Fishery Data Series No. 93-43

Annual Summary of Alaska Department of Fish and Game Instream Flow Reservation Applications

by

Christopher C. Estes

October 1993

Alaska Department of Fish and Game Division of Sport Fish

FISHERY DATA SERIES NO. 93-43

ANNUAL SUMMARY OF ALASKA DEPARTMENT OF FISH AND GAME INSTREAM FLOW RESERVATION APPLICATIONS[1]

By

Christopher C. Estes

Alaska Department of Fish and Game
Division of Sport Fish
Anchorage, Alaska

October 1993

[1] This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-8, Job No. H-1.

The Fishery Data Series was established in 1987 for the publication of technically oriented results for a single project or group of closely related projects. Fishery Data Series reports are intended for fishery and other technical professionals. Distribution is to state and local publication distribution centers, libraries and individuals and, on request, to other libraries, agencies, and individuals. This publication has undergone editorial and peer review.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

This report summarizes the principal instream flow activities of the Alaska Department of Fish and Game during the seventh year of its program, and reviews the status of its instream flow applications filed in previous years.

Between July 1, 1991 and June 30, 1993, instream flow analyses were completed for: Wulik River (Kotzebue area), Snake River (Nome area), Taku River (Juneau area), Stikine River (Petersburg Area), and Karta River (Prince of Wales Island). Applications to acquire instream flow reservations were prepared based on these analyses and will soon be submitted to the Alaska Department of Natural Resources for adjudication.

Ten instream flow reservation requests filed by the Alaska Department of Fish and Game in previous years have been granted by the Alaska Department of Natural Resources: Terror River, Willow Creek, Rabbit Creek, Little Rabbit Creek, Little Survival Creek, upper Little Susitna River, two reaches of Campbell Creek, Indian River, and Cottonwood Creek.

Other applications from prior years are in various stages of the process of adjudication. These are: Little Susitna River (middle reach), Chena River (two reaches including a third application for a flushing flow), Fish Creek (two reaches), Meadow Creek, Sawmill Creek, Ketchikan Creek, Salcha River, Buskin River, Buskin Lake, Monashka Creek, Pillar Creek, North Fork of Campbell Creek, South Fork of Campbell Creek, Ship Creek, Anchor River, Kenai River (two reaches), Ward Creek, Chatanika River (two reaches), Delta Clearwater River (Clearwater Creek), Talkeetna River, Ninilchik River, Montana Creek, Jim River, Deshka River, Deception Creek, Mendenhall River (two reaches), Auke Creek, and Baranof River (three reaches), Eagle River, Chilkat River (two reaches), and Lake Creek.

A summary of instream flow related Alaskan legislation, regulations, and actions of other agencies and the private sector is also presented.

KEY WORDS: instream flow, flow reservation, water rights, Tennant Method, Montana Method, Alaska, flushing flow, Willow Creek, Little Susitna River, Rabbit Creek, Little Rabbit Creek, Little Survival Creek, Terror River, Montana Creek, Chena River, Cottonwood Creek, Fish Creek, Meadow Creek, Campbell Creek, North Fork of Campbell Creek, South Fork of Campbell Creek, Chatanika River, Delta Clearwater River, Clearwater Creek, Ninilchik River, Talkeetna River, Fish Creek Sawmill Creek, Ketchikan Creek, Salcha River, Ship Creek, Kenai River, Anchor River, Buskin River, Buskin Lake, Pillar Creek, Monashka Creek, Indian River, Ward Creek, Jim River, Mendenhall River, Deshka River, Deception Creek, Auke Creek, Baranof River, Eagle River, Lake Creek, and Chilkat River, Orchard Lake, Snettisham Hydroelectric Project, Snake River, Wulik River, Taku River, Stikine River, Karta River.

INTRODUCTION

Alaska has abundant and diversified sport fisheries which are of considerable recreational importance to anglers and others. To date, over 12,000 water bodies in Alaska have been identified as supporting anadromous and resident fish species (ADF&G 1992). Many others have yet to be investigated.

In 1991 an estimated 425,025 sport anglers took 1.7 million household trips and fished about 2.5 million days[1] to harvest 3.3 million fish (Mills 1992). These values represent significant increases over those noted in the late seventies and early eighties (Mills 1979, 1980, 1981a, 1981b, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992).

The continued production of Alaska's valuable fishery resources is, in part, dependent upon maintaining important habitat characteristics, including the quantity and quality of water within fish bearing waters. Without adequate safeguards, private and commercial developments and activities (hydroelectric projects, recreation, subdivisions, mining, water marketing, interstate diversions, agriculture, aquaculture, forestry, manufacturing, oil and gas development, etc.) can contribute to negative changes to both riparian and instream habitats, among them elimination of sufficient instream flows. The term instream flow is normally used to describe the quantity of water that flows past a given point within a stream channel during one second. It can also be used to refer to the volume of water in a lake.

Fortunately, the Alaska Legislature recognized the importance of instream flow protection by amending the Water Use Act (Alaska Statute, AS, 46) in 1980. The amendments (AS 46.15.03 and AS 46.15.145) provided the opportunity for private individuals; in addition to state, federal, and local government agencies to legally acquire instream flow water rights in rivers, streams, and lakes for one or a combination of four types of uses:

1) protection of fish and wildlife habitat, migration, and propagation;

2) recreation and parks purposes;

3) navigation and transportation purposes; and

4) sanitary and water quality purposes.

Instream flow reservation requests can be quantified as rates of flow, surface water elevations, or water depths.

Regulations to implement the instream flow law were adopted by the Alaska Department of Natural Resources (DNR) in September 1983 and modified in 1990 and 1992. Additional regulation modifications relating to instream flows were approved in 1993. Forms required to apply for instream flows were first made available by the DNR in November 1983.

---

[1] Any part of a day (24-hour period) that is fished by an individual is counted as one day fished.

The Fish and Game Act (AS 16) requires the Alaska Department of Fish and Game (ADF&G) to, among other responsibilities, "manage, protect, maintain, improve, and extend the fish, game and aquatic plant resources of the state in the interest of the economy and general well-being of the state" (AS 16.05.020). One of the AS 16 provisions enables the ADF&G to acquire water rights to further its objectives or purposes (AS 16.05.050). To take advantage of the new opportunities provided by the instream flow legislation and better meet its statutory mandates, the Division of Sport Fish of the ADF&G acquired funding in 1986 to initiate an ongoing program to formally acquire instream flow water rights to protect sport fish resources (Estes 1987).

To reserve instream flows, an application containing supporting data and analyses that substantiate the flows being requested must be submitted to the DNR for adjudication (the administrative determination of the validity and amount of a water right, including the settlement of conflicting claims among competing appropriators).

This report summarizes the seventh year of this program in which the primary objective was to apply for instream flow reservations for the protection of sport fishery resources in a minimum of four Alaskan rivers. Included in the Discussion Section is a summary of other instream flow related activities by the private sector and other agencies.

METHODS

Study Design

Procedures were selected that complied with instream flow application instructions and requirements established by state law (AS 46.15.145), state regulations (11 AAC 93.141-146), instream flow application form instructions (Appendix A1), and the *"State of Alaska Instream Flow Handbook"* (DNR 1985).

Site Selection

Locations for reserving instream flows were nominated by an interdepartmental team of ADF&G biologists and resource specialists (ADF&G 1984, Estes 1985, Instream Flow Committee 1986). The Division of Sport Fish made final selections by evaluating the importance of nominated streams to the sport fishery, the likelihood for competing out-of-stream or diversionary water appropriations, whether existing hydrologic and biologic data for a stream reach were adequate for performing an instream flow analysis, and whether other state and federal statutory mechanisms would provide better and more cost effective protection.

Five reaches (Appendices A2-6; Figure 1) were selected for instream flow analyses and preparation of instream flow reservations in Fiscal Year 1993 (FY 93, July 1, 1992 to June 30, 1993): Wulik River (Kotzebue area), Snake River (Nome area), Taku River (Juneau area), Stikine River (Petersburg Area), and Karta River (Prince of Wales Island).

Stream reach boundaries for each FY 93 instream flow application were selected to insure that flow, habitat, and fish periodicity (seasonal use of habitat for passage, spawning, incubation, and rearing) characteristics within the reach were uniform. Reaches were defined on U.S. Geological Survey (USGS)

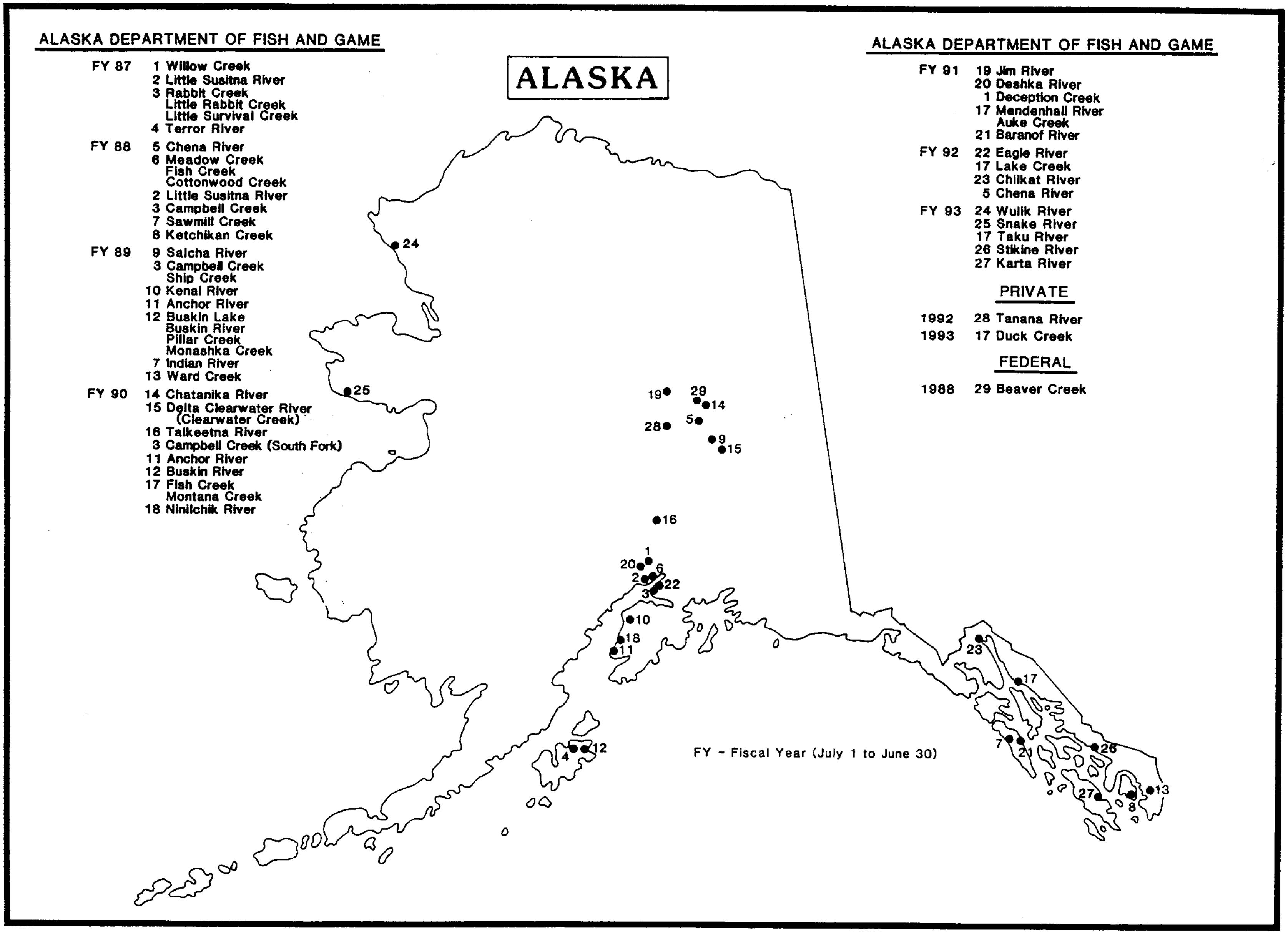


Figure 1. Locations of instream flow reservation application reaches, July 1, 1986 to June 30, 1993.

topographic maps with the assistance of ADF&G biologists and USGS hydrologists. Topography, watershed, and channel patterns, fish periodicity, USGS gage site descriptions and mean daily flow data were collectively analyzed.

