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

by

Christopher C. Estes

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Division of Sport Fish

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ABSTRACT

This report summarizes the principal instream flow activities of the Alaska Department of Fish and Game during the sixth year of its program, reviews the status of its instream flow applications filed in previous years, and summarizes Alaska legislation and regulations pertaining to instream flow protection.

Between July 1, 1991 and June 30, 1992, five instream flow analyses were completed for four water bodies. Reservation applications were completed for submittal to the Alaska Department of Natural Resources for Eagle River (Eagle River area), two reaches of the Chilkat River (Haines area), Lake Creek (Juneau area), and one reach of the Chena River (Fairbanks area).

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), 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).

Amendments to the Alaska Water Use Act, governing the sale and export of water, were passed by the Alaska Legislature and signed into law by Governor Walter J. Hickel in 1992.

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, 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, water legislation, House Bill 210, House Bill 353, House Bill 354, House Bill 355, House Bill 596, Senate Bill 442, water exports

INTRODUCTION

Alaska has abundant and diversified sport fisheries which are of considerable recreational importance. In 1991, for example, an estimated 425,025 anglers took 1.7 million household trips and fished 2.5 million angler days (Mills 1992). During this period, anglers caught 5.4 million fish (fish harvested plus fish released) and harvested 3.3 million. These values represent significant increases over those reported in the late seventies and early eighties (Mills 1979, 1980, 1981, 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. Forms required to apply for instream flows were made available by the DNR in November 1983.

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 sixth 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.

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, and whether existing hydrologic and biologic data for a stream reach were adequate for performing an instream flow analysis.

Five reaches (Appendices A2-5; Figure 1) were selected for instream flow analyses and preparation of instream flow reservations in Fiscal Year 1992 (FY 92, July 1, 1991 to June 30, 1992): Eagle River (Eagle River area), Lake Creek (Juneau area), two reaches of the Chilkat River (Haines area), and a reach of the Chena River (Fairbanks area). The first four sites were selected to acquire instream flow protection for fish production (spawning, incubation, rearing, and passage). The fifth site was selected for the purpose of applying for a flushing flow water right to maintain suitable channel characteristics and supplement an earlier instream flow reservation application filed for fish production (ADF&G 1988).

Stream reach boundaries for each FY 92 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) 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.

