, Culvert is poorly aligned

-continued-

Site ID	Assessment date	Road name	Stream name	Latitude	Longitude	Site rating	Site condition rating	Site observations
10203184	7/17/13	Mitkof Highway	Unnamed	56.6075	-132.78625	Gray	5	Culvert gradient red, Outfall height gray, Culvert is poorly aligned
10203185	7/25/13	Mitkof Highway	Unnamed	56.61818	-132.83182	Red	3	Outfall height red, Culvert gradient red, Constriction ratio red
10203186	7/25/13	Mitkof Highway	Unnamed	56.61653	-132.82538	Green	2	Structural Problem, Culvert gradient gray, Constriction ratio gray, Culvert is poorly aligned, Culvert is too short
10203187	7/25/13	Mitkof Highway	Unnamed	56.61605	-132.8237	Red	3	Culvert is poorly aligned, Culvert gradient red, Outfall height red, Mechanical damage or joints parting
10203188	7/15/13	Mitkof Highway	Blind River	56.59654	-132.76097	Gray	4	Culvert gradient red, Culvert is poorly aligned, Culvert gradient gray
10203189	7/26/13	Mitkof Highway	Unnamed	56.61984	-132.84273	Red	1	Culvert gradient red
10203190	7/15/13	Mitkof Highway	Unnamed	56.59441	-132.75488	Green	4	None of this type
10203191	7/15/13	Mitkof Highway	Unnamed	56.59366	-132.7529	Red	4	Culvert gradient red, Constriction ratio gray
10203192	7/13/13	Mitkof Highway	Strange Creek	56.55647	-132.72977	Red	3	Structural Problem, Inlet perch, Constriction ratio red, Outfall height gray
10203193	7/26/13	Mitkof Highway	Unnamed	56.61894	-132.83591	Red	2	Outfall height red, Culvert gradient red
10203194	7/26/13	Mitkof Highway	Unnamed	56.61827	-132.83379	Red	3	Culvert gradient red, Hydraulic flows exceeded capacity, Sediment accumulation
10203195	7/13/13	Mitkof Highway	Unnamed	56.5675	-132.73456	Red	4	Inlet perch, Outfall height red, Culvert gradient red
10203196	7/12/13	Mitkof Highway	Unnamed	56.53979	-132.69646	Gray	4	Beaver Activity, Culvert gradient gray

-continued-

Appendix B1.–Page 4 of 9.

Site ID	Assessment date	Road name	Stream name	Latitude	Longitude	Site rating	Site condition rating	Site observations
10203197	7/17/13	Mitkof Highway	Unnamed	56.60811	-132.78755	Red	5	Culvert gradient red, Outfall height red, Culvert is poorly aligned
10203206	7/12/13	Mitkof Highway	Unnamed	56.54048	-132.69214	Red	4	Culvert gradient red, Outfall height red, Constriction ratio red, Culvert is poorly aligned
10203214	6/26/13	Mitkof Highway	Unnamed	56.5666	-132.59697	Red	3	Constriction ratio red, Culvert gradient red, Outfall height red
10203215	7/14/13	Mitkof Highway	Unnamed	56.58895	-132.74547	Gray	4	Culvert is poorly aligned
10203216	6/27/13	Mitkof Highway	Unnamed	56.56718	-132.58672	Black		None recorded
10203217	6/26/13	Mitkof Highway	Unnamed	56.57013	-132.57877	Gray	1	Culvert gradient red, Constriction ratio red, Inlet perch, Sediment accumulation
10203218	7/16/13	Mitkof Highway	Blind River tributary	56.59997	-132.7699	Gray	4	Inlet perch, Culvert is poorly aligned, Outfall height gray
10203219	7/16/13	Mitkof Highway	Blind River tributary	56.59969	-132.76933	Gray	4	Culvert is poorly aligned, Culvert gradient red, Outfall height gray
10203220	7/18/13	Mitkof Highway	Blind Slough tributary	56.6156	-132.82146	Red	1	Culvert gradient red, Culvert is poorly aligned
10203221	7/14/13	Mitkof Highway	Unnamed	56.57216	-132.73724	Gray	4	Baffles
10203222	7/14/13	Mitkof Highway	Unnamed	56.59005	-132.74622	Green	3	Culvert gradient gray, Constriction ratio red, Culvert is poorly aligned
10203223	7/18/13	Mitkof Highway	Blind Slough tributary	56.6154	-132.82007	Red	3	Outfall height gray, Culvert gradient red, Culvert is poorly aligned
10203224	7/18/13	Mitkof Highway	Blind Slough tributary	56.61509	-132.81851	Red	3	Culvert gradient red, Inlet perch