Fish periodicity data for defining stream reaches and flow requirements were obtained and summarized from reviews of scientific literature, interviews with fishery and habitat biologists from the ADF&G and other agencies, the "Catalog of Waters Important for Spawning, Rearing, or Migration of Anadromous Fishes" (ADF&G 1992), and the Division of Sport Fish statewide harvest survey publication series (Mills 1979-1992). ADF&G biologists, responsible for the areas encompassing targeted instream flow reaches, reviewed and refined the syntheses of periodicity data.

Flow data and gage site descriptions used for delineating reach boundaries were obtained from USGS "*Water-Data*" Reports; and from interviews with ADF&G biologists, USGS hydrologists, DNR Division of Geological and Geophysical Survey hydrologists, DNR land and Water Management Division resource specialists, and other resource specialists that are known to have data pertinent to the reservation.

Instream Flow Analysis

Although an applicant's choice and use of a specific method for quantifying instream flow requirements is not restricted by laws, regulations, or set standards (DNR 1985, Estes and Harle 1987), the rationale for the selection of a method or methods must be documented and accompany the instream flow application.

One method was chosen in FY 93, the Tennant Method, also referred to as the Montana Method (Tennant 1972, 1976). The Tennant Method analysis was combined with an evaluation of mean daily flow, monthly flow, and other hydrologic characteristics (Orsborn and Watts 1980, Estes 1984, Estes and Orsborn 1986, Shaw 1988) to determine whether sufficient water could be expected to be within each study reach during the various periods of the year in which the reservation was requested and to enable a refinement of the instream flow choices derived with these analyses.

Flow databases of the USGS, required for performing all of these analyses, were obtained via archived data on tape acquired from the USGS for historical data and downloaded from local USGS computers for current data.

Each data set was transferred into Statistical Analysis System (SAS) data files (SAS 1985). Summary analysis was used to check the data for simple errors. After initial error checking was complete, the data were analyzed by a series of SAS programs using the procedures outlined below to estimate the long-term average annual and average monthly mean daily flow values and the monthly (and/or semi-monthly) flow duration parameters.

Descriptive information pertaining to the fishery and hydrologic characteristics of the study sites were acquired through literature review and interviews with ADF&G biologists, USGS hydrologists, DNR Division of Water hydrologists, and other state, federal, and private resource specialists that were known to have data pertinent to the reservation analyses. ADF&G

biologists and USGS hydrologists, most familiar with each study site, assisted with the refinement of this information whenever discrepancies occurred.

Tennant Method:

The choice of the Tennant Method was based on its acceptance by both the DNR and courts as a valid instream flow analytical procedure, and the limited availability of data, previous analyses, and financial resources required to prepare instream flow applications.

The first step of the Tennant Method was to calculate the average annual flow, QAA, (arithmetic mean of the annual mean of mean daily flows for all years of record) for each stream reach. Next, each QAA was multiplied by eight Tennant Method coefficients (percentages) to calculate instream flows for eight habitat categories. Seven of the Tennant Method habitat categories (ranging from 10% to 100% of the QAA) represent a range of poor to optimum habitat quality conditions for fish and wildlife. The eighth category (200% of the QAA) represents the short-term flushing flow that Tennant (1972) considers necessary to maintain channel substrate characteristics suitable for fish spawning and egg incubation, and benthic invertebrate production. Research by Estes (1984, Reiser et al. 1985) suggests supplemental analyses are required to modify or substitute for Tennant Method flushing flow calculations.

Next, hydrologic analyses were performed to estimate baseline flow conditions in each stream reach. This involved calculating mean monthly flows (QAM), the arithmetic mean of the monthly mean daily discharge for a given month for the entire period of record, and flow duration estimates (the expected frequency of occurrence of mean daily flows within a particular month).

Finally, seasonal instream flow requirements for individual life phases of fish for each stream reach were chosen by comparing the eight Tennant Method flows, fish periodicity data, QAM, and flow duration estimates. With the exception of flushing flows, instream flows were selected that corresponded to both fish periodicity and the highest of the other seven Tennant Method habitat categories that did not exceed flow duration estimates during that same period. Tennant's flushing flow recommendations were not used due to the inability to legally reserve this type of flow in free flowing systems. Resources were also unavailable to perform supplemental analyses suggested by Estes (1984) for modifying or substituting for Tennant's flushing flow calculations.

Average Annual Flow Procedures:

Calculation of QAA, from the existing USGS mean daily flow records for the stream reaches, involved first obtaining the mean of the mean daily flows within each water year (October 1-September 30):

$$qaa_h = \frac{\sum_{i=1}^{d_h} q_{hi}}{d_h} ; \qquad (1)$$

where: qaa_h equaled the mean annual daily flow for each year (h) of record;

d_h equaled the number of days in each year of record (note that only complete years of record were used in this analysis; d_h varied only between leap and non-leap years); q_{hi} equaled the daily mean flow in cubic feet per second for each day in the record.

Next, QAA was estimated as a mean of the annual mean daily flow values over all complete years of record:

$$\hat{QAA} = \frac{\sum_{h=1}^{n} qaa_h}{n} ; \qquad (2)$$

where: n equaled the years of record (with complete daily flow records for each water year).

Mean Monthly Flow Procedures:

The QAM was estimated similarly by first estimating the mean daily discharge for each complete month in the record:

$$qam_{jh} = \frac{\sum_{k=1}^{d_{jh}} q_{jhk}}{d_{jh}} ; \qquad (3)$$

where: qam_{jh} equaled the monthly mean daily flow for each month (j) for each year of record (h); d_{jh} equaled the number of days in each month of record (note that only complete months of record were used in this analysis); q_{jhk} equaled the daily mean flow in cubic feet per second for each day in the record.

Next, QAM was estimated as a mean of the monthly mean daily flow values over all complete years of record:

$$\hat{QAM}_j = \frac{\sum_{h=1}^{n} qam_{jh}}{n_j} ; \qquad (4)$$

where: n_j equaled the years of record with complete daily flow records for each j.

Duration Analysis Procedures:

Flow duration estimates were calculated as percentiles of the distribution of observed values within the time periods involved over the years of record. For example, flow duration estimates for the month of April were calculated by combining all mean daily flow values for April (for all years having complete April records). Then the empirically defined distribution (observed-combined mean daily flow values) was calculated as follows. If the quantity to be calculated was defined as the "t^{th}" percentile, where $p = t / 100$, then setting:

$$np = j + g$$

where: n was equal to the number of observed mean daily flow values in the combined group (for example 300 days for a 10-year record of complete months of April); j was the integer part of n times p; and g was the fractional part of n times p.[2]

Then the t^{th} percentile (y) was defined as:

$$y = (x_{(j)} + x_{(j+1)}) / 2 \qquad \text{if } g = 0 ; \qquad (4a)$$

or

$$= x_{(j+1)} \qquad \text{if } g > 0 ; \qquad (4b)$$

where: $x_{(j)}$ and $x_{(j+1)}$ were the ordered (from smallest to largest) values in the combined group of mean daily flow values.

The above information was incorporated into instream flow application forms (Appendix A1) with other required information following procedures defined by the DNR (1985). Additional descriptions of procedures are presented in each instream flow application (ADF&G 1993a, b, c, d, e).

RESULTS

Analyses were completed and applications prepared to request instream flow protection for fish in five stream reaches in five river systems (Figure 1, Appendices A2-A6; ADF&G 1993a, b, c, d, e): Wulik River (Kotzebue area), Snake River (Nome area), Taku River (Juneau area), Stikine River (Petersburg Area) and Karta River (Prince of Wales Island). Applications are undergoing final review prior to submitting them to the ADNR.

The lengths of the five stream reaches, ranged from less than one mile (Karta River, Appendix A6) to 30 miles (Wulik River, Appendix A2).

Fish periodicity for each stream is illustrated in Appendices A7-A11. The Snake River (Appendix A8) had the lowest variety of fish species (ten) and the Taku (Appendix A9 and Stikine Rivers (Appendix A10) the most, with thirteen species each. Appendix A12 lists the common and scientific names of the fish species listed in the periodicity charts.

Historical records of USGS mean daily flow data varied from 4 years for the Taku River to 25 years for the Snake River (Appendix A13).

QAA, mean monthly flow, and Tennant Method results are summarized in Appendices A14-A18. QAA values ranged from 188 cubic feet per second (cfs)

---

2 For example, if n = 300 and we wanted to calculate the 97th percentile, then j = 291 and g = 0; or for the 2.5th percentile, then j = 7 and g = 5.

for the Snake River (Appendix A15) to 56,731 cfs for the Stikine River (Appendix A17). Mean monthly flows ranged from 17 cfs in the Snake River Creek during April (Appendix A15) to 138,758 cfs in the Stikine River during July (Appendix A17). Optimum habitat flows ranged from 113-188 cfs for the Snake River (Appendix A15) to 34,038-56,731 cfs (Appendix A17) for the Stikine River. Poor habitat flows ranged from 19 cfs for the Snake River (Appendix A15) to 5,673 cfs for the Stikine River (Appendix A17). Tennant flushing flow values ranged from 376 cfs for the Snake River (Appendix A15) to 113,462 cfs (Appendix A17) for the Stikine River.

Instream flow values requested usually ranged from 60% to 100% of the QAA for the spawning and passage seasons, and 10% to 40% of the QAA for incubation and rearing seasons (ADF&G 1993a, b, c, d, e).

There is presently no legal mechanism for reserving flushing flows in unregulated streams and rivers in Alaska. Research by Estes (1984) suggests flushing flow calculations, using the Tennant Method, require additional analyses that were not funded. Therefore, Tennant values were not modified and used for reserving flushing flows for the five river reaches. Nonetheless, to establish a basis for protecting flushing flows in these unregulated systems (until an acceptable method is developed) a statement was included in each application explaining that flushing flows were required to maintain fish habitat and (at a minimum) must be safeguarded whenever significant flow modifications or a structure capable of controlling flows is planned.

Instream flow regimes requested are not included in this report because they are subject to modification both while undergoing departmental review prior to submission to the DNR and during the various stages of the DNR adjudication process. These data will be presented in future reports following the completion of these processes.

DISCUSSION

Five instream flow applications were completed for FY 93. This is the same number of applications that were prepared in FY 92 and half of the 5-year average of 10 applications prepared annually between 1986 and 1991 (Figure 1; Table 1; Estes 1987, 1988, 1989, 1990, 1991, 1992). The reduction in the number of applications completed can be attributed to the loss of seasonal support staff at the same time that requests for instream flow related technical support by other staff, agencies and the private sector continually increase.

In an attempt to compensate for these limitations, the ADF&G has developed and refined a cost-effective approach to acquire the majority of its instream flow protection for fish by using the Tennant Method as its primary technique for analyzing instream flow needs. When necessary, new procedures requiring minimal resource expenditures have been developed to request specialized instream flow reservations (e.g., flushing flows, and water depth and area in lakes). Consequently, as a rule, the use of more sophisticated and expensive methods for reserving instream flows has been limited to situations where competition between out-of-stream uses and instream requirements was likely to be highly controversial and required an incremental quantitative flow

Table 1. Status of Alaska Department of Fish and Game instream flow reservation applications, July 1, 1986 to June 30, 1993.