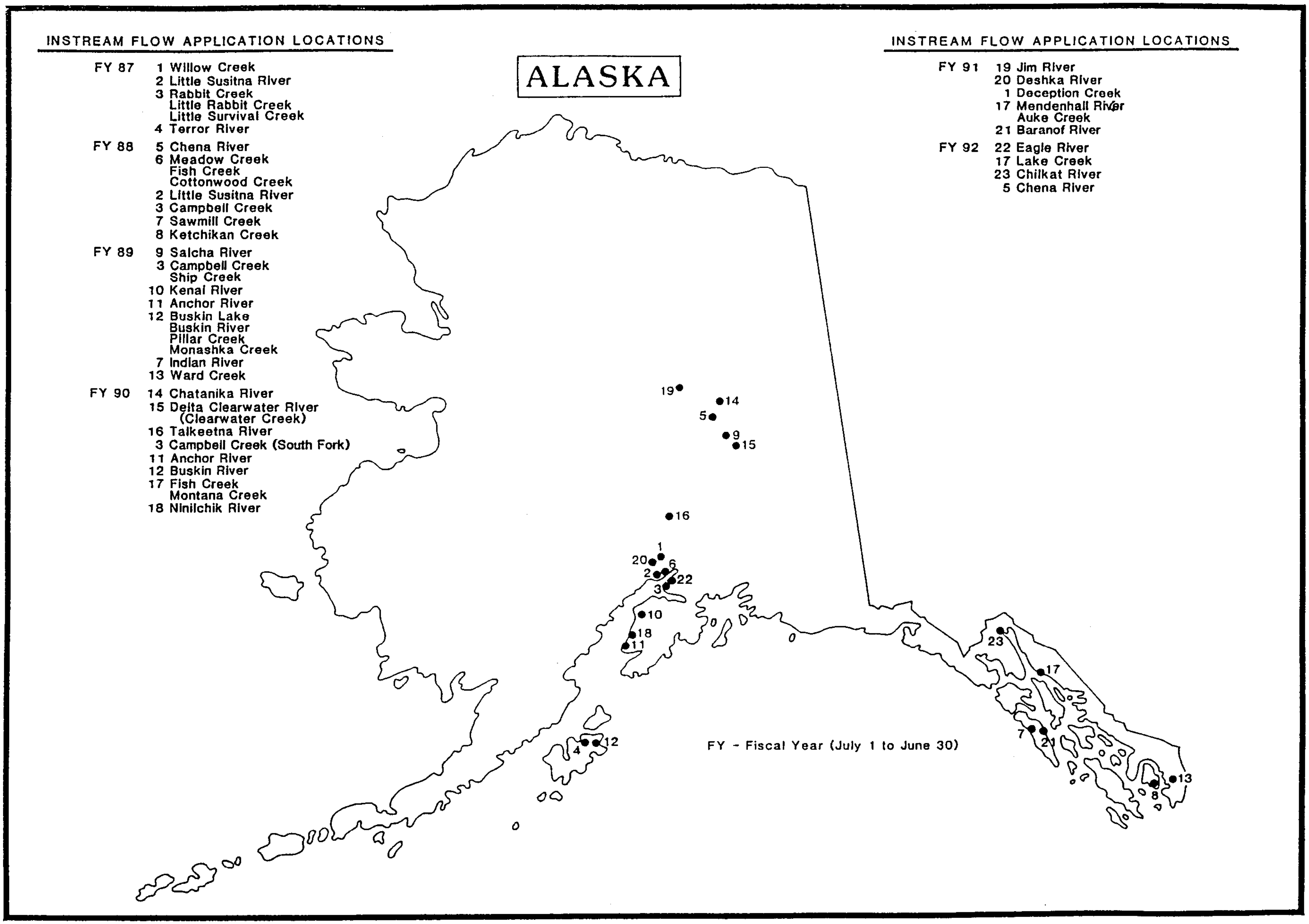

Figure 1. Alaska Department of Fish and Game instream flow reservation application locations, July 1, 1991 to June 30, 1992.

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 1991), and the Division of Sport Fish statewide harvest survey publication series (Mills 1979-1991). 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.

Two methods were chosen in FY 92: the Tennant Method, also referred to as the Montana Method (Tennant 1972, 1976) for Eagle River, Lake Creek, the two Chilkat River sites; and the Estes and Orsborn Method (Estes 1984; Reiser et al. 1985) for the flushing flow analysis for the Chena River site. Both analyses were 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 us to refine 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. In some instances the on-line programs of the USGS computer systems were used to calculate estimates directly (i.e., the flushing flow).

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.

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. Flushing flow recommendations were not calculated for the Eagle River, Lake Creek, Chilkat River-Reach A, and Chilkat Reach-B, sites due to insufficient resources to perform supplemental analyses suggested by research by Estes (1984).

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 for 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:

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

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:

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

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:

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

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.[1]

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.

Estes and Orsborn Method:

The Estes and Orsborn Method (Estes 1984; Reiser et al. 1985) was developed and selected as an alternative to the Tennant Method for estimating flushing flow requirements. Research by Estes (1984) suggests that the Tennant Method underestimated flushing flow requirements for Alaskan streams and rivers without calibration by flow quantity and duration. The choice of the Estes and Orsborn Method to quantify flushing flow requirements for the Chena River was also based on the availability of existing data.

For purposes of this analysis, the flushing flow was defined as the 2-year recurrence interval for the 7-day average flood (Q7F2) associated with bank full flow conditions (Reiser et al. 1985). This corresponded to the 50th percentile of the empirical distribution of the mean daily flows for the contiguous 7-day flow periods around the maximum annual flow for all years of record (non-flow regulated years only).

The 50th percentile was obtained as outlined above (equations 4a and 4b). On-line computer programs of the USGS were used to obtain the flushing flow estimate.

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 1992a, b, c, d, e).

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[1] 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.

RESULTS

Analyses were completed and applications prepared to request instream flow protection for fish in five stream reaches in four river systems (Figure 1, Appendices A2-A5; ADF&G 1992a, b, c, d, e): Eagle River (Eagle River area), Lake Creek (Juneau area), and two reaches of the Chilkat River (Haines area). 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 (Lake Creek, Appendix A3) to 24 miles (Chilkat River-Reach A, Appendix A4).

Fish periodicity for each stream is illustrated in Appendices A6-A10. Eagle River (Appendix A6) had the lowest variety of fish species (six) and the Chilkat River River-Reach A (Appendix A8) the most, with thirteen species each. Appendix A11 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 2 years for Chilkat River-Reach B to 31 years of the 43 years of record for Chena River Reach B (Appendix A12). We restricted our analysis to these 31 years of flow records for the Chena River because they represented the period prior to flow regulation.