-continued-

Site ID	Assessment date	Road name	Stream name	Latitude	Longitude	Site rating	Site condition rating	Site observations
10203225	7/18/13	Mitkof Highway	Blind River tributary	56.61433	-132.81459	Red	3	Outfall height red, Culvert gradient red, Culvert is poorly aligned, Constriction ratio gray, Sediment accumulation, Woody Debris
10203246	7/12/13	Mitkof Highway	Green Creek	56.5393	-132.69919	Green	4	None of this type
10203271	6/12/14	Mitkof Highway	Unnamed	56.66192	-132.90701	Gray	3	Inlet perch, Constriction ratio gray
10203272	6/10/14	Mitkof Highway	Fur Farm Creek	56.70911	-132.93669	Red	4	Inlet perch, Culvert gradient red, Outfall height red, Constriction ratio red
10203275	6/8/14	Mitkof Highway	Unnamed	56.62404	-132.85596	Red	3	Structural Problem, Outfall height red, Culvert gradient red
10203276	6/8/14	Mitkof Highway	Unnamed	56.6258	-132.86038	Red	3	Structural Problem, Outfall height red, Constriction ratio gray, Culvert gradient red
10203282	6/12/14	Mitkof Highway	Big Gulch	56.64518	-132.89362	Gray	4	Constriction ratio gray, Culvert gradient gray, Inlet perch
10203284	6/12/14	Mitkof Highway	Unnamed	56.65371	-132.90077	Red	3	Culvert gradient red, Outfall height gray
10203290	6/11/14	Mitkof Highway	Unnamed	56.63593	-132.88605	Red	2	Culvert gradient red, Hydraulic flows exceeded capacity
10203292	6/21/14	Mitkof Highway	Unnamed	56.77261	-132.96216	Red	1	Inlet perch, Compound gradient in pipe, Mechanical damage or joints parting, Culvert gradient red, Outfall height red, Constriction ratio red
10203294	6/21/14	Mitkof Highway	Unnamed	56.72222	-132.92947	Red	2	Mechanical damage or joints parting, Constriction ratio gray, Outfall height red, Culvert gradient gray
10203295	6/21/14	Mitkof Highway	Taain Creek	56.74299	-132.94048	Red	2	Structural Problem, Outfall height red, Culvert is too short, Inlet perch, Constriction ratio red, Culvert gradient red

-continued-

Site ID	Assessment date	Road name	Stream name	Latitude	Longitude	Site rating	Site condition rating	Site observations
10203298	6/19/14	Mitkof Highway	Unnamed	56.6969	-132.93312	Red	2	Inlet perch, Mechanical damage or joints parting, Culvert is poorly aligned, Outfall height red, Culvert gradient red
10203299	6/19/14	Mitkof Highway	Unnamed	56.67491	-132.91678	Red	3	Mechanical damage or joints parting, Culvert gradient red
10203300	6/19/14	Mitkof Highway	Unnamed	56.6956	-132.93362	Red	4	Inlet perch, Outfall height red, Culvert gradient red, Constriction ratio gray
10203301	6/19/14	Mitkof Highway	Letti Creek	56.668	-132.90884	Red	2	Inlet perch, Mechanical damage or joints parting, Outfall height red, Constriction ratio gray, Culvert gradient red
10203302	6/7/14	Mitkof Highway	Blowdown Creek	56.6203	-132.84523	Red	3	Constriction ratio red, Culvert gradient red, Outfall height red
10203303	6/7/14	Mitkof Highway	Mabel Creek	56.62175	-132.8492	Red	2	Mechanical damage or joints parting, Culvert is poorly aligned, Constriction ratio red, Culvert gradient gray
10203304	6/7/14	Mitkof Highway	Unnamed	56.62249	-132.85207	Red	4	Culvert sagging in middle, Culvert is poorly aligned, Constriction ratio red, Culvert gradient red, Outfall height red
10203305	6/8/14	Mitkof Highway	Unnamed	56.62323	-132.85347	Red	4	Culvert is poorly aligned, Constriction ratio gray, Culvert gradient red
10203307	6/8/14	Mitkof Highway	Baxter Creek	56.62505	-132.85799	Red	4	Outfall height red, Inlet perch, Constriction ratio red, Culvert gradient red
10203308	6/22/14	Mitkof Highway	Unnamed	56.77882	-132.96518	Gray	3	Culvert gradient red, Constriction ratio gray
10203313	6/9/14	Mitkof Highway	Unnamed	56.62752	-132.86844	Gray	3	Constriction ratio gray, Hydraulic flows exceeded capacity
10203314	6/9/14	Mitkof Highway	Unnamed	56.62674	-132.86449	Red	2	Culvert gradient red, Constriction ratio red