Instream Flow Application Location	Status	Priority Date
Terror River	Granted (05-20-1987)	07-06-1984
Willow Creek	Granted (07-08-1988)	07-31-1987
Little Susitna River (Upper Reach)	Granted (11-01-1988)	07-31-1987
Rabbit Creek	Granted (02-19-1988)	06-30-1987
Little Rabbit Creek	Granted (02-19-1988)	06-30-1987
Little Survival Creek	Granted (11-19-1988)	06-30-1987
Chena River-Reach A	In Process of Adjudication	07-14-1988
Chena River-Reach B	In Process of Adjudication	07-14-1988
Meadow Creek	In Process of Adjudication	07-14-1988
Fish Creek-Reach A	In Process of Adjudication	07-14-1988
Fish Creek-Reach B	In Process of Adjudication	07-14-1988
Cottonwood Creek	Granted (05-15-1991)	07-14-1988
Little Susitna River (Middle Reach)	In Process of Adjudication	07-14-1988
Campbell Creek (Middle Reach)	Granted (05-15-1991)	07-14-1988
Sawmill Creek	Pending Adjudication	07-14-1988
Ketchikan Creek	Pending Adjudication	07-14-1988
Campbell Creek (Lower Reach)	Granted (06-28-1990)	07-25-1988
Indian River	Granted (08-03-1990)	01-12-1989
Salcha River	Pending Adjudication	02-05-1990
Campbell Creek (North Fork)	Pending Adjudication	02-05-1990
Ship Creek	Pending Adjudication	02-05-1990
Kenai River (Reach A)	Pending Adjudication	02-05-1990
Kenai River (Reach B)	Pending Adjudication	02-05-1990
Anchor River (Lower Reach)	Pending Adjudication	02-05-1990
Buskin Lake	Pending Adjudication	02-05-1990
Buskin River (Lower Reach)	Pending Adjudication	02-05-1990
Pillar Creek	Pending Adjudication	02-05-1990
Monashka Creek	Pending Adjudication	02-05-1990
Ward Creek	Pending Adjudication	02-05-1990
Chatanika River-Reach A	Pending Adjudication	03-19-1991
Chatanika River-Reach B	Pending Adjudication	03-19-1991
Delta Clearwater River	Pending Adjudication	03-19-1991
Talkeetna River-Reach A	Pending Adjudication	03-19-1991
Campbell Creek (South Fork)	Pending Adjudication	03-19-1991
Buskin River-Reach B	Pending Adjudication	03-19-1991
Anchor River-Reach B	Pending Adjudication	03-19-1991
Fish Creek (near Juneau)	Pending Adjudication	03-19-1991
Montana Creek (near Juneau)	Pending Adjudication	03-19-1991
Ninilchik River-Reach A	Pending Adjudication	03-19-1991
Jim River	Pending Adjudication	04-10-1992
Deshka River	Pending Adjudication	04-10-1992
Deception Creek	Pending Adjudication	04-10-1992
Mendenhall River-Reach A	Pending Adjudication	04-10-1992
Mendenhall River-Reach B	Pending Adjudication	04-10-1992
Auke Creek	Pending Adjudication	04-10-1992
Baranof River-Reach A	Pending Adjudication	04-10-1992
Baranof River-Reach B	Pending Adjudication	04-10-1992
Baranof River-Reach C	Pending Adjudication	04-10-1992
Eagle River	Pending Adjudication	06-04-1993
Lake Creek	Pending Adjudication	06-04-1993
Chilkat River-Reach A	Pending Adjudication	06-04-1993
Chilkat River-Reach B	Pending Adjudication	06-04-1993
Chena River-Reach B (flushing flow)	Pending Adjudication	06-04-1993
Wulik River	In Preparation	
Snake River	In Preparation	
Taku River	In Preparation	
Stikine River	In Preparation	
Karta River	In Preparation	

analysis. Occasionally, projects under federal jurisdiction (e.g., projects requiring a Federal Energy Regulatory License) have also mandated a specific data collection and analytical procedure. In the past, supplemental funding was available for projects requiring application of the more sophisticated methods.

The Tennant Method requires minimal data and is one of the easiest and least expensive procedures for quantifying instream flows. It has been used for quantifying instream flows for all but five of the ADF&G applications since 1986. Supplemental resources were acquired on three occasions when the ADF&G selected to use the more sophisticated Instream Flow Incremental Methodology, IFIM (Bovee 1982), to evaluate fish habitat suitability for specific increments of water (Estes 1987). The IFIM is the most time consuming, data and analysis intensive, and expensive of the instream flow analytical procedures. A new method was developed and used to quantify and file for instream flows to protect fish spawning in an Alaskan lake by Estes and Hoffmann in 1989 (Estes 1989). The Estes and Orsborn Method was applied in Alaska for the first time in 1992 to quantify and request flushing flows in streams and rivers that have flow control structures (Estes 1992). The acceptance of the lake and flushing flow methods by the ADNR remain unknown, because the applications based on these methods are pending in the adjudication process.

The DNR has received 62 applications for instream flows since passage of the 1980 enabling legislation (Estes 1987, 1988, 1989, 1990, 1991, 1992; Harle 1988). Fifty-three of the applications were submitted by the ADF&G (Table 1), one by the U.S. Bureau of Land Management (BLM), four by the Anchorage Audubon Society, two by private individuals, one by the Arctic Unit of the Alaska Chapter of the American Fisheries Society (AFS), and one by the Juneau Chapter of Trout Unlimited (TU). Only the 53 ADF&G applications and 1 BLM application, the TU, and AFS applications met DNR requirements and were accepted for adjudication. The other six applications were rejected by the DNR for a variety of reasons: two had been filed before regulations to process them were adopted in 1983, documentation was insufficient to support the reservation requests in three of the applications, and the instream flow reservation desired was not specified in one of them (Harle 1988).

Instream flow water rights have been granted for 10 of the ADF&G applications and the BLM application; the remainder of the ADF&G applications are in various stages of the process of adjudication (Table 1).

Although Alaska's instream flow law and regulations are among the most progressive in the country, there is an obvious need for improvement. Considering there are more than 12,000 fish bearing water bodies in Alaska (ADF&G 1985, 1992), the significance of fish to recreation, subsistence, and Alaska's economy, and that private citizens (in addition to agencies) can request instream flow water rights, one may question why more applications have not been filed. There are several reasons: insufficient hydrologic data, costly and lengthy administrative processes, insufficient public education, and except for state agencies, application fees.

The dearth of hydrologic data in Alaska is perhaps the most limiting factor governing our ability to define instream flow and other water uses. Over ninety-nine percent of the rivers and streams in Alaska are ungaged.

Altogether, less than 400 USGS stream gaging sites have been established in Alaska since 1908 (Thompson 1992). This translates to an average of one stream gage per 7,000 square miles in Alaska as opposed to the lower "48" average of one gage site per 400 square miles. Typically, no more than 25 percent of these Alaskan gages are active in any one year due to funding restrictions (Thompson 1992, Emery 1987, Emery 1989). This trend is alarming because less than half of these sites can meet the USGS 10-year minimum historical data standards for supporting a statistically reliable regional flow analysis.

Ironically, to quantify instream flow requirements and apply for instream flow water rights at ungaged stream reaches, one must use regional hydrologic models to estimate flow characteristics. It is obvious, the USGS data bases, from which these models were developed, will limit one's ability to evaluate naturally occurring hydrologic patterns at these sites with confidence. It is also more time consuming to estimate flow characteristics for streams having a limited or non-existent data base as opposed to summarizing data for a stream having an adequate historical record. Precipitation information also required for these ungaged flow models is also limited, further complicating the process for estimating flow availability.

Basic hydrologic data are required by all potential water users and management agencies to enable them to project the reliability and amount of water that might be available, even if there were no other competitors for their targeted water source. Unless a commitment can be made to close these data gaps in Alaska, we are limited to making decisions regarding water allocation using these models with little or no hope for improving the precision or accuracy of our flow estimates. Therefore, it should be obvious that additional gaging stations are required to improve the accuracy of the information used to make decisions pertaining to water availability and allocation in Alaska.

Administrative processes are, in many instances, also a deterrent to potential instream flow applicants, including the ADF&G. Without additional staffing and financial resources, these processes could hamper the ability of the ADF&G to maintain its average production rate of 10 applications per year. The backlog of 43 ADF&G applications and the additional FY 93 ADF&G applications will each require from 1 to 3 weeks of time by ADF&G personnel to participate in the various phases of the DNR adjudication. Additionally, there are no fixed adjudication schedules because the DNR has a backlog of water rights applications. There have been no adjudications of ADF&G instream flow applications since 1991 (Table 1). If too many adjudications were scheduled by the DNR (at any one time), the added resource and time requirements would overtax existing ADF&G resources. Fortunately, a priority date and time is assigned to each application at the time it is accepted by the DNR. This protects applicants by establishing the order of priority for the allocation of water, regardless of when the adjudication process is completed. Thus, until a water right application is adjudicated, it can be assumed 100% of the original amount of water requested by an applicant must be managed on behalf of the applicant. As long as there are no other competitors for water from the same source, this should not be a problem.

Alaskan law requires the DNR to review instream flow water rights once every 10 years to evaluate whether flow modifications are warranted. Consequently, proprietors of instream flow water rights must maintain a permanent storage system for the original data and analyses. Documentation must be sufficient to enable original applicants (or representatives) to defend their instream flow water rights. This data storage requirement is costly in terms of space and serves as an impediment to private applicants with limited resources. It is also unclear whether owners of instream flow water rights must fund their own participation in 10-year reviews. There are no equivalent provisions for automatic reviews of out-of-stream or diversionary water rights.

Fees charged by the DNR for filing instream flow applications are another deterrent to applicants. With the exception of state agencies, all instream flow applicants are charged $500 per application. There is no charge to state agencies. This fee is expensive relative to application fees charged by the DNR for most other water rights and (unlike other water rights) is not based on the amount of water requested. An additional regulatory fee was adopted by the DNR in 1993 (AAC 1993). It enables the DNR to charge for the cost of staff time expended on the adjudication of water rights that exceeds the application fee. This supplemental fee is discretionary and will probably serve as another obstacle for filing instream flow applications by the private sector, and perhaps federal agencies.

Formal programs to educate and assist the public to file for instream flow water rights are nonexistent. Procedural and background publications to aid instream flow applicants are inadequate. The DNR however, is in the process of establishing a new water education program to correct this deficiency. The ADF&G has also provided educational information, assistance, and lectures to the public upon request. Recently the ADF&G provided technical instruction and assisted TU to perform an instream flow analysis and prepare an instream flow application.

The above factors and the complexity of water law all contribute to the low number of applications filed. Some of these and related concerns are being addressed by the Alaska Legislature, and an interagency federal, state, and local Water Management Council formed in 1992.

Alaska legislation enacted in 1992, relating to the export and marketing of water (House Bill 596), has the potential to affect instream flow protection on a large scale (Estes 1992). Regulations to execute the provisions of the law have not been completed. Furthermore, the DNR has indicated there is legislative interest to revise the water export and marketing law in 1994 (Prokosch 1993). Accordingly, the impact of this law cannot be assessed at this time.

Interest for exporting water from Alaska to other states and countries appears to be increasing. Two water use applications to export water from Alaska were filed by Sun Belt, a California based company, prior to the passage of HB 596. The applications are pending due to incomplete information. If the water rights are granted by the DNR, Sun Belt will withdraw water from Orchard Lake in Ketchikan and the tailrace of the Snettisham Hydroelectric Project in Juneau. It is unknown whether these two applications are grandfathered under earlier laws or subject to the provisions of HB 596. Water is presently being purchased from the Municipality of Anchorage water supply for export to Seattle, and eventually Saudi Arabia, by Alaska Glacier Fresh. The company hopes to eventually export 14 million gallons of water per tanker load using a Saudi Arabian ocean vessel (Prokosch 1993). The effects of water exports and sales will undoubtedly increase as time passes, placing a greater emphasis on the laws passed to regulate these activities.

The DNR portion of the 1993 Capital Improvement Project budget approved by the Alaska legislature included $200,000 funding to perform a stream gage network evaluation to evaluate the existing gage network and develop priorities for future gaging. Funding for this evaluation has been requested for several years (Estes 1991, 1992)

The Alaska Water Management Council established in 1992 is continuing its efforts to attempt to improve water management through better interagency coordination and cooperation. The Governor of Alaska signed an Administrative Order formalizing the activities of the council (Hickel 1993).

