<u>Attachment C</u> Instream Water Right Analysis Process

I. Introduction

The Alaska National Interest Lands Conservation Act (ANILCA) P.L. 96-487 and the National Wildlife Refuge System Improvement Act of 1997 (NWRSIA) P.L. 105-57 state that one of the purposes of National Wildlife Refuges in Alaska is to maintain adequate water quantity and water quality to conserve fish and wildlife and their habitats. Biological information and surface data, such as streamflow, limnologic data, and water quality data are scarce in Alaska. Biological data are generally limited to species presence/absence and general population numbers. Species specific habitat data are generally not documented. Plant species critical to winter habitats for terrestrial species are not clearly understood. Thus, species specific instream flow methods, such as the Instream Flow Incremental Method, that evaluate fish and wildlife habitat needs are not feasible under present hydrologic, biologic and funding limitations.

Region 7 of the U.S. Fish and Wildlife Service has developed a hydrologic-based instream flow method that is based on the natural flow pattern from which aquatic and riparian habitats have evolved. The objective of this method is to maintain a flow pattern with a wide range of flows, both high and low, to meet riparian and aquatic habitat needs and to maintain the different habitat features of the river system. This method analyzes the natural flow pattern and its annual variability, and provides recommendations for instream flow requirements that conform to western water law, specifically Alaska water law.

II. Hydrologic-Based Instream Flow Method

Alaska is extremely large with relatively few miles of road, presenting both logistical and financial challenges for ecological data collection. As a result, the distribution, detailed habitat requirements, and seasonal use patterns of many fish and wildlife species are largely undocumented. For example, we may know what species of salmon inhabit a given rivers system. However, where they spawn, rear, and over-winter is often unknown. Similarly, the location of critical riparian habitat for over-wintering of moose and other wildlife is not well known. Thus a new approach for quantifying instream water rights is necessary to maintain healthy habitats and populations of the fish and wildlife that make the State of Alaska unique. This hydrologic-based instream flow method mimics the natural flow regime as represented by the average annual hydrograph (Poff et al. 1997).

The intent of the hydrologic-based instream flow method is to protect natural habitats and preserve fish and wildlife diversity through maintenance of natural flow variability, while providing water for other users. With the special considerations described on page 6, the method is applicable statewide; protects natural resources; uses limited hydrologic and biologic data; conforms to Alaska State water law; and is affordable in time and dollars. The hydrologic-based instream flow method is based upon the following premises:

- Habitats in and adjacent to the river channel have evolved from the diversity of flows represented by the average annual hydrograph. The average annual hydrograph represents a predictable pattern of high and low flows that normally occur throughout the year.
- Rivers are not regulated, and natural high and low flows are expected to occur each year.

- For the purpose of a water right, five years of daily discharge are sufficient to quantify instream flows or to synthesize a hydrograph for similar watersheds.
- Biological data include, at a minimum, species presence/absence and periodicity.
- Special considerations may alter the analysis during specific times of year. These special considerations may include, but are not limited to recreation, fish migration and propagation, water quality, and fish overwintering. See special considerations below.

Given that aquatic and riparian environments have evolved from a predictable flow pattern, it follows that, reserving instream water rights that mimic this natural rhythm will provide the water necessary to maintain the natural aquatic and riparian habitats.

III. Procedure

The first step is to assemble the daily average flow record for the stream reach of interest. A minimum of 5 years record should make up this database. With less than five years of data there is an inherent risk that a single unusual large storm or extended dry period may skew the data for a given period of the year. The larger the database, the more likely the hydrograph reflects the true historical natural flow pattern.

A hydrograph is a graph showing stream discharge over time. An average annual hydrograph is developed by finding the average of all daily discharges for a given day and plotting this average daily discharge on a single graph for the entire year. This graph provides a visual representation of the seasonal variability for the watershed at the point of measurement (Figure 1).