QAA, mean monthly flow, and Tennant Method results are summarized in Appendices A13-A17. QAA values ranged from 13 cubic feet per second (cfs) for the Lake Creek reach (Appendix A14) to 3,262 cfs for Chilkat River-Reach A (Appendix A15). Mean monthly flows ranged from 3 cfs in Lake Creek during December and February (Appendix A14) to 9,023 cfs in Chilkat River-Reach A during July (Appendix A15). Optimum habitat flows ranged from 8-13 cfs for the Lake Creek reach (Appendix A14) to 1,957-3,262 cfs (Appendix A15) for Chilkat River-Reach A. Poor habitat flows ranged from 1 cfs for the Lake Creek Reach (Appendix A14) to 326 cfs for Chilkat River-Reach A (Appendix A15). Tennant flushing flow values ranged from 26 cfs for the Lake Creek reach (Appendix A14) to 6,524 cfs (Appendix A15) for Chilkat River-Reach A. Two flushing flow values were estimated for the Chena River (based on the duration of the flow) using the Estes and Orsborn Method. These flows ranged from 7,100 cfs for a 7-day duration to 8,960 cfs for a shorter 3-day period as compared to the recommended unadjusted 24-hour flow of 2,806 cfs calculated with the Tennant Method (Appendix A17).

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 1992a, b, c, d, e).

There is presently no legal mechanism for reserving flushing flows in unregulated streams and rivers in Alaska. Therefore, flushing flow values were not calculated for the Eagle River, Lake Creek, and two Chilkat 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.

Table 1. Status of Alaska Department of Fish and Game instream flow reservation applications, July 1, 1986 to June 30, 1992.

Instream Flow Application Location	Status
Willow Creek	Granted (July 8, 1988)
Little Susitna River (Upper Reach)	Granted (November 1, 1988)
Rabbit Creek	Granted (February 19, 1988)
Little Rabbit Creek	Granted (February 19, 1988)
Little Survival Creek	Granted (February 19, 1988)
Terror River	Granted (May 20, 1987)
Chena River-Reach A	In Process of Adjudication
Chena River-Reach B	In Process of Adjudication
Meadow Creek	In Process of Adjudication
Fish Creek-Reach A	In Process of Adjudication
Fish Creek-Reach B	In Process of Adjudication
Cottonwood Creek	Granted (May 15, 1991)
Little Susitna River (Middle Reach)	In Process of Adjudication
Campbell Creek (Middle Reach)	Granted (May 15, 1991)
Sawmill Creek	Pending Adjudication
Ketchikan Creek	Pending Adjudication
Salcha River	Pending Adjudication
Campbell Creek (Lower Reach)	Granted (June 28, 1990)
Campbell Creek (North Fork)	Pending Adjudication
Ship Creek	Pending Adjudication
Kenai River (Reach A)	Pending Adjudication
Kenai River (Reach B)	Pending Adjudication
Anchor River (Lower Reach)	Pending Adjudication
Buskin Lake	Pending Adjudication
Buskin River (Lower Reach)	Pending Adjudication
Pillar Creek	Pending Adjudication
Monashka Creek	Pending Adjudication
Indian River	Granted (August 3, 1990)
Ward Creek	Pending Adjudication
Chatanika River-Reach A	Pending Adjudication
Chatanika River-Reach B	Pending Adjudication
Delta Clearwater River	Pending Adjudication
(Clearwater Creek)	Pending Adjudication
Talkeetna River-Reach A	Pending Adjudication
Campbell Creek (South Fork)	Pending Adjudication
Buskin River-Reach B	Pending Adjudication
Anchor River-Reach B	Pending Adjudication
Fish Creek (near Juneau)	Pending Adjudication
Montana Creek (near Juneau)	Pending Adjudication
Ninilchik River-Reach A	Pending Adjudication
Jim River	Pending Adjudication
Deshka River	Pending Adjudication
Deception Creek	Pending Adjudication
Mendenhall River-Reach A	Pending Adjudication
Mendenhall River-Reach B	Pending Adjudication
Auke Creek	Pending Adjudication
Baranof River-Reach A	Pending Adjudication
Baranof River-Reach B	Pending Adjudication
Baranof River-Reach C	Pending Adjudication
Eagle River	In Preparation
Lake Creek	In Preparation
Chilkat River-Reach A	In Preparation
Chilkat River-Reach B	In Preparation
Chena River-Reach B (flushing flow)	In Preparation

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 92. This is half of the previous 5-year annual average of 10 applications (Figure 1; Table 1; Estes 1987, 1988, 1989, 1990, 1991). During the past 6 years, the ADF&G developed a cost-effective approach to acquire instream flow protection for fish by using the Tennant Method as the primary technique for analyzing instream flow needs. On occasion, more expensive methods for reserving instream flows were used and when necessary new procedures were developed and used to request specialized instream flow reservations (e.g., flushing flows, and water depth and area in lakes).

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 three 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 acceptance of the lake method remains unknown because the application is pending in the adjudication process. And, as part of our activities this year, we refined, tested and used a method for the first time to quantify and request flushing flows in streams and rivers that have flow control structures.