Based upon the experiences of the ADF&G, the following seven recommendations to improve the instream flow reservation process are provided:

1) Additional staff (fishery biologists and hydrologists) and financial resources should be allocated to allow for a greater number of applications to be processed.

2) Legislation should be enacted to fund additional stream gage data collection stations based upon the outcome of network evaluation. The stations are required to improve flow projection models and estimates and to determine the availability of water for out-of-stream and instream uses.

3) Out-of-stream appropriation certificates should be automatically reviewed by the DNR once every 10 years, as are instream flow reservations.

4) Legislation should be enacted or regulations established that will guarantee a base level of instream flow protection for stream reaches that are classified as supporting fish.

5) A formal instream flow educational program should be funded to encourage public participation in the instream flow reservation process.

6) An instream flow methods and application handbook should be prepared to provide sufficient guidance for the public and other interested parties to file for instream flow reservations.

7) Instream flow reservations should be exempt from additional fees to pay for staff adjudication time.

In summary, the ability to complete instream flow applications by the ADF&G has improved with experiences gained through analysis and preparation of each application. Unfortunately, data requirements and lengthy adjudication processes have begun and will continue to limit the number of reservations completed and submitted. To counter these limitations, additional resources will be required for data collection and analyses, and the preparation and defense of applications.

ACKNOWLEDGMENTS

The author expresses his appreciation to his supervisor, Mike Mills, for support of this program. Appreciation is also extended to regional and area biologists who contributed information and data for analysis: Alan Townsend, Fred DeCicco, Rob Bentz, Alvin Ott, Robert McLean, Steven Elliott, Stephen Hoffman, and Kelly Hepler. Contributions from: Carol Hepler for providing scientific illustration support; Allen Bingham, Gary Fidler, Allen Howe, Sandra Sonnichsen, Wolfgang Kurtz, Gail Heineman, Gwyn Alexander, Dora Sigurdsson, Ardys Armstrong and other Research and Technical Services Section staff who summarized and analyzed hydrologic data and/or provided editorial suggestions and assistance; Bob Burrows, Bob Lamke, Gary Solin, Harold Seitz, Phil Carpenter, Ken Thompson, Richard Kemnitz, Bruce Bigelow, Tim Brabets, Dick Snyder, Ron Rickman, and Joe Torava (USGS) who provided hydrologic analysis support.

LITERATURE CITED

AAC (Alaska Administrative Code). 1990. 11 AAC 93. Revisions to the water management regulations. November 1990. Alaska Department of Natural Resources. Anchorage, Alaska.

_____. 1992. 11 AAC 03. Revisions to the water management fees for department services. September 1992. Alaska Department of Natural Resources. Anchorage, Alaska.

_____. 1993. 11 AAC 05.010(8)(O). Revisions to the water management fees. July 1993. Alaska Department of Natural Resources. Anchorage, Alaska.

ADF&G (Alaska Department of Fish and Game). 1984. Instream flow work plan. Alaska Department of Fish and Game, Anchorage, Alaska.

_____. 1985. Alaska habitat management guides. Alaska Department of Fish and Game, Division of Habitat. Anchorage, Alaska.

_____. 1992. An atlas to the catalog of waters important for spawning, rearing or migration of anadromous fishes. Alaska Department of Fish and Game, Division of Habitat. Anchorage, Alaska.

_____. 1993a. *In Prep*. Application for reservation of water. Wulik River. Sport Fish RTS No. I.700.300.12000. Located at the Alaska Department of Fish and Game. Anchorage, Alaska.

_____. 1993b. *In Prep*. Application for reservation of water, Snake River. Sport Fish RTS No. I.700.300.8215. Located at the Alaska Department of Fish and Game. Anchorage, Alaska.

_____. 1993c. *In Prep*. Application for reservation of water. Taku River. Sport Fish RTS No. I.700.300.9250. Located at the Alaska Department of Fish and Game. Anchorage, Alaska.

_____. 1993d. *In Prep*. Application for reservation of water. Stikine River. Sport Fish RTS No. I.700.300.8900. Located at the Alaska Department of Fish and Game. Anchorage, Alaska.

_____. 1993e. *In Prep*. Application for reservation of water. Karta River. Sport Fish RTS No. I.700.300.3400. Located at the Alaska Department of Fish and Game. Anchorage, Alaska.

Bovee, K. D. 1982. A guide to stream habitat analysis using the Instream Flow Incremental Flow methodology. Instream Flow Information Paper No. 122. FWS/OBS/82/26. U.S. Fish and Wildlife Service. Ft. Collins, Colorado.

DNR (Alaska Department of Natural Resources). 1985. State of Alaska instream flow handbook. Alaska Department of Natural Resources, Anchorage, Alaska.

Emery, P. A. 1987. Letter to Christopher Estes (Alaska Department of Fish and Game), November 9, 1987 regarding U.S. Geological Survey requirements to calculate stream flows. U.S. Geological Survey. Water Resources Division. Anchorage, Alaska.

_____. 1989. Letter to Christopher Estes (Alaska Department of Fish and Game), March 6, 1989, regarding U.S. Geological Survey stream flow gaging stations. U.S. Geological Survey. Water Resources Division. Anchorage, Alaska.

Estes, C. C. 1984. Evaluation of methods for recommending instream flows to support spawning by salmon. Master's thesis, Washington State University, Pullman, Washington.

_____. 1985. Organization of departmental instream flow program. Memorandum to Richard Logan, September 12, 1985. Alaska Department of Fish and Game, Anchorage, Alaska.

_____. 1987. Instream flow. Alaska Department of Fish and Game, Fishery Data Series No. 23, Juneau, Alaska.

_____. 1988. Annual summary of statewide instream flow reservation applications. Alaska Department of Fish and Game, Fishery Data Series No. 55, Juneau, Alaska.

_____. 1989. Annual summary of statewide instream flow reservation applications. Alaska Department of Fish and Game, Fishery Data Series No. 121, Juneau, Alaska.

_____. 1990. Annual summary of statewide instream flow reservation applications. Alaska Department of Fish and Game, Fishery Data Series No. 90-43, Anchorage, Alaska.

_____. 1991. Annual summary of Alaska Department of Fish and Game instream flow reservation applications. Alaska Department of Fish and Game, Fishery Data Series No. 91-65, Anchorage, Alaska.

_____. 1992. Annual summary of Alaska Department of Fish and Game instream flow reservation applications. Alaska Department of Fish and Game, Fishery Data Series No. 92-45, Anchorage, Alaska.

Estes, C. C. and M. L. Harle. 1987. Alaska's instream flow program. Instream Flow Chronicle. Colorado State University. Ft. Collins, Colorado. IV(1):1-2.

Estes, C. C. and J. F. Orsborn. 1986. Review and analysis of methods for quantifying instream flow requirements. Water Resources Bulletin. 22(3):389-398.

Harle, M. L. 1988. Private appropriations of instream flows in Alaska. In: Instream Flow Protection in the Western United States: A Practical Symposium. Natural Resources Law Center. March 31 - April 1, 1988. University of Colorado School of Law. Boulder, Colorado.

Harrison, G. S. 1982. A citizen's guide to the constitution of Alaska. Institute of Social and Economic Research. University of Alaska. Anchorage, Alaska.

Hickel, W. J. 1993. Administrative order number 133. State of Alaska. Office of the Governor. Juneau, Alaska.

Instream Flow Committee. 1986. Memorandum to directors, October 1, 1986. Alaska Department of Fish and Game, Anchorage, Alaska.

Mills, M. J. 1979. Statewide harvest study. 1977 data. Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Performance Report 1978-1979, Project F-9-11, Volume 20 (SW-I-A), Juneau, Alaska.

_____. 1980. Statewide harvest study. 1978 data. Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Performance Report 1979-1980, Project F-9-12, Volume 21 (SW-I-A), Juneau, Alaska.

_____. 1981a. Statewide harvest study - 1979 data. Alaska Department of Fish and Game, Federal Aid in Fish Restoration and Anadromous Fish Studies, Annual Performance Report 1980-1981, Project F-9-13, Volume 22 (SW-I-A), Juneau, Alaska.

_____. 1981b. Statewide harvest study - 1980 data. Alaska Department of Fish and Game, Federal Aid in Fish Restoration and Anadromous Fish Studies, Annual Performance Report 1980-1981, Project F-9-13, Volume 22 (SW-I-A), Juneau, Alaska.

_____. 1982. Statewide harvest study - 1981 data. Alaska Department of Fish and Game, Federal Aid in Fish Restoration and Anadromous Fish Studies, Annual Performance Report 1981-1982, Project F-9-14, Volume 23 (SW-I-A), Juneau, Alaska.

_____. 1983. Statewide harvest survey. 1982 data. Alaska Department of Fish and Game, Federal Aid in Fish Restoration and Anadromous Fish Studies, Annual Performance Report 1982-1983, Project F-9-15, Volume 24 (SW-I-A), Juneau, Alaska.

_____. 1984. Statewide harvest survey. 1983 data. Alaska Department of Fish and Game, Federal Aid in Fish Restoration and Anadromous Fish Studies, Annual Performance Report 1983-1984, Project F-9-16, Volume 25 (SW-I-A), Juneau, Alaska.

_____. 1985. Statewide harvest report. 1984 data. Alaska Department of Fish and Game, Federal Aid in Fish Restoration and Anadromous Fish Studies, Annual Performance Report 1984-1985, Project F-9-17, Volume 26 (SW-I-A), Juneau, Alaska.

_____. 1986. Statewide harvest report. 1985 data. Alaska Department of Fish and Game, Federal Aid in Fish Restoration and Anadromous Fish Studies, Annual Performance Report 1985-1986, Project F-9-18, Volume 27 (RT-2), Juneau, Alaska.

_____. 1987. Alaska statewide sport fisheries harvest report. Alaska Department of Fish and Game, Fishery Data Series No. 2, Juneau, Alaska.

_____. 1988. Alaska statewide sport fisheries harvest report. Alaska Department of Fish and Game, Fishery Data Series No. 52, Juneau, Alaska.

_____. 1989. Alaska statewide sport fisheries harvest report, 1988. Alaska Department of Fish and Game, Fishery Data Series No. 122, Juneau, Alaska.

_____. 1990. Harvest and participation in Alaska sport fisheries during 1989. Alaska Department of Fish and Game, Fishery Data Series No. 90-44, Anchorage, Alaska.

_____. 1991. Harvest, catch, and participation in Alaska sport fisheries in 1990. Alaska Department of Fish and Game, Fishery Data Series No. 91-58, Anchorage, Alaska.

_____. 1992. Harvest, catch, and participation in Alaska sport fisheries in 1991. Alaska Department of Fish and Game, Fishery Data Series No. 92-40, Anchorage, Alaska.

Orsborn, J. F. and F. J. Watts. 1980. Hydraulics and hydrology for fisheries biologists. U.S. Fish and Wildlife Service, Fisheries Academy, Kearneysville, Virginia.

Prokosch, G. 1993. Personal communication regarding water export and marketing legislation and activities. Alaska Department of Natural Resources. Division of Water. Anchorage, Alaska.

Reiser, D. W., M. P. Ramey, and T. R. Lambert. 1985. Review of flushing flow requirements in regulated streams. Pacific Gas and Electric Company. San Ramon, California.

SAS (SAS Institute Inc.). 1985. SAS guide for personal computers. Version 6 Edition. SAS Institute Inc. Cary, North Carolina.

Shaw, E. M., editor. 1988. Hydrology in practice. Van Nostrand Reinhold Co. Ltd., London, England.

Tennant, D. L. 1972. A method for determining instream flow requirements for fish, wildlife and aquatic environment. Pages 3-11 *in* Pacific Northwest River Basin Commission Transcript of Proceedings of Instream Flow Requirements Workshop, March 15-16, 1972. Pacific Northwest River Basin Commission, Portland, Oregon.

______. 1976. Instream flow regimes for fish, wildlife, recreation, and related environmental resources. Pages 359-373 *in* J. F. Orsborn and C. H. Allman, editors. Instream Flow Needs, Volume II, American Fisheries Society, Bethesda, Maryland.