-continued-

Site ID	Assessment date	Road name	Stream name	Latitude	Longitude	Site rating	Site condition rating	Site observations
10203316	6/9/14	Mitkof Highway	Unnamed	56.62967	-132.87746	Red	3	Constriction ratio gray, Culvert gradient red
10203317	6/9/14	Mitkof Highway	DelMar Creek	56.63248	-132.88257	Red	4	Constriction ratio gray, Culvert gradient red
10203319	6/20/14	Mitkof Highway	Unnamed	56.69903	-132.93388	Red	3	Outfall height red, Culvert gradient red, Constriction ratio gray
10203321	6/20/14	Mitkof Highway	Unnamed	56.70345	-132.93434	Red	2	Constriction ratio gray, Debris Flow, Culvert gradient red, Outfall height gray, Inlet perch
10203322	6/20/14	Mitkof Highway	Unnamed	56.71804	-132.9299	Red	2	Outfall height red, Compound gradient in pipe, Culvert gradient red, Constriction ratio gray
10203324	6/20/14	Mitkof Highway	Unnamed	56.71698	-132.93083	Red	3	Outfall height red, Hydraulic flows exceeded capacity
10203325	6/11/14	Mitkof Highway	Unnamed	56.64337	-132.89209	Red	1	Culvert gradient red
10203329	6/22/14	Mitkof Highway	Unnamed	56.77768	-132.96481	Gray	3	Culvert gradient red, Hydraulic flows exceeded capacity, Constriction ratio gray
10203144	6/13/13	Mitkof Highway - Pullout	Unnamed	56.80738	-132.96536	Red	1	Culvert gradient red, Structural Problem
10203283	6/12/14	Mitkof Hwy	Luna Creek	56.66085	-132.90625	Red	1	Culvert is poorly aligned, Beaver Activity, Mechanical damage or joints parting, Outfall height red, Culvert gradient red, Beaver Activity
10203331	6/19/14	Mitkof Hwy	Unnamed	56.6976	-132.93292	Red	3	Mechanical damage or joints parting, Culvert is poorly aligned, Inlet perch, Constriction ratio red, Culvert gradient red, Outfall height red
10203168	6/10/13	Nordic Avenue	Unnamed	56.81748	-132.9539	Gray	2	Culvert gradient red, Outfall height red

-continued-

Appendix B1.–Page 8 of 9.

Site ID	Assessment date	Road name	Stream name	Latitude	Longitude	Site rating	Site condition rating	Site observations
10203173	6/9/13	Noseeum Road	Milk Creek	56.80561	-132.95923	Red	3	Culvert gradient red, Constriction ratio red, Structural Problem, Hydraulic flows exceeded capacity
10203179	6/8/13	Noseeum Road	Milk Creek tributary	56.80562	-132.9606	Red	3	Outfall height red, Hydraulic flows exceeded capacity, Culvert is poorly aligned, Woody Debris, Constriction ratio gray, Culvert gradient gray
10203180	6/8/13	Noseeum Road	Milk Creek tributary	56.80555	-132.96045	Red	3	Outfall height red, Culvert gradient red, Constriction ratio gray, Mechanical damage or joints parting, Hydraulic flows exceeded capacity
10203320	6/20/14	Private Drive	Unnamed	56.71662	-132.93088	Red	1	Compound gradient in pipe, Mechanical damage or joints parting, Constriction ratio gray, Outfall height red
10203297	6/19/14	Private Driveway	Unnamed	56.6968	-132.9337	Gray	3	Compound gradient in pipe
10203323	6/20/14	Private Driveway	Unnamed	56.71683	-132.9305	Red	1	Outfall height gray, Culvert gradient red, Constriction ratio gray
10203166	6/10/13	Sandy Beach Park Access Road	Unnamed	56.80403	-132.9192	Red	3	Culvert is poorly aligned, Culvert gradient red, Outfall height gray, Structural Problem, Culvert sagging in middle
10203152	6/12/13	Sandy Beach Road	Unnamed	56.81276	-132.92336	Red	4	Constriction ratio red, Culvert gradient red, Inlet perch
10203159	6/11/13	Sandy Beach Road	Unnamed	56.80466	-132.92059	Red	2	Constriction ratio gray, Culvert gradient red, Structural Problem, Mechanical damage or joints parting, Compound gradient in pipe
10203163	6/11/13	Sandy Beach Road	Unnamed	56.80582	-132.92062	Red	3	Culvert is poorly aligned, Culvert gradient gray, Constriction ratio red

-continued-

Site ID	Assessment date	Road name	Stream name	Latitude	Longitude	Site rating	Site condition rating	Site observations
10203171	6/10/13	Sandy Beach Road	Unnamed	56.80348	-132.91846	Red	3	Culvert gradient red, Outfall height red, Constriction ratio gray, Structural Problem, Mechanical damage or joints parting, Culvert sagging in middle
10203306	6/22/14	Scow Bay Waterline Access Road	Unnamed	56.79912	-132.92398	Red	3	Culvert gradient red, Culvert is poorly aligned
10203326	6/22/14	Scow Bay Waterline Access Road	Unnamed	56.7946	-132.91713	Gray	3	Culvert gradient gray
10203181	6/12/13	South Nordic Drive	Unnamed	56.80936	-132.96074	Gray	4	Constriction ratio gray
10203178	6/9/13	Wrangell Avenue	McCabe Creek	56.81698	-132.95239	Gray	3	Constriction ratio gray, Culvert gradient red

Appendix B2.–Site list, by road, for all sites assessed on the Ketchikan road system.