The DNR has received 55 applications for instream flows since passage of the 1980 enabling legislation (Estes 1987, 1988, 1989, 1990, 1991; Harle 1988). Forty-eight 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 Audobon Society, and two by private individuals. Only the 48 ADF&G applications and 1 BLM application 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, 1991), the significance of fish to recreation, subsistence, and our 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. Funding limitations restrict the number of gage sites that are active in any one year. Accordingly, only one-hundred-seventy-one of the Alaskan gage sites have continuous flow records of 10 or more years. Of these, it is estimated that 160 represent flow characteristics of undiverted or uncontrolled rivers. Another seventy sites have flow records of 5 to 9 years, and 119 have records representing less than five years (Thompson 1992; Emery 1989). Eighty-two USGS gage sites were operated in Alaska during 1991 (a 37 percent reduction from the number of active sites in 1972). This trend is alarming because the USGS considers a 10-year record as the minimum data base required to support 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.

These 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, 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, if we are to improve our efficiency and the accuracy of the information used to make decisions pertaining to water availability and allocation.

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 38 ADF&G applications and the additional FY 92 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. 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 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.

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 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 students at the University of Alaska at Fairbanks (belonging to the Arctic Unit of the Alaska Chapter of the American Fishery Society) to prepare an instream flow application which should soon be ready for submittal to the DNR. If the student application is accepted by the DNR, and a portion or all of the instream flow request granted, this will constitute the first instream flow water rights granted to a private entity in Alaska.

The above factors and the complexity of water law all contribute to the low number of applications filed. Some of these and related concerns have been improved by modifications to the DNR water management regulations (Alaska Administrative Code 1990, 1992) adopted in 1990 and 1992. Others are being addressed by the Alaska Legislature and an interagency federal, state, and local Water Management Council formed in 1992.

Among the beneficial regulatory changes is the addition of a new process that allows applicants to file an application for instream flows and acquire a priority date from the DNR before completing all of their data collection and analyses. To qualify, an applicant must estimate instream flow requirements and is granted 3 years (from the date of filing) to complete data collection and analyses. In spite of the advantages of this provision, a lack of DNR standards for substantiating estimates might prove to be a stumbling block for applicants. No one has tested this new procedure to date.

Another regulatory revision eliminated a stipulation (associated with the mandatory 10-year review) that had granted the DNR the option to place the burden for collecting and analyzing supplemental instream flow data on owners of instream flow water rights. This is a major improvement.

A new addition to the regulations requires applicants for out-of-stream water rights to quantify baseline seasonal flows when requesting more than 100,000 gallons per day (.05 cfs). A similar requirement for instream flow applicants has been in effect since 1983. This information will assist the DNR to balance an applicant's request with water availability for other out-of-stream and instream flow needs. It will also help prevent overappropriation from streams that are ungaged. The most recent modifications to the regulations increased the application fees for out-of-stream and diversionary water rights applications and revised a few definitions and temporary water use standards.

Three pieces of water related legislation (House Bills 353, 354, and 355) were introduced in the spring of 1991 by Representative Cliff Davidson of the Alaska Legislature (Davidson 1991a, b, c) to improve instream protection and water management processes. Legislation (Senate Bill 442) was also introduced by Governor Walter J. Hickel in 1992 to enable the state to market and sell water (Hickel 1992). All four failed to pass. However, at the end of the 1992 legislative session, House Bill (HB) 596, a bill containing a variety of license and user fee provisions, was amended to include portions of both HB 355 and Senate Bill 442 (House Finance Committee 1992). HB 596 was approved by both the legislature and governor and enacted into law in July.

House Bill (HB) 353 would have provided funding ($239,400) to the DNR to complete the automation of its water rights data base. Presently, the DNR must retrieve water rights information on a site by site basis. This is a time consuming process, does not allow for reach specific evaluations, and is subject to error. If funded someday, the automated system should enable the DNR to retrieve water ownership and status and related information on a stream reach basis in a relatively short period of time.

HB 354 would have provided-pass through matching funding ($242,000) to the USGS through the DNR to perform a surface water data network evaluation of the Alaska stream gaging program and database. The evaluation would have addressed the adequacy of the existing stream gage network, databases, and existing models used to estimate streamflows at ungaged sites. Recommendations and priorities for locating and maintaining existing and future gage sites would have been reported as one of the products of this legislation. Several gage sites would also have been funded by this legislation. Legislation similar to HB 354 would improve the ability of the ADF&G and other water data users to evaluate existing water quantity information and prioritize their support and requests for gaging sites.