Thompson, K. 1992. Alaska water-resources tidbits. U.S. Geological Survey. Water Resources Division. Anchorage, Alaska.

APPENDIX A

Appendix A1. Example of instream flow reservation application.

STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF LAND AND WATER MANAGEMENT

☐ Northcentral District
4420 Airport Way
Fairbanks, Alaska 99701
(907) 479-2243

☐ Southcentral District
Pouch 7-005
Anchorage, Alaska 99510
(907) 276-2653

☐ Southeastern District
230 S. Franklin, Room 407
Juneau, Alaska 99801
(907) 465-3400

OFFICE USE ONLY

LAS

APPLICATION FOR RESERVATION OF WATER

INSTRUCTIONS: This is an application to reserve a specific instream flow or level of water under AS 46.15.145 and 11 AAC 93.141-147. This application must be filled out completely and all requested attachments submitted with it. Failure to complete all parts of the application may result in return of the application. Attach extra pages to fully answer questions. If a report is attached as part of this application, indicate appropriate page numbers following each question. Submit this application to the district in which the proposed reservation is located (identified above). Please type or print in ink.

1. Full legal name of applicant(s): ____

   ____

2. Mailing Address: ____

   City: ____________________ State: __________ Zip: __________

   Business Phone: ____________________ Home Phone: ____________________

3. Name of the stream or water body in which water is proposed to be reserved:

   ____

4. Location of the proposed reservation of water:

   (a) List ALL sections, townships, ranges and meridians from the beginning to the end of the stream segment and for all parts of the lake or waterbody in which water is requested to be reserved. (Attach extra pages if needed.)

   ____

   ____

   ____

   ____

p. 1 of 4

10-1151 (11/83)

-continued-

(b) Describe the location of the point or points defining the boundary of the proposed reservation of water by river mile index, river mile, geographical or cultural landmark, etc., on the stream or water body. (Attach extra pages if needed.) ______________________

____

____

____

____

(c) ATTACH a U.S. Geological Survey map at 1:63,360 scale, or 1:250,000 scale if 1:63,360 scale is unavailable for the area, clearly identifying the following for the proposed reservation of water:

(1) Sections, townships, ranges and meridians

(2) The stream or water body in which the reservation of water is proposed

(3) Specific point or points defining the boundary of the proposed reservation of water

(4) Permanent, temporary or planned locations of water measurement devices (such as gaging stations, weirs, staff gages)

(5) Permanent, temporary or planned bench marks

5. (a) Identify the purpose(s) of the proposed reservation of water by checking the appropriate box(es).

[ ] protection of fish and wildlife habitat, migration, and propagation

[ ] recreation and park purposes

[ ] navigation and transportation purposes

[ ] sanitary and water quality purposes

(b) Describe in detail the purpose(s) of the proposed reservation, including, when appropriate; species and life stage, type of recreation, vehicle, or water quality parameter, or other relevant information. (Attach extra page if needed.) ______________________

____

____

____

____

____

p. 2 of 4

10-1151 (11/83)

-continued-

6. Is the water currently being used for the purpose(s) applied for?

[ ] Yes.

[ ] No. If no, when will use for this purpose begin? Specify approximate date. ______________________________

7. (a) Water requested to be reserved (check one):

[ ] to maintain a specific instream flow rate, measured in cubic feet per second

[ ] to maintain a specific level of surface water, measured in cubic feet or acre feet

[ ] to maintain a specific surface water elevation, measured in relation to a permanent benchmark

(b) Quantify the specific amount of water requested to be reserved: Identify and quantify, as appropriate; flow rates, quantities, surface water elevations, depths, etc., as they relate to the daily durations and months of the year during which the reservation is proposed. Include any flow release schedules from projects upstream of the proposed reservation that would apply. (Attach extra pages if needed.)

____
____
____
____
____
____
____
____
____
____
____
____

8. Attach and submit with this application documentation or reports showing facts to support the following:

(a) The need for the proposed reservation of water, including reasons why the reservation is being requested.

-continued-

(b) Identify and describe the methodology, data, and data analysis used to substantiate the need for and the quantity of water requested for the proposed reservation of water, including:

(1) Name and description of method used,

(2) Who conducted the study and analysis,

(3) Schedule of when data collection and analysis occurred,

(4) Type(s) of instrument(s) used to collect and analyze data,

(5) Description of data and how the data was collected, including when applicable, (A) selection of stream reach, study site and transect selection, (B) flow, survey, elevation, and depth measurements, (C) pertinent physical, biological, water chemistry and socio-economic data,

(6) Description of how data was analyzed, and

(7) Maps, photos, aerial photos, calculations, and any other documents supporting this application.

9. If there are provisions for monitoring this proposed reservation of water, include the following:

(a) Description of monitoring equipment (such as gaging stations, staff gages, weirs)
(b) Location of monitoring equipment
(c) Provisions for payment of monitoring
(d) Reporting system

Statements contained in this application are true and correct to the best of my knowledge.

Signed ______________________________
Applicant(s) Full Legal Name(s)

Date ______________________________

p. 4 of 4

10-1151 (11/83)

-continued-

Summary of Application Form Requirements

Among the specific information an applicant must include with an application form to reserve instream flows for fish are:

- maps and legal descriptions identifying the upstream and downstream boundaries of the instream flow reservation area (rivers and streams)

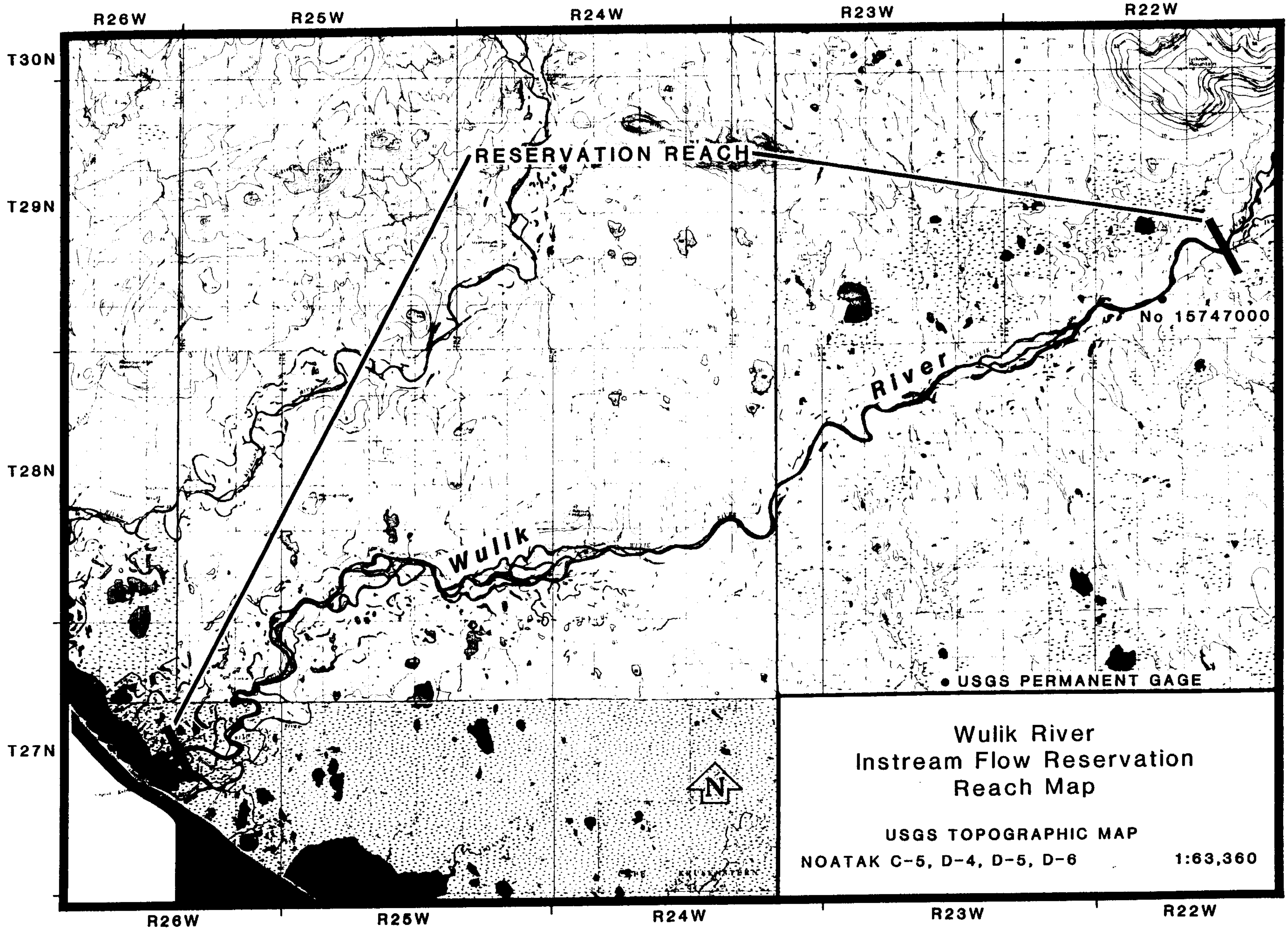
- maps and legal descriptions identifying the boundaries of the instream flow reservation area including inflows and outflows (lakes)

- maps and legal descriptions of benchmarks and gaging stations within the reservation area.

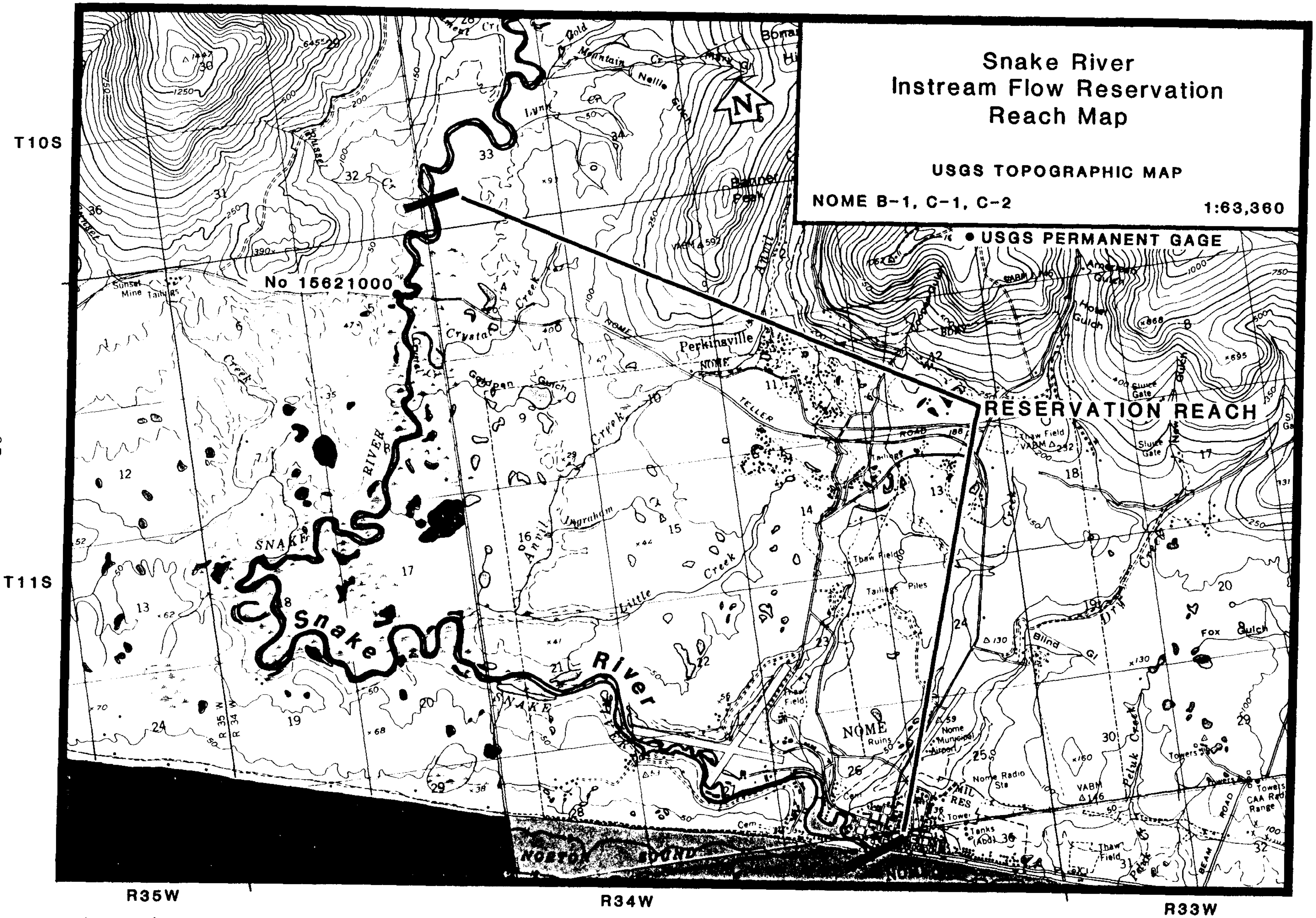
- the natural hydrology specific to the portion of the water body to be reserved. For rivers and streams, an applicant is required, at a minimum, to use the best available data at the time of application submittal to calculate the mean annual flow and if available mean monthly flow. When sufficient data are not available, an estimate of mean annual flow using acceptable hydrologic methods must be provided. Minimum data requirements for reserving a depth (stage), or volume of water within a lake are: maximum surface area, water and volume capacity or estimates, and if available, bathymetry.