Site ID	Assessment date	Road name	Stream name	Latitude	Longitude	Site rating	Site condition rating	Site observations
10103240	8/23/13	Abandoned Road Grade	Hoadly Creek tributary	55.35894	-131.68048	Red	3	Culvert gradient red, Outfall height red
10103147	8/26/13	Abandoned Road Pullout	Unnamed	55.38073	-131.73216	Red	2	Outfall height red, Inlet perch
10103241	8/22/13	Baranof Avenue	Hoadly Creek	55.35614	-131.68503	Red	3	Hydraulic flows exceeded capacity, Constriction ratio red, Outfall height red, Culvert gradient red, Culvert is poorly aligned
10103211	8/15/13	D1 Loop Road	Unnamed	55.42751	-131.77983	Red	4	Inlet perch, Constriction ratio gray, Culvert gradient red, Outfall height red
10103244	8/15/13	D1 Loop Road	Unnamed Creek	55.42654	-131.77635	Red	3	Outfall height red, Culvert gradient red, Constriction ratio red, Inlet perch
10103212	8/15/13	D2 Loop Road	Unnamed	55.42539	-131.77788	Red	4	Culvert is poorly aligned, Inlet perch, Constriction ratio red, Outfall height red, Culvert gradient red
10103140	8/14/13	Driveway off North Tongass Hwy	Unnamed	55.41633	-131.75923	Red	2	Outfall height red
10103198	8/10/13	Driveway off Schoenbar Road	Schoenbar Creek tributary	55.34668	-131.63907	Green	3	Road Fill (pushed off road by grader)
10103200	8/10/13	Driveway off Schoenbar Road	Schoenbar Creek	55.34566	-131.63733	Green	3	None of this type

-continued-

Site ID	Assessment date	Road name	Stream name	Latitude	Longitude	Site rating	Site condition rating	Site observations
10103245	8/23/13	Driveway off Shoreline Drive	Unnamed	55.38025	-131.73221	Black	1	None recorded
10103207	8/11/13	Franklin Drive	Forks Creek	55.30079	-131.5293	Green	4	None of this type
10103143	8/25/13	Gravina Island Highway	Unnamed	55.34112	-131.6953	Red	3	Compound gradient in pipe, Culvert is poorly aligned, Culvert gradient red, Outfall height gray
10103151	8/25/13	Gravina Island Highway	Unnamed	55.33678	-131.68744	Red	4	Culvert gradient red
10103153	8/25/13	Gravina Island Highway	Unnamed	55.32507	-131.68311	Gray	4	Culvert is poorly aligned
10103154	8/25/13	Gravina Island Highway	Clam Creek	55.3167	-131.66263	Green	4	Road Fill (pushed off road by grader)
10103157	8/24/13	Gravina Island Highway	Unnamed	55.3215	-131.67636	Green	4	None of this type
10103158	8/24/13	Gravina Island Highway	Unnamed	55.31448	-131.65562	Green	4	Culvert is poorly aligned
10103160	8/24/13	Gravina Island Highway	Stensland Creek	55.31948	-131.67032	Green	4	None of this type
10103233	8/12/13	Gravina Island Highway	Unnamed	55.35582	-131.72665	Green	4	Culvert is poorly aligned

-continued-

Site ID	Assessment date	Road name	Stream name	Latitude	Longitude	Site rating	Site condition rating	Site observations
10103235	8/12/13	Gravina Island Highway	Unnamed	55.34521	-131.70827	Green	4	None of this type
10103243	8/22/13	Hospital Parking Lot	Hoadly Creek	55.35395	-131.68748	Red	3	Culvert gradient red, Constriction ratio gray, Compound gradient in pipe
10103242	8/22/13	Jackson Street	Hoadly Creek	55.35874	-131.68053	Red	3	Inlet perch, Outfall height red, Constriction ratio red, Culvert gradient red, Hydraulic flows exceeded capacity
10103149	8/25/13	Lewis Reef Road	Unnamed	55.34653	-131.70021	Gray	4	Culvert gradient gray, Constriction ratio gray
10103213	8/15/13	North Point Higgins Road	Unnamed	55.47158	-131.81349	Gray	3	Inlet perch, Constriction ratio gray, Structural Problem, Culvert gradient gray
10103141	8/14/13	North Tongass Highway	Unnamed	55.41648	-131.76047	Gray	3	None of this type
10103146	8/26/13	North Tongass Highway	Unnamed	55.38063	-131.73233	Red	3	Culvert gradient red, Outfall height red
10103162	8/23/13	North Tongass Highway	Unnamed	55.37706	-131.72672	Red	1	Structural Problem, Mechanical damage or joints parting, Road bank erosion, Constriction ratio red, Outfall height red, Culvert gradient red
10103164	8/23/13	North Tongass Highway	Unnamed	55.37713	-131.72685	Red	3	Outfall height red, Culvert gradient red, Constriction ratio red, Inlet perch, Hydraulic flows exceeded capacity

-continued-

Appendix B2.–Page 4 of 6.