Using the hydrograph shown in Figure 1, incremental time periods for analysis are identified. Incremental time periods may vary in length from weeks to several months. The goal is to separate the homogenous discharge periods, from periods where significant hydrologic change is occurring. Using Figure 1 as an example of a typical interior Alaska stream, a single incremental period during the winter may be defined from January 1 through April 15. Beginning about April 15, discharge begins to increase as air temperatures begin to rise and the snowpack begins to melt. A second incremental time period representing the period of spring snowmelt and/or river breakup would be from April 15 through May 15. A third incremental time period would begin May 16 and would end near the peak of the rising hydrograph on May 30. An additional time period would bracket the falling limb of the hydrograph to a point in time around the end of June or first of July, when the curve of the hydrograph flattens to summer flows. During the summer there may be frequent small spikes resulting from rain events. However, these small spikes occur sporadically and are not considered significant hydrologic changes, and do not justify separate incremental time periods. A separate incremental time period is justified only when there is a significant change of average discharge over time. Separate incremental time periods are based on a predictable pattern (events) that occurs annually, e.g., spring breakup, rising limb, falling limb, summer flows, fall flows, early and late winter flows, etc. (Figure 1).

Once incremental periods are selected from the average annual hydrograph, a flow exceedance curve is developed for each incremental time period (Figure 2). An exceedance curve is a cumulative frequency curve of discharge resulting in a smooth line fit to a group of daily discharge data. A point along the curve indicates the percent of the time that a given discharge can be expected to be equaled or exceeded. The discharge associated with the 50 percent exceedance (Q_{50}) is the median discharge for that period of time (not to be confused with the average or mean discharge). Data for the exceedance curves are then summarized into flow exceedance tables (Table 1) for the water right application.

Given that the ecosystem within and adjacent to the river corridor has evolved about the flow regime of the river, it is reasonable that the instream flow recommendation would be the discharge associated with the 50 percent exceedance. The 50 percent exceedance (median discharge) then, is equaled or exceeded half of the time during that time period. For most incremental time periods this is a good estimate of the instream flow need. However, there may be special considerations for a given time period that require modifying the instream flow recommendation (see IV Special Considerations on the following pages). Examples of special considerations include, but are not limited to, channel maintenance flows, water quality concerns, riparian habitat, considerations based on professional judgment and field experience, and specific wildlife-defined needs such as fish spawning, migration, rearing or incubation requirements.