- a description of each use and times of use for the water to be reserved (e.g., channel maintenance, individual fish species and seasonal occurrence by life phases: passage, spawning, incubation, and rearing, etc.) .

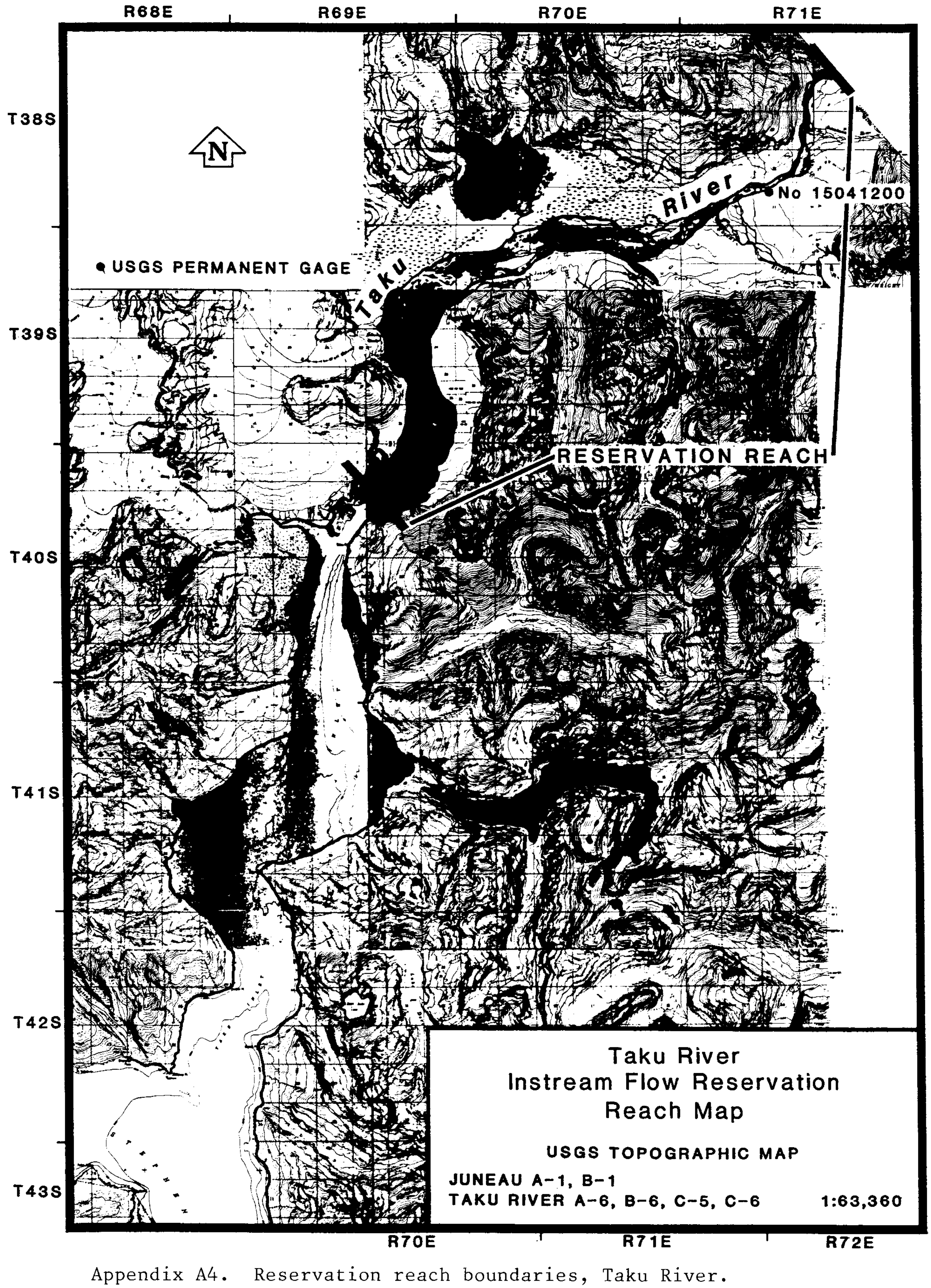
- the water quantities, stage or elevation requested during specific time periods accompanied by supporting documentation that justifies and describes the data and analyses utilized. Measurement unit requirements are: cubic feet per second (cfs), or cubic feet, acre feet, or an elevation relative to a permanent benchmark.



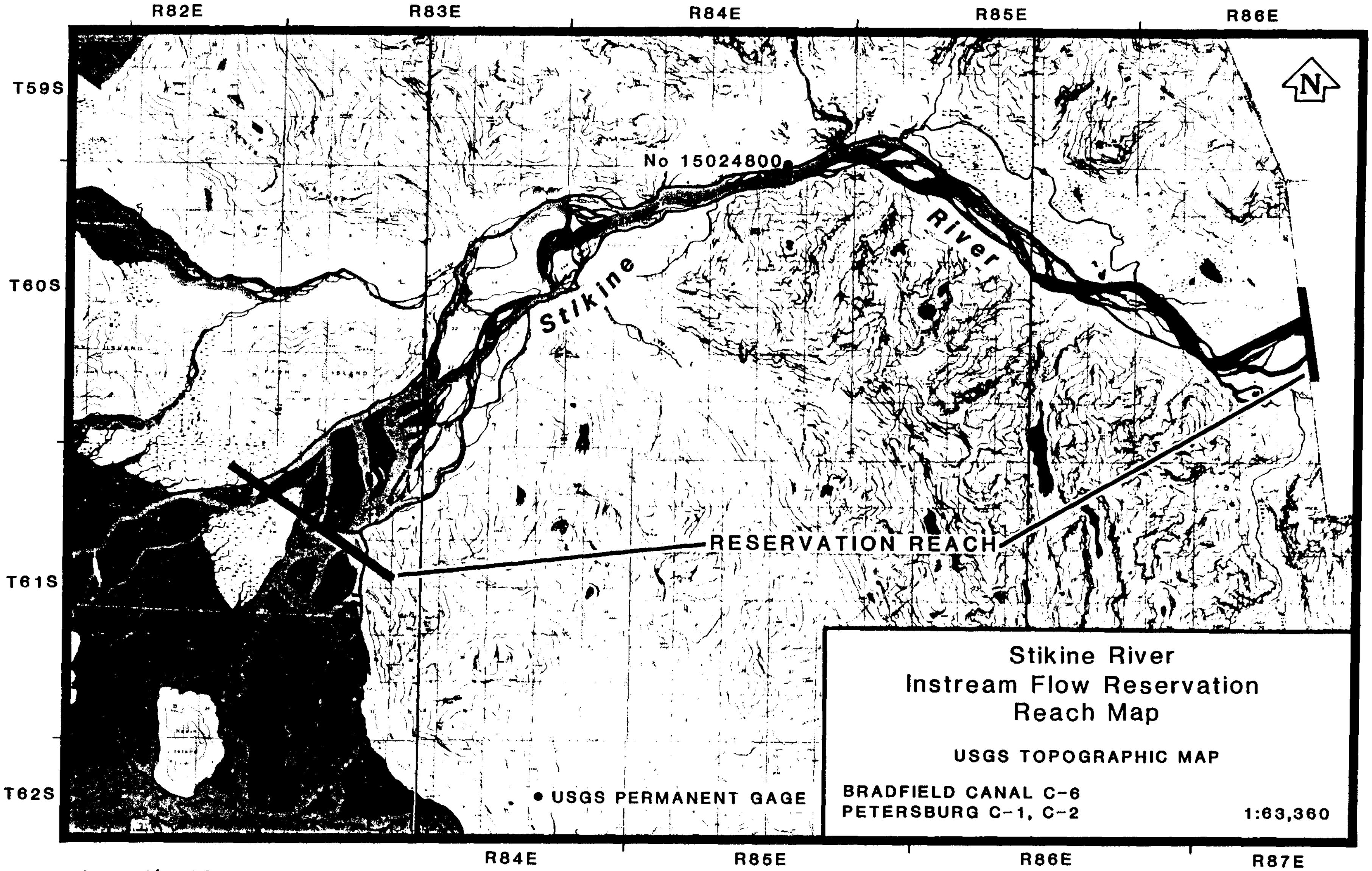
Appendix A2. Reservation reach boundaries, Wulik River.



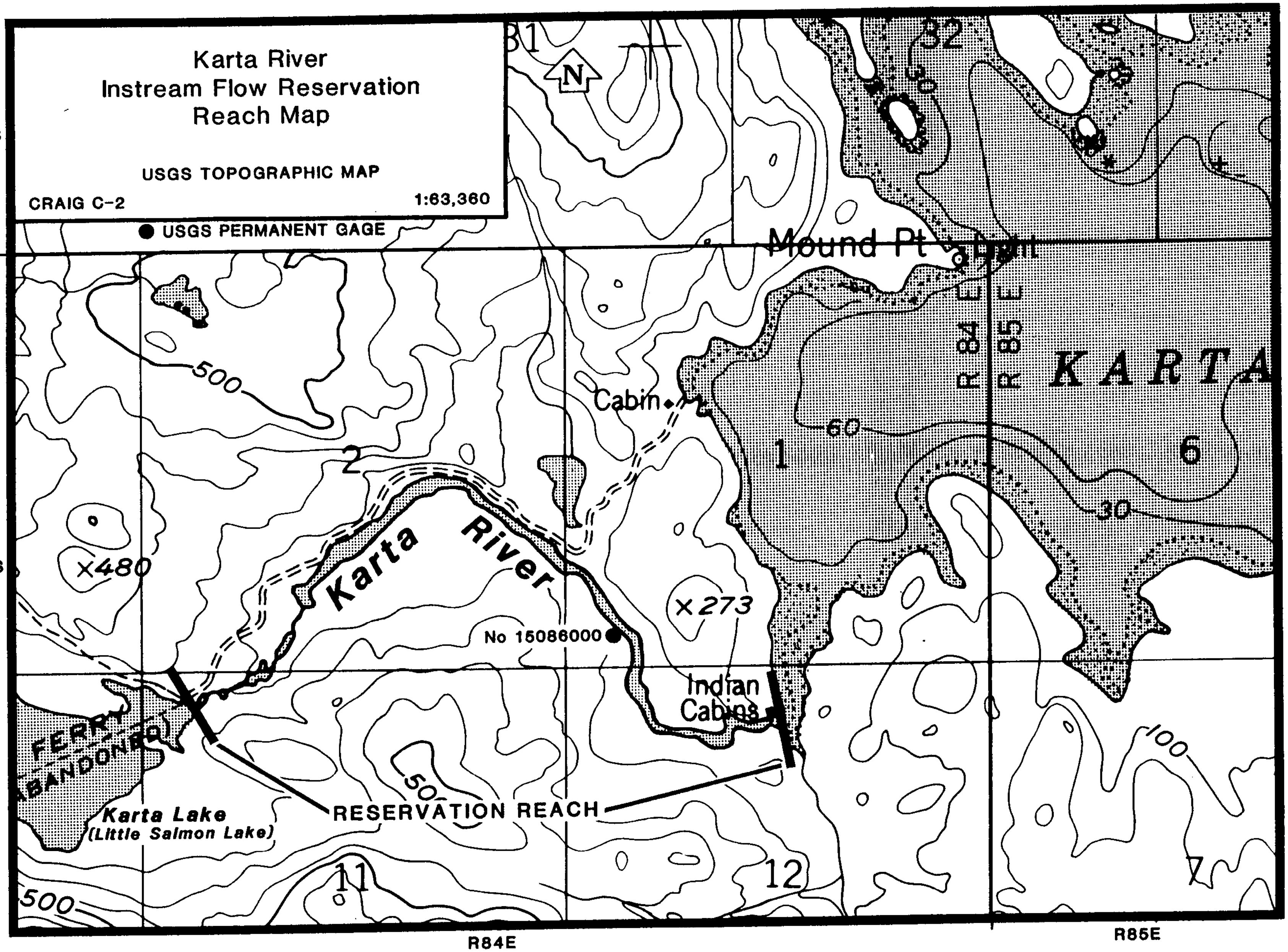
Appendix A3. Reservation reach boundaries, Snake River.