Site ID	Assessment date	Road name	Stream name	Latitude	Longitude	Site rating	Site condition rating	Site observations
10103205	8/9/13	North Tongass Highway	Unnamed	55.47467	-131.78412	Red	2	Inlet perch, Hydraulic flows exceeded capacity, Structural Problem, Outfall height red, Culvert gradient red
10103209	8/13/13	North Tongass Highway	Unnamed	55.41577	-131.76076	Gray	4	Culvert gradient red, tidal, baffles
10103210	8/15/13	North Tongass Highway	Unnamed	55.42588	-131.78075	Gray	4	Culvert is poorly aligned, Culvert gradient red, Constriction ratio gray
10103229	8/14/13	North Tongass Highway	Trollers Creek	55.4679	-131.79893	Red	2	Culvert gradient red, Outfall height red, Constriction ratio gray, Hydraulic flows exceeded capacity
10103230	8/13/13	North Tongass Highway	1st Waterfall Creek	55.47238	-131.78827	Red	3	Outfall height red, Constriction ratio gray, Culvert gradient red
10103228	8/10/13	Parking Lot	Schoenbar Creek tributary	55.34677	-131.63986	Black	4	None recorded
10103201	8/8/13	Revella Road	Ward Creek Tributary	55.41509	-131.70854	Green	4	None of this type
10103204	8/9/13	Revella Road	Unnamed	55.41357	-131.71593	Red	4	Culvert gradient red, Outfall height red
10103226	8/9/13	Revilla Road	Unnamed Creek	55.41073	-131.71953	Gray	4	Culvert gradient gray
10103227	8/10/13	Scheonbar Road	Scheonbar Creek	55.34493	-131.63661	Gray	1	Culvert gradient gray, Mechanical damage or joints parting, Structural Problem

-continued-

Appendix B2.–Page 5 of 6.

Site ID	Assessment date	Road name	Stream name	Latitude	Longitude	Site rating	Site condition rating	Site observations
10103199	8/10/13	Schoenbar Road	Schoenbar Creek	55.34633	-131.6382	Gray	3	Culvert gradient gray, Hydraulic flows exceeded capacity, Constriction ratio gray
10103238	8/23/13	Shoreline Drive	Unnamed	55.37668	-131.7282	Red	1	Outfall height red, Culvert gradient red, Structural Problem, Culvert is poorly aligned, Inlet perch
10103239	8/23/13	Shoreline Drive	Unnamed	55.38009	-131.73239	Red	4	Outfall height red, Culvert is poorly aligned
10103145	8/26/13	South Tongass Highway	Unnamed	55.32381	-131.60991	Gray	1	Culvert gradient red, Culvert is poorly aligned, Structural Problem
10103208	8/11/13	South Tongass Highway	Unnamed	55.3166	-131.59236	Red	2	Outfall height red, Structural Problem, Constriction ratio gray, Culvert gradient red
10103231	8/13/13	South Tongass Highway	Adams Creek	55.31057	-131.58199	Gray	4	None of this type
10103236	8/11/13	South Tongass Highway	Homestead Creek	55.30693	-131.56718	Gray	4	Baffles, Tidal
10103232	8/12/13	Unnamed	Unnamed	55.35178	-131.73244	Red	3	Outfall height red
10103234	8/12/13	Unnamed	Unnamed	55.33895	-131.74423	Gray	4	Culvert is poorly aligned
10103165	8/11/13	Ward Lake Road	Unnamed	55.43204	-131.68687	Red	4	Outfall height red, Culvert gradient gray
10103167	8/1/13	Ward Lake Road	Unnamed	55.43945	-131.67738	Red	1	Inlet perch, Mechanical damage or joints parting, Culvert gradient red, Outfall height red

-continued-

Appendix B2.–Page 6 of 6.

Site ID	Assessment date	Road name	Stream name	Latitude	Longitude	Site rating	Site condition rating	Site observations
10103169	7/31/13	Ward Lake Road	Ward Creek tributary	55.4564	-131.65866	Red	3	Constriction ratio gray, Outfall height red, Culvert gradient red, Debris Flow
10103170	7/31/13	Ward Lake Road	Unnamed	55.46792	-131.62686	Red	2	Outfall height red, Culvert gradient red, Constriction ratio gray
10103172	7/31/13	Ward Lake Road	Ward Creek	55.46687	-131.63461	Red	2	Outfall height red, Culvert gradient red, Woody Debris, Debris Flow, Inlet perch, Road bank erosion
10103174	7/30/13	Ward Lake Road	Unnamed Tributary to Talbot Lake	55.46465	-131.62546	Red	4	Inlet perch, Constriction ratio gray, Culvert gradient red, Outfall height red
10103175	7/30/13	Ward Lake Road	Unnamed	55.46745	-131.62553	Red	3	Inlet perch, Outfall height red, Road bank erosion, Woody Debris, Culvert gradient red
10103202	8/8/13	Ward Lake Road	Ward Creek tributary	55.42355	-131.69395	Gray	3	None of this type
10103203	8/8/13	Ward Lake Road	Unnamed	55.42918	-131.68996	Green	3	Mechanical damage or joints parting
10103237	8/11/13	Wood Road	Unnamed Tributary to Herring Cove Creek	55.32568	-131.53001	Red	1	Culvert gradient red, Outfall height red, Compound gradient in pipe, Structural Problem, Mechanical damage or joints parting

Appendix B3.–Site list, by road, for sites assessed on the Wrangell road system.