HB 355 would have guaranteed the allocation of instream flow water rights for fish. This legislation had many similarities to instream flow legislation submitted by Representative Davidson 2 years ago (HB 210) which failed to pass

(Estes 1990). HB 355 would not have applied to public water supplies, single family domestic uses of water, non consumptive uses of water, and, in many instances, uses of groundwater of 5000 gallons per day or less. Unlike HB 210, HB 355 did not specify a formula and procedure for quantifying the amount of water that would be reserved for fish and wildlife. Before it was amended and died, HB 355 included a provision which would have also guaranteed instream flow protection to wildlife. It appears HB 355 would have also provided the legal mechanism to enable the DNR to require water use permits for diversions from bodies of water that are fish bearing or used by wildlife. Presently, the DNR does not manage water that is diverted from a stream or river when the water is not put to a use and does not harm another water right holder. Therefore, had HB 355 passed, fish and wildlife would have acquired legal water rights and qualified for automatic protection from harmful diversions.

Three sections of the newly enacted HB 596 relate to the Water Use Act (AS 46): Sections 30, 31, and 32. These provisions will only apply when water is removed from a Hydrologic Unit and not returned to that same Hydrologic Unit. Hydrologic Units are defined in the bill as the Subregion category established by the USGS. Alaska is subdivided into six subregions: Arctic Slope, Northwest, Southwest, Yukon, Southcentral, and Southeast (Figure 2). The bill includes stipulations that are intended to prevent the export of water from a hydrologic unit unless it can be demonstrated that the remaining water would be adequate to provide sufficient instream flows for fish in addition to supporting other instream and offstream uses. However, these safeguards could be negated by other mechanisms that allow the Commissioner of the Department of Natural Resources to adjust the instream flow protection after acquiring input from the public and the Commissioner of the Department of Fish and Game. The next process that will determine the impact of this law will be to develop and approve regulations. They too, will further define the effectiveness of this law for protecting instream flows.

The large size of each of the six subregions probably means this new law will have little or no impact on uses of water within the state, or the majority of water appropriations. The legislation and future regulations will instead primarily affect the administration's efforts to market Alaska's water to other states and countries. Ironically, two water export applications were filed by Sun Belt, a California based company, prior to the passage of HB 596. The applications are pending, and if approved by the DNR, will enable Sun Belt to 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.

Perhaps solutions to these and other water related concerns can be achieved by the newly formed Water Management Council. The Water Management Council was established to improve water management through better interagency coordination and cooperation.