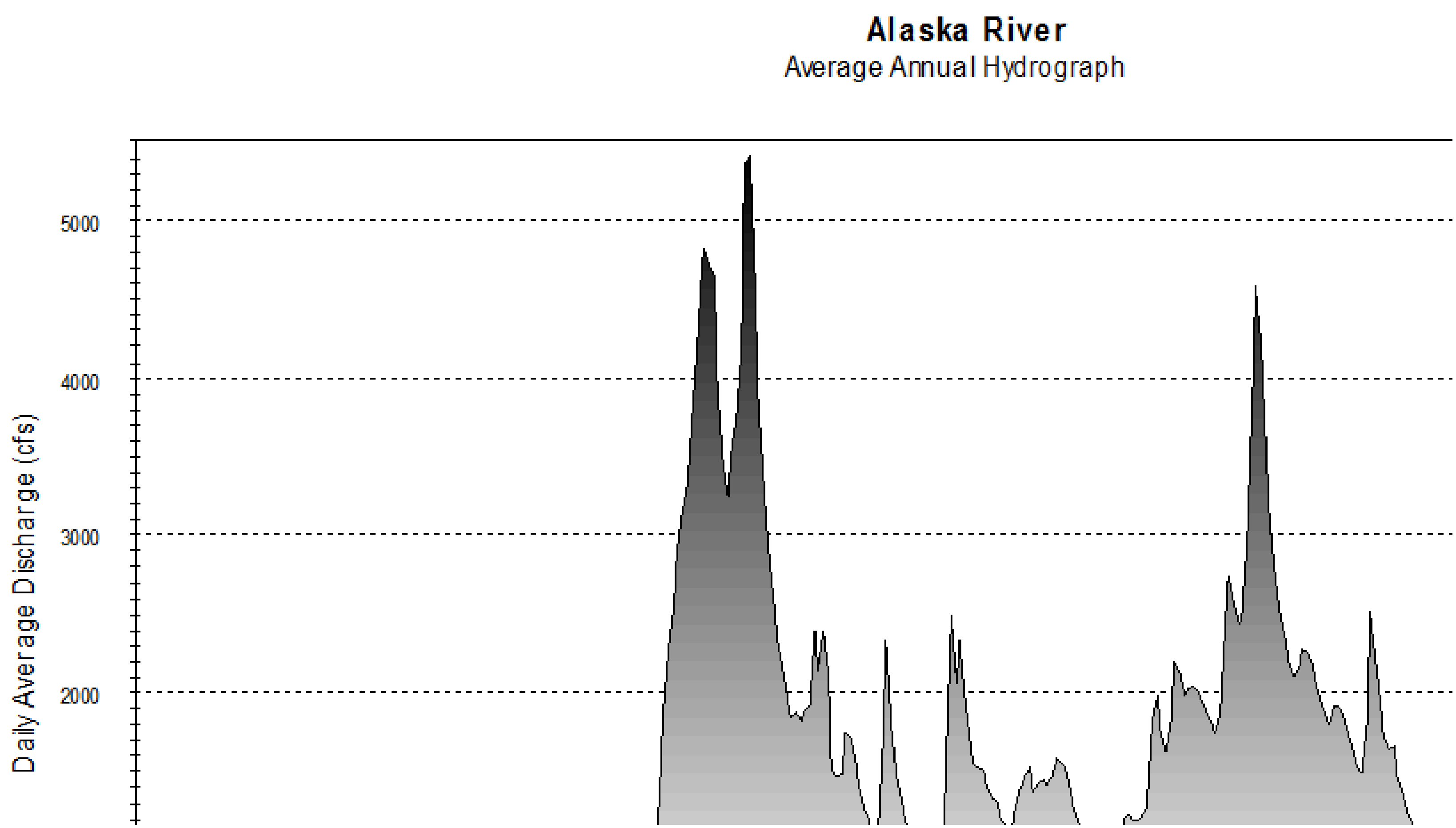

Figure 1. Example of typical hydrograph for interior Alaska rivers.

Table 1. An example of a flow exceedance table indicating the percent of time discharge equals or exceeds a given discharge in cubic feet per second.

Percent Exceedance	Jan 1 - April 30	May 1 - 31	June 1 - 30	July 1 - 31	Aug 1 - 31	Sept 1 Oct 31	Nov 1 - Dec 31
95%	17	605	553	375	663	311	138
90%	32	965	723	539	811	482	166
85%	44	1255	843	670	927	609	191
80%	56	1489	921	773	1016	703	213
75%	66	1677	966	852	1086	771	232
70%	75	1832	989	912	1142	822	248
65%	84	1964	998	958	1193	865	261
60%	93	2087	1002	996	1243	909	273
55%	101	2211	1012	1030	1301	962	283
50%	110	2348	1036	1064	1371	1034	292
45%	119	2510	1083	1104	1462	1134	301
40%	129	2709	1163	1155	1579	1269	309
35%	140	2957	1286	1222	1729	1449	317
30%	152	3265	1460	1309	1919	1682	326
25%	166	3644	1695	1421	2155	1978	335
20%	181	4108	2000	1564	2445	2345	346
15%	199	4667	2385	1741	2793	2792	359
10%	218	5333	2858	1959	3208	3328	373
5%	240	6118	3430	2222	3695	3961	390

IV. Special Considerations

Special considerations may apply depending on geographic locations and/or specific stream characteristics. For instance, a special consideration appropriate for a stream on the Arctic coastal plain may not be applicable for a coastal stream of southwestern Alaska. The following list accounts for situations that may warrant adjustment to the standard procedures used to define instream flow recommendations:

- Over-bank flow: to provide necessary water to support wetlands and riparian habitat adjacent to the channel, and other water dependent habitats during critical times(s) of the year. These flows also fill oxbow lakes and allow for migration of fish in and out of these lakes, and are necessary to replenish the nutrients of the wetlands and oxbow lakes. Step-backwater, elevation, or high water mark surveys are indirect methods to help determine this flow.
- Channel maintenance flow: discharge of a specific magnitude and velocity sufficient to move the substrate for the purposes of flushing fine sediments from spawning gravels, and seeds and seedlings from gravel bars, etc. At least one high flow period each year is necessary to maintain the in-channel characteristics. An instream maintenance flow is two times (2X) the average annual discharge. Using this as a rule of thumb, the instream flow for the incremental period with the greatest discharge will be the larger of either the 50 percent exceedance (Q_{50}) or two times the average discharge (QAA).
- Water quality maintenance flow: specific discharges to maintain water temperatures, sediment dilution, contaminant dilution, desired salinity in estuaries, nutrient replenishment, and desired water quality levels in oxbow lakes.
- Incubation or over-wintering flow: the limiting factor that defines fish egg incubation success is the 7-day average winter low flow (Milhouse 1982). As the stage of the stream drops during the winter months, fish eggs in the gravels along the margin of the stream become dry and/or freeze, then die. The viable eggs are those in gravels below the water stage associated with the 7-day average winter low flow. The eggs near the upper parts of this flow will freeze and die unless thermic conditions of the gravels are adequate to prevent freezing of the substrate. Thus, discharge must be maintained at a level above the 7-day average winter low flow in order to maintain thermic conditions to prevent freezing of the substrate and to incubate fish eggs. The winter instream flow must be greater than two times (2X) the 7-day average low-flow. The winter instream flow must also be the lower of the two flow values, the 25 percent exceedance (Q_{25}) or the average discharge for the winter incremental period.
- Spring breakup flow: to flush ice from the river systems and provide thermic water to the estuaries that initiate melting of the ice pack and allow fish migration. In areas of Alaska, such as the North Slope or the northwest coast, where substantial sea ice forms and early migrating fish species occur, riverine water is required to initiate sea ice melting. This thermic situation requires an instream flow of the 25 percent exceedance (Q_{25}) for a minimum of 1 week.
- Spawning flow: discharge necessary to meet spawning velocity conditions for the purpose of moving gravels onto the fish redds. Periodicity tables for each target species are required.
- Fish passage flow: discharge necessary to support fish passage of adults upstream for spawning and flush fry and juveniles downstream for out migration.
- Recreation and navigation flow: discharge to support rafting, kayaking, or general navigation.

- Fish harvest: discharge to support fish harvest by subsistence users, commercial fish operations, and the operation of fish wheels, nets, etc.

V. Products

Annual Hydrograph: A graph representing the average annual daily discharge is developed, Figure 1. This figure is an aid to identifying the incremental periods and is part of the water right application.

Exceedance Table: When the exceedance analysis is completed for each incremental period, an exceedance table should be developed, Table 1. This table should include an expected discharge at 5 percent exceedance intervals for each incremental period. This table will be included in the water right application.

Water Right Summary Table: A table that includes the average discharge and water right need for each incremental period will be developed for inclusion in the water right application, Table 2. The intent of this table is to provide a quick reference for comparing the water right request to the average discharge which can be expected during each incremental period.

Table 2. Example of the water right summary table.

SEASONAL PERIOD	AVG. DISCHARGE FOR PERIOD (cfs)	INSTREAM FLOW RESERVATION (cfs)
Jan 1-Apr 30 *	208	165
May 1-31	3294	2350
June 1-30	1463	1035
July 1-31	1402	1065
Aug 1-31	1710	1370
Sept 1 - Oct 31	1695	1035
Nov 1-Dec 31	283	290

* The lower of 25 percent exceedance flow or average discharge.

Water Right Summary Graph: The information from the Water Right Summary Table can also be summarized in a bar graph to provide a visual graphic of the water right request as compared to the average discharge for the incremental period. This graph should be included in the water right application.