Site ID	Assessment date	Road name	Stream name	Latitude	Longitude	Site rating	Site condition rating	Site observations
10203504	7/20/16	Access road off Zimovia Hwy	Unnamed	56.39694	-132.33546	Green	3	Beaver Activity
10203496	7/24/16	Driveway off Zimovia Highway	Unnamed Stream	56.43082	-132.3661	Red	3	Culvert gradient red
10203497	7/25/16	Old Road Grade	Unnamed	56.4343	-132.37012	Red	3	Outfall height red
10203310	6/24/14	Park Road	Playground Creek	56.45393	-132.38319	Gray	3	Compound gradient in pipe, Subsidence, Culvert gradient red
10203280	6/25/14	Private Drive	Unnamed	56.31893	-132.34435	Black	3	Culvert is poorly aligned
10203285	7/3/14	Private Drive	Unnamed	56.33338	-132.34019	Red	3	Outfall height red, Mechanical damage or joints parting, Shallow fill; inadequate roadfill volume above culvert
10203498	7/21/16	Shoemaker Bay Loop	Unnamed	56.40423	-132.338	Red	3	Outfall height red, Culvert gradient red, Hydraulic flows exceeded capacity
10203499	7/21/16	Shoemaker Bay Loop	Unnamed	56.40706	-132.34116	Gray	1	Constriction ratio gray, Compound gradient in pipe
10203500	7/22/16	Shoemaker Bay Loop	Unnamed	56.4106	-132.34071	Red	3	Culvert gradient red, Outfall height gray, Constriction ratio gray
10203293	6/24/14	Stikine/Evergreen Ave	Unnamed	56.48212	-132.39136	Red	3	Inlet perch, Culvert gradient red
10203277	6/24/14	Zimovia Highway	Unnamed	56.31617	-132.34428	Red	4	Culvert is poorly aligned, Constriction ratio gray, Outfall height red, Culvert gradient red
10203278	6/24/14	Zimovia Highway	Unnamed	56.31765	-132.34404	Red	3	Culvert gradient red, Outfall height red, Constriction ratio gray

-continued-

Appendix B3.–Page 2 of 4.

Site ID	Assessment date	Road name	Stream name	Latitude	Longitude	Site rating	Site condition rating	Site observations
10203279	6/24/14	Zimovia Highway	Unnamed	56.34214	-132.33882	Red	4	Inlet perch, Culvert gradient red
10203281	6/25/14	Zimovia Highway	Unnamed	56.31826	-132.34402	Red	3	Culvert gradient red, Outfall height red
10203287	7/3/14	Zimovia Highway	Unnamed	56.33501	-132.34026	Red	3	Compound gradient in pipe, Inlet perch, Culvert gradient red, Outfall height red
10203288	7/3/14	Zimovia Highway	Unnamed`	56.33732	-132.33937	Red	3	Constriction ratio red, Hydraulic flows exceeded capacity, Outfall height red, Culvert gradient red
10203289	7/3/14	Zimovia Highway	Unnamed	56.33336	-132.34074	Red	4	Outfall height red, Culvert gradient red, Road bank erosion
10203312	6/24/14	Zimovia Highway	Playground Creek	56.45272	-132.38182	Red	3	Culvert is poorly aligned, Inlet perch, Outfall height red, Culvert gradient red, Constriction ratio gray
10203315	7/3/14	Zimovia Highway	Unnamed	56.41335	-132.34064	Gray	3	Inlet perch, Mechanical damage or joints parting, Outfall height red, Culvert gradient red
10203327	6/25/14	Zimovia Highway	Unnamed	56.31893	-132.34395	Red	3	Outfall height red, Culvert gradient red
10203328	6/25/14	Zimovia Highway	Unnamed	56.31805	-132.34396	Red	3	Culvert gradient gray, Outfall height red
10203330	6/25/14	Zimovia Highway	Unnamed	56.32277	-132.34364	Red	3	Outfall height red, Culvert gradient red, Constriction ratio gray, Hydraulic flows exceeded capacity, Structural Problem
10203332	6/26/14	Zimovia Highway	Unnamed	56.32556	-132.34337	Red	4	Outfall height red, Culvert gradient red
10203333	6/26/14	Zimovia Highway	Unnamed	56.32938	-132.34195	Red	4	Outfall height red, Culvert gradient red

-continued-

Appendix B3.–Page 3 of 4.