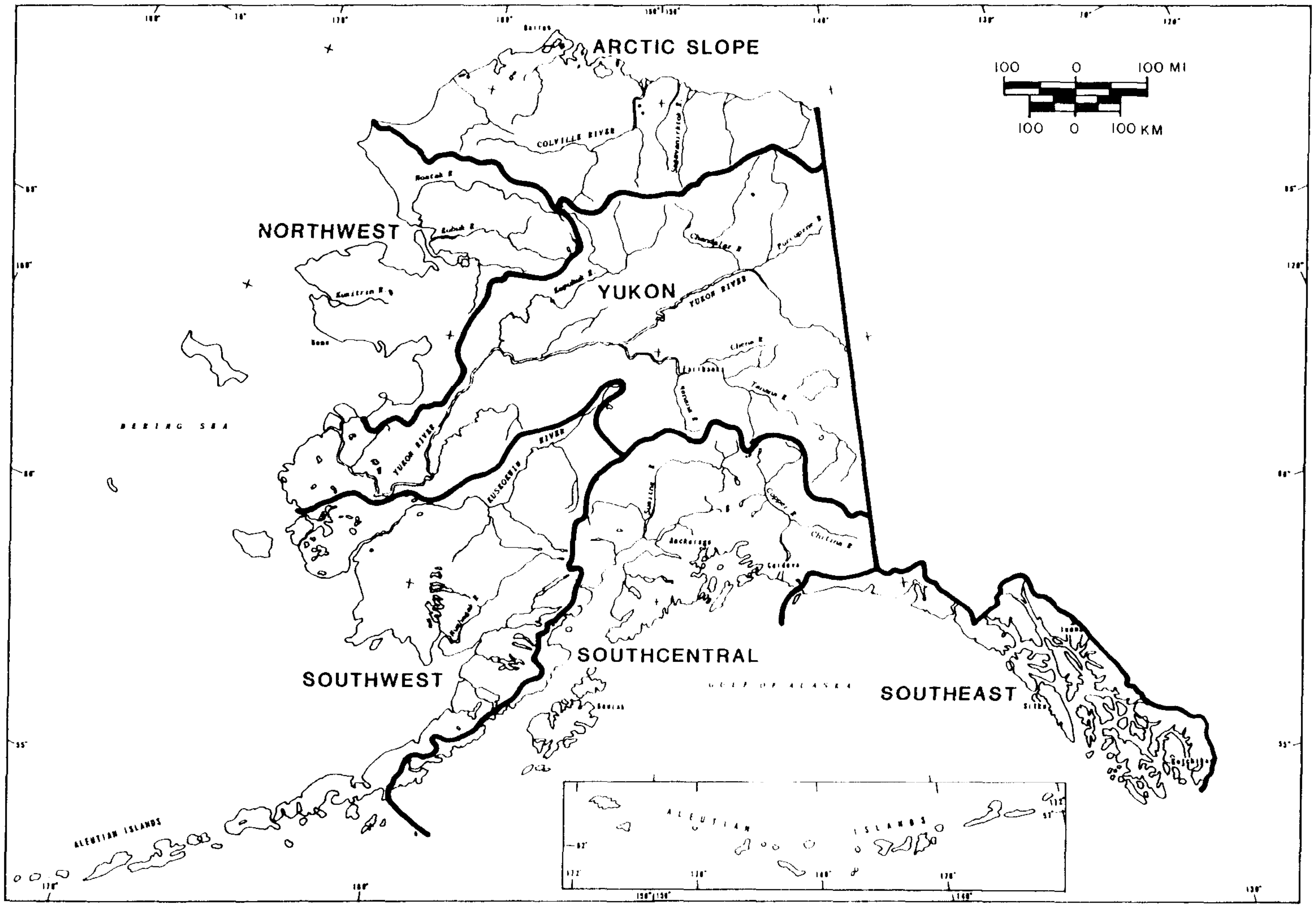

Figure 2. Hydrologic subregions of Alaska.

Based upon the experiences of the ADF&G, the following six 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 improve the USGS stream gaging station network and to evaluate the precision and accuracy of hydrologic models used to estimate flow characteristics for ungaged sites in Alaska. Additional data collection sites should be funded based upon the network evaluation 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.

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, Gary Sanders, Larry Engel, 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 Karcz, 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, Joe Torava (USGS) who provided hydrologic analysis support; and William Beck (Marine Solution Services Inc.) who provided editorial suggestions are all appreciated.

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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.)

   ____

   ____

   ____

   ____

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-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.) ____________

____

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____

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____

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-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.)

____

____

____

____

____

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____

____

____

____

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 ______________________________

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-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)

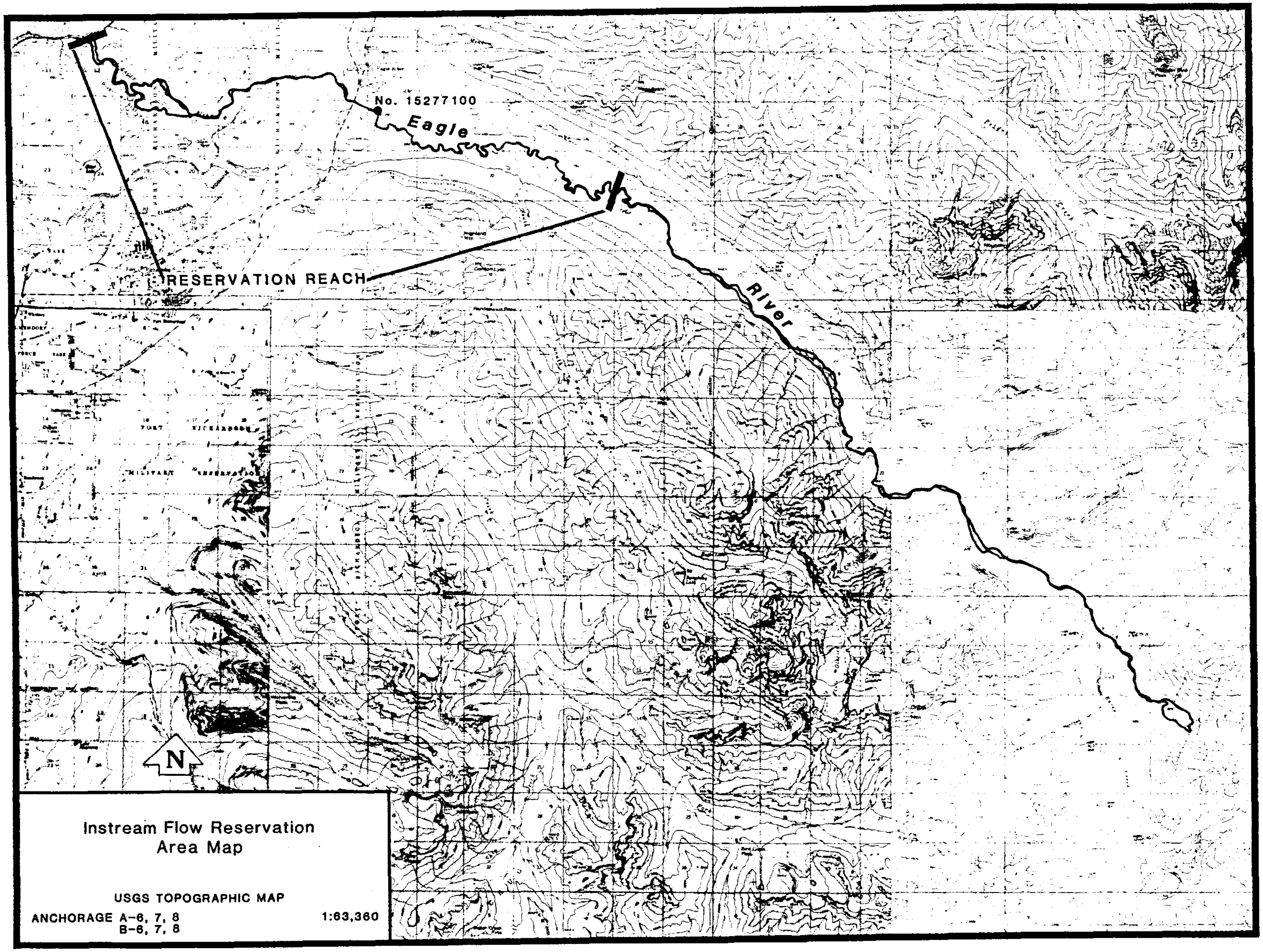
- maps and legal descriptions identifying the boundaries of the instream flow reservation area including inflows and outflows (lakes)