Appendix A4. Reservation reach boundaries, Taku River.



Appendix A5. Reservation reach boundaries, Stikine River.



Appendix A6. Reservation reach boundaries, Karta River.

Appendix A7. Species periodicity chart for Wulik River.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
COHO SALMON												
Passage								XXXX	XXXX	XXX		
Spawning								XX	XXXX	XXXX		
Incubation	XXXX	XXXX	XXXX	XXXX	XX?			XX	XXXX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
CHINOOK SALMON												
Passage							XXXX	X?				
Spawning							XX	XX?				
Incubation	XXXX	XXXX	XXXX	XXXX	XXXX	XXX	XX	XXXX	XXXX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
PINK SALMON												
Passage							XXXX	XXXX	X			
Spawning							XXX	XXXX	X?			
Incubation	XXXX	XXXX	XXXX	XXXX	XX		XXX	XXXX	XXXX	XXXX	XXXX	XXXX
Rearing					?XXX	XXXX	XXX?					
CHUM SALMON												
Passage							XXX	XXXX	XXX			
Spawning							XX	XXXX	XXXX	?		
Incubation	XXXX	XXXX	XXXX	XXXX	X?		XX	XXXX	XXXX	XXXX	XXXX	XXXX
Rearing					XXXX	XX??						
SOCKEYE SALMON												
Passage							XX	XXXX	XXXX	X?		
Spawning							X	XXXX	XXXX	XX?		
Incubation	XXXX	XXXX	XXXX	XXXX	XX?		X	XXXX	XXXX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
DOLLY VARDEN												
Passage	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Spawning							XX	XXXX	XXXX	XXX		
Incubation	XXXX	XXXX	XXXX	XXXX	XXXX	?	XX	XXXX	XXXX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
ARCTIC GRAYLING												
Passage	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Spawning					XXX	XXXX						
Incubation					XXX	XXXX	X?					
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
BURBOT												
Passage	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Spawning											?X	XXXX
Incubation	XX?										?X	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Based on professional judgment of ADF&G biologists.
Passage life phase for anadromous fish is immigration.
Passage life phase for resident fish includes immigration and emigration.
Incubation life phase includes period from egg deposition to fry emergence.
? = Data not available or timing information is incomplete.

-continued-

Appendix A7. (Page 2 of 2).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ROUND WHITEFISH												
Passage	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Spawning									?XX	XX?		
Incubation	XXXX	XXXX	XXXX	XXXX	?				XX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
HUMPBACK WHITEFISH												
Passage				?XX	XXXX	XXX?			XXXX	XXXX	XXX?	
Spawning					XXXX	XX				?X	XXXX	?
Incubation	XXXX	XXXX	XXXX	XXXX	XX					X	XXXX	XXXX
Rearing ?												
SLIMY SCULPIN												
Passage	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Spawning ?												
Incubation ?												
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Based on professional judgment of ADF&G biologists.
Passage life phase for anadromous fish is immigration.
Passage life phase for resident fish includes immigration and emigration.
Incubation life phase includes period from egg deposition to fry emergence.
? = Data not available or timing information is incomplete.

Appendix A8. Species periodicity chart for Snake River.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
COHO SALMON												
Passage								XXXX	XXXX	XXX		
Spawning								XX	XXXX	XXXX	XXXX	XXXX
Incubation	XXXX	XXXX	XXXX	XXXX	XX			XX	XXXX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
CHINOOK SALMON												
Passage							XXXX					
Spawning							?XX	XX?				
Incubation	XXXX	XXXX	XXXX	XXXX	XX		XX	XXXX	XXXX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
PINK SALMON												
Passage							XXXX	XXXX	X			
Spawning							XXX	XXXX	XX			
Incubation	XXXX	XXXX	XXXX	XXXX	XX		XXX	XXXX	XXXX	XXXX	XXXX	XXXX
Rearing					XX	XXXX	XX					
CHUM SALMON												
Passage							XXXX	XXXX	X			
Spawning							XX	XXXX	XXXX			
Incubation	XXXX	XXXX	XXXX	XXXX	XX		XX	XXXX	XXXX	XXXX	XXXX	XXXX
Rearing					XX	XXXX	XXXX					
ARCTIC GRAYLING												
Passage	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Spawning					XXX	XXXX						
Incubation					XXX	XXXX	X?					
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
DOLLY VARDEN												
Passage	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Spawning								XXXX	XXXX	XX		
Incubation	XXXX	XXXX	XXXX	XXXX	XX			XXXX	XXXX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
BURBOT												
Passage	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Spawning?											?X	XXXX
Incubation	XXXX	?									?X	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
ROUND WHITEFISH												
Passage	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Spawning									XX	XXXX		
Incubation	XXXX	XXXX	XXXX	XXXX	XX				X	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Based on professional judgment of ADF&G biologists.
Passage life phase for anadromous fish is immigration.
Passage life phase for resident fish includes immigration and emigration.
Incubation life phase includes period from egg deposition to fry emergence.
? = Data not available or timing information is incomplete.

-continued-

Appendix A8. (Page 2 of 2).

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
HUMPBACK WHITEFISH													
Passage					?XX	XXXX	XXX?			XXXX	XXXX	XXX?	
Spawning						XXXX	XX				?X	XXXX	?
Incubation		XXXX	XXXX	XXXX	XXXX	XX					X	XXXX	XXXX
Rearing	?												
SLIMY SCULPIN													
Passage		XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Spawning	?												
Incubation	?												
Rearing		XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Based on professional judgment of ADF&G biologists.
Passage life phase for anadromous fish is immigration.
Passage life phase for resident fish includes immigration and emigration.
Incubation life phase includes period from egg deposition to fry emergence.
? = Data not available or timing information is incomplete.

Appendix A9. Species periodicity chart for Taku River.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
COHO SALMON													
Passage I							X	XXXX	XXXX	XXXX	XXXX	????	??
Passage E					XXX	XXXX	XXXX	X					
Spawning	?	XX											
Incubation	?	XXXX	XXXX	XXXX	X								
Rearing		XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
SOCKEYE SALMON													
Passage I						X	XXXX	XXXX	XXXX	XXXX	X		
Passage E						XX	XXXX	XX					
Spawning	?												
Incubation	?												
Rearing		XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
CHINOOK SALMON													
Passage I					XXX	XXXX	XXXX	XXX					
Passage E					XXXX	XXXX	XXXX						
Spawning	?							XX	XXXX				
Incubation	?												
Rearing	?	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
PINK SALMON													
Passage I								XXXX	XXXX				
Passage E					XXXX	XX							
Spawning	?												
Incubation	?												
Rearing	?			XX	XX								
CHUM SALMON													
Passage I								XX	XXXX	XXXX	XXXX	X	
Passage E					XXXX	XX							
Spawning										XXXX	XXXX	XXXX	
Incubation		XXXX	XXXX	XXXX	XX					XX	XXXX	XXXX	XXXX
Rearing	?				XX	XX							
STEELHEAD TROUT													
Passage I					????	????				XXX	XXXX	XX	
Passage E					XX	XXXX	XXXX						
Spawning	?												
Incubation	?												
Rearing	?												

Based upon professional judgment of ADF&G biologists.
Passage I life phase for anadromous fish is immigration.
Passage E life phase for anadromous fish is emigration.
Passage life phase for resident fish includes immigration and emigration.
Incubation life phase includes period from egg deposition to fry emergence.
? = Data not available or timing is incomplete.

-continued-

Appendix A9. (Page 2 of 2).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CUTTHROAT TROUT												
Passage ?				XX	XXXX	XXXX						
Spawning ?												
Incubation ?												
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
DOLLY VARDEN												
Passage				XX	XXXX	XXXX		XXXX	XXXX	XXXX	XXXX	
Spawning?												
Incubation?												
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
ROUND WHITEFISH												
Passage ?								XXXX	XXXX			
Spawning ?												
Incubation ?												
Rearing ?												
EULACHON												
Passage				XX	XXXX	XXX						
Spawning					XXXX	XX						
Incubation					XXXX	XXXX	XXXX	XX				
Rearing ?												
SLIMY SCULPIN												
Passage ?												
Spawning ?												
Incubation ?												
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
3-SPINED STICKLEBACK												
Passage ?												
Spawning ?												
Incubation ?												
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
RIVER LAMPREY												
Passage				XXXX	XXXX	XX						
Spawning ?												
Incubation ?												
Rearing ?												

Based upon professional judgment of ADF&G biologists.
Passage I life phase for anadromous fish is immigration.
Passage E life phase for anadromous fish is emigration.
Passage life phase for resident fish includes immigration and emigration.
Incubation life phase includes period from egg deposition to fry emergence.
? = Data not available or timing is incomplete.

Appendix A10. Species periodicity chart for Stikine River.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
COHO SALMON													
Passage I							X	XXXX	XXXX	XXXX	XXXX	????	??
Passage E					XXX	XXXX	XXXX	X					
Spawning		XX							XX	XXXX	XXXX	XXXX	XXXX
Incubation		XXXX	XXXX	XXXX	X				X	XXXX	XXXX	XXXX	XXXX
Rearing		XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
SOCKEYE SALMON													
Passage I						X	XXXX	XXXX	XXXX	XXXX	X		
Passage E						XX	XXXX	XX					
Spawning	?								XX	XXXX	XX		
Incubation	?	XXXX	XXXX	XXXX	XXXX				X	XXXX	XXXX	XXXX	XXXX
Rearing		XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
CHINOOK SALMON													
Passage I					XXX	XXXX	XXXX	XXX					
Passage E					XXXX	XXXX	XXXX						
Spawning	?							XX	XXXX				
Incubation	?	XXXX	XXXX	XXXX	XXXX	XX		X	XXXX	XXXX	XXXX	XXXX	XXXX
Rearing		XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
PINK SALMON													
Passage I								XXXX	XXXX				
Passage E					XXXX	XX							
Spawning	?					XXXX	X						
Incubation	?	XXXX	XXXX	XX		X	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Rearing	?			XX	XX								
CHUM SALMON													
Passage I								XX	XXXX	XXXX	XXXX		
Passage E					XXXX	XX							
Spawning										XXXX	XXXX	XXXX	
Incubation		XXXX	XXXX	XXXX	XX					XX	XXXX	XXXX	XXXX
Rearing	?				XX	XX							
STEELHEAD TROUT													
Passage I					????	????				XXX	XXXX	XX	
Passage E					XX	XXXX	XXXX						
Spawning	?												
Incubation	?												
Rearing	?												