Site ID	Assessment date	Road name	Stream name	Latitude	Longitude	Site rating	Site condition rating	Site observations
10203334	6/26/14	Zimovia Highway	Unnamed	56.32904	-132.34201	Red	4	Other, including vibrations, cavitation, etc., Constriction ratio gray, Culvert gradient red, Compound gradient in pipe, Outfall height gray
10203335	6/25/14	Zimovia Highway	Unnamed	56.32475	-132.34314	Red	3	Hydraulic flows exceeded capacity, Outfall height red, Constriction ratio gray, Culvert gradient red
10203501	7/19/16	Zimovia Highway	Unnamed	56.38725	-132.3526	Red	3	Compound gradient in pipe, Culvert gradient red, Outfall height red
10203502	7/16/16	Zimovia Highway	Unnamed	56.39398	-132.34024	Red	3	Constriction ratio red, Culvert gradient red, Hydraulic flows exceeded capacity
10203503	7/20/16	Zimovia Highway	Unnamed	56.39717	-132.33574	Red	2	Culvert gradient red, Debris Flow, Beaver Activity, Hydraulic flows exceeded capacity
10203505	7/21/16	Zimovia Highway	Unnamed	56.40149	-132.33617	Black	3	None recorded
10203506	7/21/16	Zimovia Highway	Unnamed	56.40466	-132.33691	Red	3	Outfall height red, Culvert gradient gray, Debris Flow, Hydraulic flows exceeded capacity
10203507	7/22/16	Zimovia Highway	Unnamed	56.40731	-132.33766	Red	3	Culvert gradient red, Outfall height red, Constriction ratio red
10203508	7/22/16	Zimovia Highway	Unnamed	56.4105	-132.33902	Red	3	Culvert gradient red, Outfall height red, Road bank erosion
10203509	7/24/16	Zimovia Highway	Unnamed	56.42048	-132.35419	Red	3	Culvert gradient red

-continued-

Appendix B3.–Page 4 of 4.

Site ID	Assessment date	Road name	Stream name	Latitude	Longitude	Site rating	Site condition rating	Site observations
10203510	7/24/16	Zimovia Highway	Unnamed	56.43083	-132.36656	Gray	3	Outfall height red
10203511	7/24/16	Zimovia Highway	Unnamed	56.43117	-132.36664	Gray	4	Outfall height red, Culvert gradient red
10203512	7/25/16	Zimovia Highway	Unnamed	56.42075	-132.3553	Red	3	Outfall height red, Culvert gradient red, Constriction ratio gray, Inlet perch
10203513	7/25/16	Zimovia Highway	Unnamed	56.43418	-132.37039	Red	3	Outfall height red, Culvert gradient red

APPENDIX C: GLOSSARY

Anadromous Waters Catalog: The *Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes* specifies which Alaskan streams, rivers, and lakes are important to anadromous fish species and therefore afforded protection under AS 16.05.871. Water bodies that are not "specified" within the Catalog are not afforded that protection. To be protected under AS 16.05.871, water bodies must be documented as supporting some life function of an anadromous fish species (salmon, trout, char, whitefish, sturgeon, etc.)

Approach angle: The angle at which the stream flows into the culvert inlet.

Apron: A length of non-erosive material designed to prevent scour holes developing at the outlet ends of culverts, outlet pipes, grade stabilization structures, and other water control devices.

Arch culvert: Corrugated steel pipe formed in an arch shape that spans the stream and sits on footers of concrete, bedrock, or wood (e.g., a bottomless arch culvert is built across the natural stream bed).

Azimuth: A horizontal angle measured clockwise from any fixed reference plane or easily established base direction line.

Bankfull flow: A condition where flow completely fills the stream channel to the top of the bank but does not spill over into the floodplain.

Baffle: Structures, usually metal plates, installed inside a culvert to deflect and/or slow the flow of water to aid upstream fish passage.

Bedload: Sediment moving on or near the streambed and frequently in contact with it.

Benchmark: A marked point of known elevation from which other elevations may be established.

Box culvert: An enclosed culvert, mainly rectangular in cross-section, typically made of corrugated steel or aluminum, but wood or concrete box culverts are also found.

Channel: A natural or artificial waterway of perceptible extent that periodically or continuously contains moving water and has a definite bed and banks, which serve to confine the water.

Channelization: Straightening of a stream or dredging a new channel to which the stream is diverted.

Culvert: A closed conduit used for the passage of surface water under or through a road or other embankment.

Diameter: Inside diameter, measured between inside crests of corrugations.

Drainage area: Total land area draining to any point in a stream, as measured on a map, aerial photograph, or other horizontal plane. Also called catchment area, watershed, or basin.

Embedded culvert: Any culvert that has substrate throughout its length, typically with an invert lower than the streambed elevation. Embedded culverts include geomorphic, stream simulation, and other types of embedment design methodologies or design standards to meet fish passage criteria.

-continued-

Fish migration: The movement of individual fish and/or fish populations for any purpose, including feeding, spawning, etc.

Flood: Any flow that exceeds the bankfull capacity of a stream or channel and flows out on the floodplain, and is greater than bankfull discharge.

Floodplain: Any flat, or nearly flat lowland that borders a stream and is covered by its waters at flood stage. Land immediately adjoining a stream which is inundated when the discharge exceeds the conveyance of the normal channel. The channel proper and the areas adjoining the channel which have been or hereafter may be covered by the regulatory or 100-year flood. Any normally dry land area that is susceptible to being inundated by water from any natural source.

Ford: A road crossing a stream where a hard causeway is provided or naturally occurs in the bed of the stream.

Fry: Juvenile salmon and trout in their first few months of life.

Gabion: A patented woven or welded wire basket filled with rocks of such a size that they do not pass through the openings in the basket. Individual baskets are stacked in place like building blocks and filled with rock to form erosion resistant structures.

Glide: A stream facet feature that is commonly indicated by smooth, relatively fast, flowing water and is the transition zone of a pool to a riffle as water moves downstream. Stretch of stream that typically separates pools from riffles. The stream bed of a glide has an adverse slope.