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

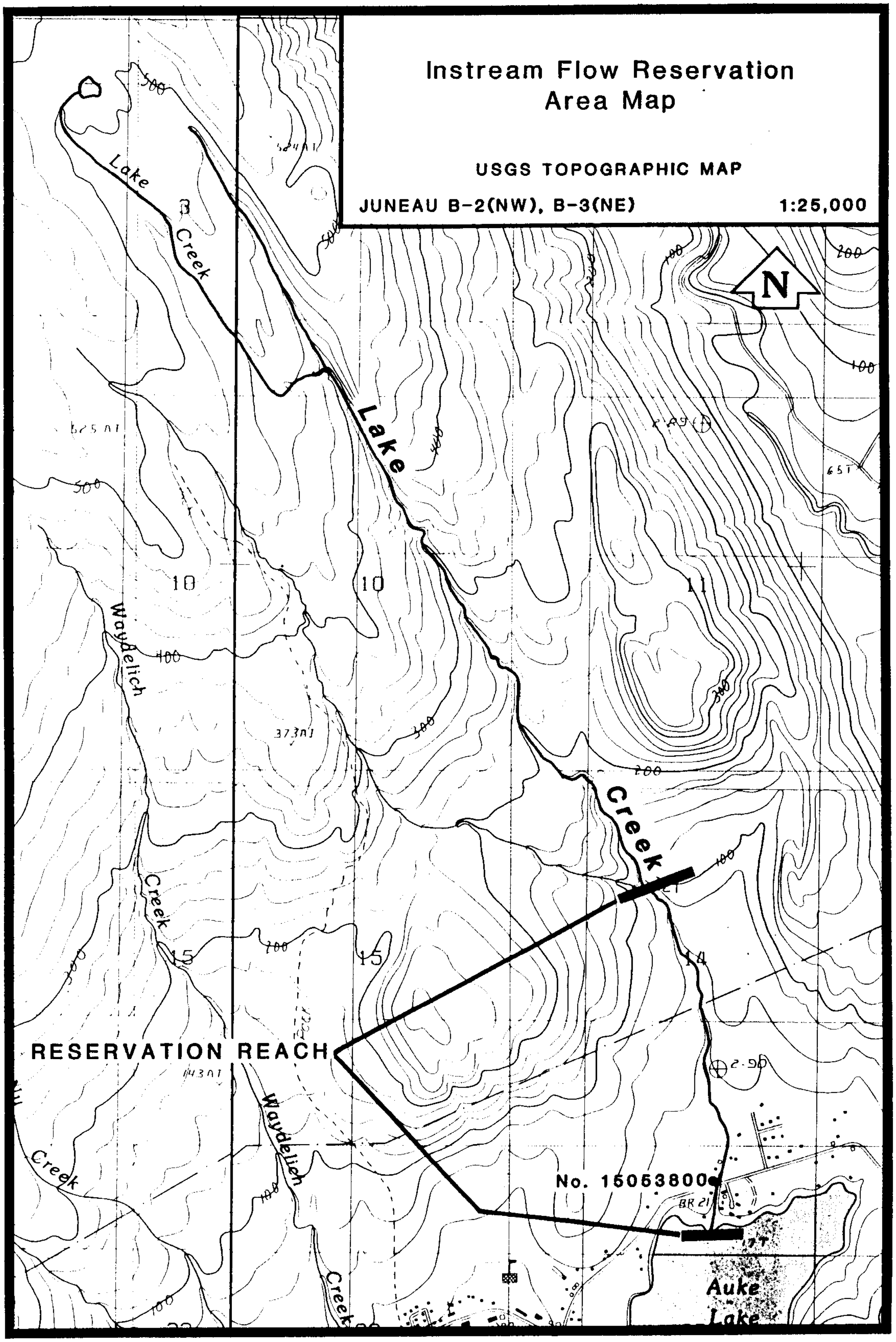
- the natural hydrology specific to the portion of the water body to be reserved. For rivers and streams, an applicant is required, at a minimum, to use the best available data at the time of application submittal to calculate the mean annual flow and if available mean monthly flow. When sufficient data 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.) .