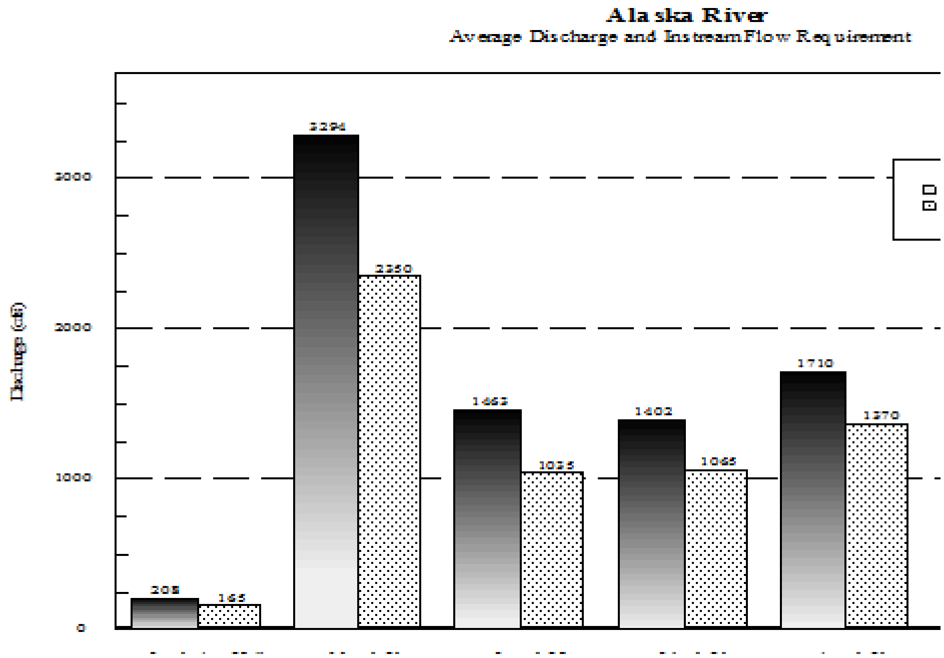

Figure 2. Example of a water right summary graph

Exceedance Curves: Exceedance curves for each incremental period used to develop the exceedance table should be available as backup reference for the exceedance table. These curves are for reference only, will be kept on file at the Water Resources Branch office.

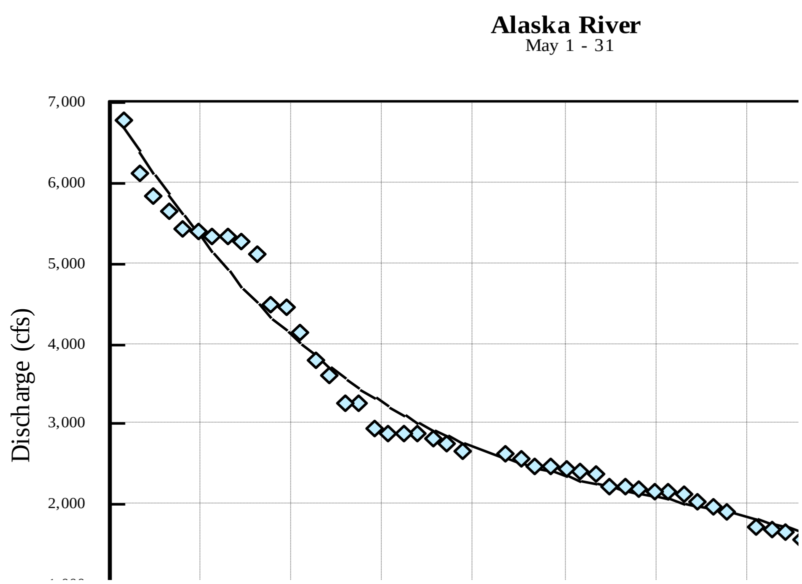

Figure 3. Example of an exceedance curve.

VI. References Cited

Milhous, Robert. 1982. Working paper on the application of the physical habitat simulation system to water management, amended 1987. Aquatic Systems Modeling Section, Aquatic Branch, National Ecology Center. U.S Fish and Wildlife Service. Fort Collins, Colorado.

Poff, N. LeRoy, J. David Allan, Mark B. Bain, James R. Karr, Karen L. Prestegaard, Brian D. Richter, Richard E. Sparks, and Julie C. Stromberg. 1997. The natural flow regime: a paradigm for river conservation and restoration. In, BioScience 47(11):769-784.