Based upon professional judgment of ADF&G biologists.
Passage I life phase for anadromous fish is immigration.
Passage E life phase for anadromous fish is emigration.
Passage life phase for resident fish includes immigration and emigration.
Incubation life phase includes period from egg deposition to fry emergence.
? = Data not available or timing is incomplete.

-continued-

Appendix A10. (Page 2 of 2).

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CUTTHROAT TROUT													
Passage	?				XX	XXXX	XXXX						
Spawning	?												
Incubation	?												
Rearing		XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
DOLLY VARDEN													
Passage					XX	XXXX	XXXX		XXXX	XXXX	XXXX	XXXX	
Spawning	?												
Incubation	?												
Rearing		XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
ROUND WHITEFISH													
Passage	?								XXXX	XXXX			
Spawning	?												
Incubation	?												
Rearing	?				X	XXXX	XXXX						
EULACHON													
Passage					XX	XXXX	XXX						
Spawning						XXXX	XX						
Incubation						XXXX	XXXX	XXXX	XX				
Rearing	?												
SLIMY SCULPIN													
Passage	?												
Spawning	?												
Incubation	?												
Rearing		XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
3-SPINED STICKLEBACK													
Passage	?												
Spawning	?												
Incubation	?												
Rearing		XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
RIVER LAMPREY													
Passage					XXXX	XXXX	XX						
Spawning	?												
Incubation	?												
Rearing	?												

Based upon professional judgment of ADF&G biologists.
Passage I life phase for anadromous fish is immigration.
Passage E life phase for anadromous fish is emigration.
Passage life phase for resident fish includes immigration and emigration.
Incubation life phase includes period from egg deposition to fry emergence.
? = Data not available or timing is incomplete.

Appendix A11. Species periodicity chart for Karta River.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CHUM SALMON												
Passage							XXXX	XXXX	XXXX			
Spawning									XXXX			
Incubation	XXXX	XXXX	XXXX	XX					XXXX	XXXX	XXXX	XXXX
Rearing			XX	XXXX	XX							
COHO SALMON												
Passage						X	XXXX	XXXX	XXXX	XXXX	XXXX	
Spawning									X	XXXX	XXXX	XX
Incubation	XXXX	XXXX	XXXX	XXXX	XXXX	XX			X	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
PINK SALMON												
Passage							XXXX	XXXX				
Spawning ?							XXXX	XXXX				
Incubation	XXXX	XXXX	XXXX	XXXX			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Rearing			XX	XXXX	XX							
SOCKEYE SALMON												
Passage						XX	XXXX	XXXX	XX			
Spawning								XX	XXXX	XXXX		
Incubation	XXXX	XXXX	XXXX	XXXX				XX	XXXX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
STEELHEAD TROUT												
Passage I	XXXX	XXXX	XXXX	XXXX	XXXX	XX				XXXX	XXXX	XXXX
Passage E					XXXX	XXXX	XX					
Spawning			XXXX	XXXX	XXXX	XX						
Incubation			XXXX	XXXX	XXXX	XXXX	XXX					
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
CUTTHROAT TROUT												
Passage					XX	XXXX	XXXX			XXXX	XXXX	
Spawning					XX	XXXX	XXXX					
Incubation					XX	XXXX	XXXX	XXXX	XXXX			
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
DOLLY VARDEN												
Passage				XX	XXXX	XXXX		XXXX	XXXX	XXXX	XXXX	
Spawning ?									XXXX	XXXX		
Incubation	XXXX	XXXX	XXXX	XX					XXXX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Based upon professional judgment of ADF&G biologists.
Passage I life phase for anadromous fish is immigration.
Passage E life phase for anadromous fish is emigration.
Passage life phase for resident fish includes immigration and emigration.
Incubation life phase includes period from egg deposition to fry emergence.
? = Data not available or timing is incomplete.

-continued-

Appendix A11. (Page 2 of 2).

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RAINBOW TROUT													
Passage	?												
Spawning						XX	XXXX	XXXX					
Incubation						XX	XXXX	XXXX	XXXX	XXXX			
Rearing		XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
SLIMY SCULPIN													
Passage	?												
Spawning	?												
Incubation	?												
Rearing		XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Based upon professional judgment of ADF&G biologists.
Passage I life phase for anadromous fish is immigration.
Passage E life phase for anadromous fish is emigration.
Passage life phase for resident fish includes immigration and emigration.
Incubation life phase includes period from egg deposition to fry emergence.
? = Data not available or timing is incomplete.

Appendix A12. Common and scientific names of fishes identified in periodicity charts (Appendices A7-A11).

COMMON NAME	SCIENTIFIC NAME
Arctic grayling	*Thymallus arcticus*
Burbot	*Lota lota*
Chinook salmon	*Oncorhynchus tshawytscha*
Chum salmon	*Oncorhynchus keta*
Coho salmon	*Oncorhynchus kisutch*
Cutthroat trout	*Oncorhynchus clarki*
Dolly Varden	*Salvelinus malma*
Eulachon	*Thaleichthys pacificus*
Humpback whitefish	*Coregonus pidshian*
Northern pike	*Esox lucius*
Pink salmon	*Oncorhynchus gorbuscha*
Rainbow Trout	*Oncorhynchus mykiss*
River lamprey	*Lampetra ayresi*
Round whitefish	*Prosopium cylindraceum*
Slimy sculpin	*Cottus cognatus*
Sockeye salmon	*Oncorhynchus nerka*
Steelhead	*Oncorhynchus mykiss*
Threespine stickleback	*Gasterosteus aculeatus*

Appendix A13. Summary of hydrologic data for 1993 instream flow reservation applications.

STREAM/REACH	USGS SITE NUMBER	YEARS OF DAILY FLOW RECORD
Wulik River below Tutak Creek	15747000	1985-1992
Snake River near Nome	15621000	1965-1990
Stikine River	15024800	1976-1991
Taku River near Juneau	15041200	1987-1991
Karta River near Kasaan	15024800	1915-1922

Appendix A14. Tennant Method analysis for Wulik River.

Tennant Method Flow Classifications (adapted from Tennant 1975)

Narrative Description of Flows	Seasonal Base Flow (Q) Regimens as Percentages (%) of Average Annual Flow (QAA)	
Location	Wulik River	
	% of QAA	Flow (cfs)
Month	Dec.- Mar.	
QAA	100	979
Flushing or Maximum	200	1958
Optimum Range	60-100	587-979
Outstanding	40	392
Excellent	30	294
Good	20	196
Fair or Degrading	10	98
Poor or Minimum	10	98
Severe Degradation	<10	<98
Month	Apr.- Nov.	
QAA	100	979
Flushing or Maximum	200	1958
Optimum Range	60-100	587-979
Outstanding	60	587
Excellent	50	490
Good	40	392
Fair or Degrading	30	294
Poor or Minimum	10	98
Severe Degradation	<10	<98

Monthly Flow Characteristics

Month	Long-term Mean Monthly Flow (cfs)
Jan	37
Feb	26
Mar	20
Apr	17
May	1090
Jun	3483
Jul	2112
Aug	2499
Sep	1630
Oct	605
Nov	128
Dec	62

Appendix A15. Tennant Method analysis for Snake River.

Tennant Method Flow Classifications (adapted from Tennant 1975)

Narrative Description of Flows	Seasonal Base Flow (Q) Regimens as Percentages (%) of Average Annual Flow (QAA)	
Location	Snake River	
	% of QAA	Flow (cfs)
Month	Jan.- Apr.	
QAA	100	188
Flushing or Maximum	200	376
Optimum Range	60-100	113-188
Outstanding	40	75
Excellent	30	56
Good	20	38
Fair or Degrading	10	19
Poor or Minimum	10	19
Severe Degradation	<10	<19
Month	May - Dec.	
QAA	100	188
Flushing or Maximum	200	376
Optimum Range	60-100	113-188
Outstanding	60	113
Excellent	50	94
Good	40	75
Fair or Degrading	30	56
Poor or Minimum	10	19
Severe Degradation	<10	<19

Monthly Flow Characteristics

Month	Long-term Mean Monthly Flow (cfs)
Jan	29
Feb	24
Mar	22
Apr	23
May	406
Jun	646
Jul	231
Aug	250
Sep	307
Oct	208
Nov	73
Dec	39

Appendix A16. Tennant Method analysis for Taku River.

Tennant Method Flow Classifications (adapted from Tennant 1975)

Narrative Description of Flows	Seasonal Base Flow (Q) Regimens as Percentages (%) of Average Annual Flow (QAA)	
Location	Taku River	
	% of QAA	Flow (cfs)
Month	Nov.- Mar.	
QAA	100	14640
Flushing or Maximum	200	29200
Optimum Range	60-100	8784-14640
Outstanding	40	5856
Excellent	30	4392
Good	20	2928
Fair or Degrading	10	1464
Poor or Minimum	10	1464
Severe Degradation	<10	<1464
Month	Apr.- Nov.	
QAA	100	14640
Flushing or Maximum	200	29280
Optimum Range	60-100	8784-14640
Outstanding	60	8784
Excellent	50	7320
Good	40	5856
Fair or Degrading	30	4392
Poor or Minimum	10	1464
Severe Degradation	<10	<1464

Monthly Flow Characteristics

Month	Long-term Mean Monthly Flow (cfs)
Jan	1973
Feb	1812
Mar	1855
Apr	4840
May	24538
Jun	36608
Jul	31997
Aug	28381
Sep	21329
Oct	12171
Nov	4849
Dec	3662

Appendix A17. Tennant Method analysis for Stikine River.

Tennant Method Flow Classifications (adapted from Tennant 1975)

Narrative Description of Flows	Seasonal Base Flow (Q) Regimens as Percentages (%) of Average Annual Flow (QAA)	
Location	Stikine River	
	% of QAA	Flow (cfs)
Month	Dec.- Mar.	
QAA	100	56731
Flushing or Maximum	200	113462
Optimum Range	60-100	34039-56731
Outstanding	40	22692
Excellent	30	17019
Good	20	11346
Fair or Degrading	10	5673
Poor or Minimum	10	5673
Severe Degradation	<10	<5673
Month	Apr. - Nov.	
QAA	100	56731
Flushing or Maximum	200	113462
Optimum Range	60-100	34039-56731
Outstanding	60	34039
Excellent	50	28366
Good	40	22692
Fair or Degrading	30	17019
Poor or Minimum	10	5673
Severe Degradation	<10	<5673

Monthly Flow Characteristics

Month	Long-term Mean Monthly Flow (cfs)
Jan	12248
Feb	9687
Mar	9143
Apr	15572
May	65912
Jun	135553
Jul	138758
Aug	111282
Sep	78477
Oct	62134
Nov	26579
Dec	13744

Appendix A18. Tennant Method analysis for Karta River.

Tennant Method Flow Classifications (adapted from Tennant 1975)

Narrative Description of Flows	Seasonal Base Flow (Q) Regimens as Percentages (%) of Average Annual Flow (QAA)	
Location	Karta River	
	% of QAA	Flow (cfs)
Month	Jan.- Mar.	
QAA	100	484
Flushing or Maximum	200	968
Optimum Range	60-100	290-484
Outstanding	40	194
Excellent	30	145
Good	20	976
Fair or Degrading	10	48
Poor or Minimum	10	48
Severe Degradation	<10	<48
Month	Apr.- Dec.	
QAA	100	484
Flushing or Maximum	200	968
Optimum Range	60-100	290-484
Outstanding	60	290
Excellent	50	242
Good	40	194
Fair or Degrading	30	145
Poor or Minimum	10	48
Severe Degradation	<10	<48

Monthly Flow Characteristics

Month	Long-term Mean Monthly Flow (cfs)
Jan	478
Feb	376
Mar	160
Apr	508
May	630
Jun	487
Jul	226
Aug	238
Sep	407
Oct	759
Nov	866
Dec	513