Gradient (slope): The rate of rise or fall of a slope expressed as a percentage or ratio as determined by a change in elevation to the length.

Head of riffle: The upstream end of a riffle and downstream end of a glide.

Headwall: A retaining wall located at either the inlet or outlet of a culvert.

Headwater: The height of water at the inlet of a culvert.

Headwater elevation: The water surface elevation upstream from a culvert entrance invert, typically measured relative to the benchmark.

Hydraulic Capacity: The effective carrying ability of a drainage structure. Measured as volume per time.

Hydraulic Unit Code (HUC): A geographic area representing part of all or a surface drainage basin, a combination of drainage basins, or a distinct hydrologic feature.

Inlet: The point where water enters a culvert.

Invert: The lowest internal point of any cross section in a culvert.

Level 1 culvert assessment: Rapid assessments based on physical measurements of the culvert and stream channel and focus on juvenile salmonid fish passage. The culvert is assessed for type, slope, outfall height, constriction, and other physical parameters and then classified as green, gray, or red using a decision matrix.

-continued-

Longitudinal profile: A survey taken down the length of a stream that is used to illustrate the gradient and other features of that stream.

Ordinary high water (OHW): This is the line between upland and bottomland that persists through successive changes in water levels, below which the presence of water is so common or recurrent, that the character of the soil and vegetation is markedly different from the upland.

Outfall height: The difference between the culvert outlet water surface and the tail water surface when a perch exists at a culvert's outlet.

Outfall types: The conditions that exist at the outlet of a culvert as water exits.

Outlet: Point on the culvert at which water exits the structure after passing through a structure.

Perch: The development of a fall or cascade at a culvert outlet due to the erosion of the stream channel downstream from a culvert barrel, bridge, apron, or ford.

Pipe arch: A corrugated metal pipe that is shaped so that it is wider than it is tall, with the widest part being located near the bottom of the culvert.

Pool: A deeper stream feature characterized by still or slow-moving water and a smooth surface. Pools can typically be 2–3 times the depth of a riffle.

Resident fish: Fish that spend their entire life cycle in freshwater. In Alaska, resident fish include landlocked anadromous fish (e.g., kokanee and coho), as well as traditionally defined resident fish species such as Arctic grayling or rainbow trout.

Riffle: A stream feature characterized by shallow, fast-moving water broken by the presence of rocks and boulders. Typically, the steepest part of a stream.

Rise: The maximum vertical height inside a culvert, usually measured at the centerline.

Roughness: A measure of the friction exerted on the moving water by the channel bed and banks as well as other elements such as vegetation and woody debris.

Run: A stream feature characterized by fast moving water that is not broken by the presence of rocks or boulders and is the transition zone of a riffle to a pool. Deeper than a riffle, a run will often have a well-defined thalweg.

Rust line: A well-defined line separating rusted and unrusted metal inside the barrel of a metal culvert that marks the extent of ordinary high water.

Salmonid: Fish belonging to the family Salmonidae, such as salmon and trout.

Scour: Channel degradation, typically at the culvert outlet resulting from erosive velocities.

Skew: The angle formed by the intersection of the line normal to the centerline of the road with the centerline of a culvert.

Snout-fork measurement: The length from the tip of the snout to the end of the middle caudal fin rays. Also known as fork length.

Soak time: The amount of time a baited trap is left in the water to capture fish.

-continued-

Streamflow: The rate at which water passes a given point in a stream, usually expressed in cubic feet per second (ft^3/s).

Stream gradient: The overall gradient of the stream through a reach.

Stream stage: The water level above some arbitrary point in the river.

Structural multi-plate: Multi-plate or structural plate culverts assembled on a treated timber or concrete foundation. Because of their size (normally in excess of 2 m in diameter) and the fact they are placed on a foundation, they are normally assembled on site. A series of interlocking steel plates are bolted together to make the required shape and length.

Substrate: Bed material in a stream channel or culvert.

Tailwater control (tailcrest): a geomorphic feature that controls the elevation of the tailwater, which is the water immediately downstream of the culvert.

Tailwater depth: The depth of water immediately downstream from a culvert, measured from the culvert outlet invert.

Tailwater elevation: The water surface elevation at the downstream side of a hydraulic structure (i.e., culvert, bridge).

Thalweg: The deepest continuous channel in a stream, generally marking the line of fastest flow.

Trash rack: A structural device used to prevent debris from entering a culvert or other hydraulic structure.

Water surface profile: A profile plot of water surface elevation through a culvert or open channel.

Watershed: An area of land that drains all the streams and rainfall to a common outlet such as the outflow of a reservoir, mouth of a bay, or any point along a stream channel. .

Weir: A small dam in a stream that causes water to back up behind it, and flow over or through it. (a) A notch or depression in a levee, dam, embankment, or other barrier across or bordering a stream, through which the flow of water is measured or regulated. (b) A barrier constructed across a stream to divert fish into a trap. (c) A dam (usually small) in a stream to raise the water level or divert its flow.

Wingwall: The retaining wall that provides a transition from the culvert headwall to the channel.