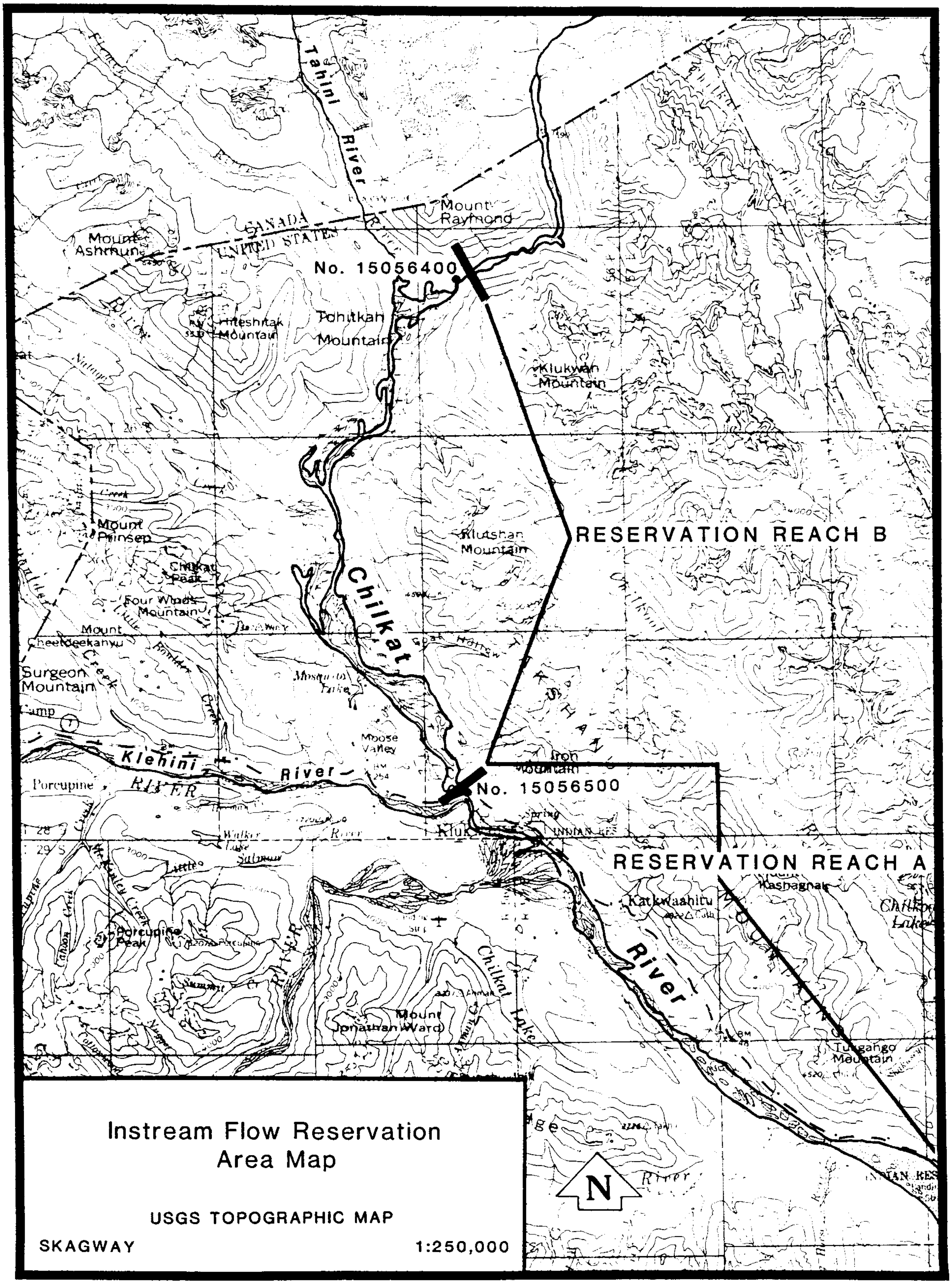
- the water quantities, stage or elevation requested during specific time periods accompanied by supporting documentation that justifies and describes the data and analyses utilized. Measurement unit requirements are: cubic feet per second (cfs), or cubic feet, acre feet, or an elevation relative to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



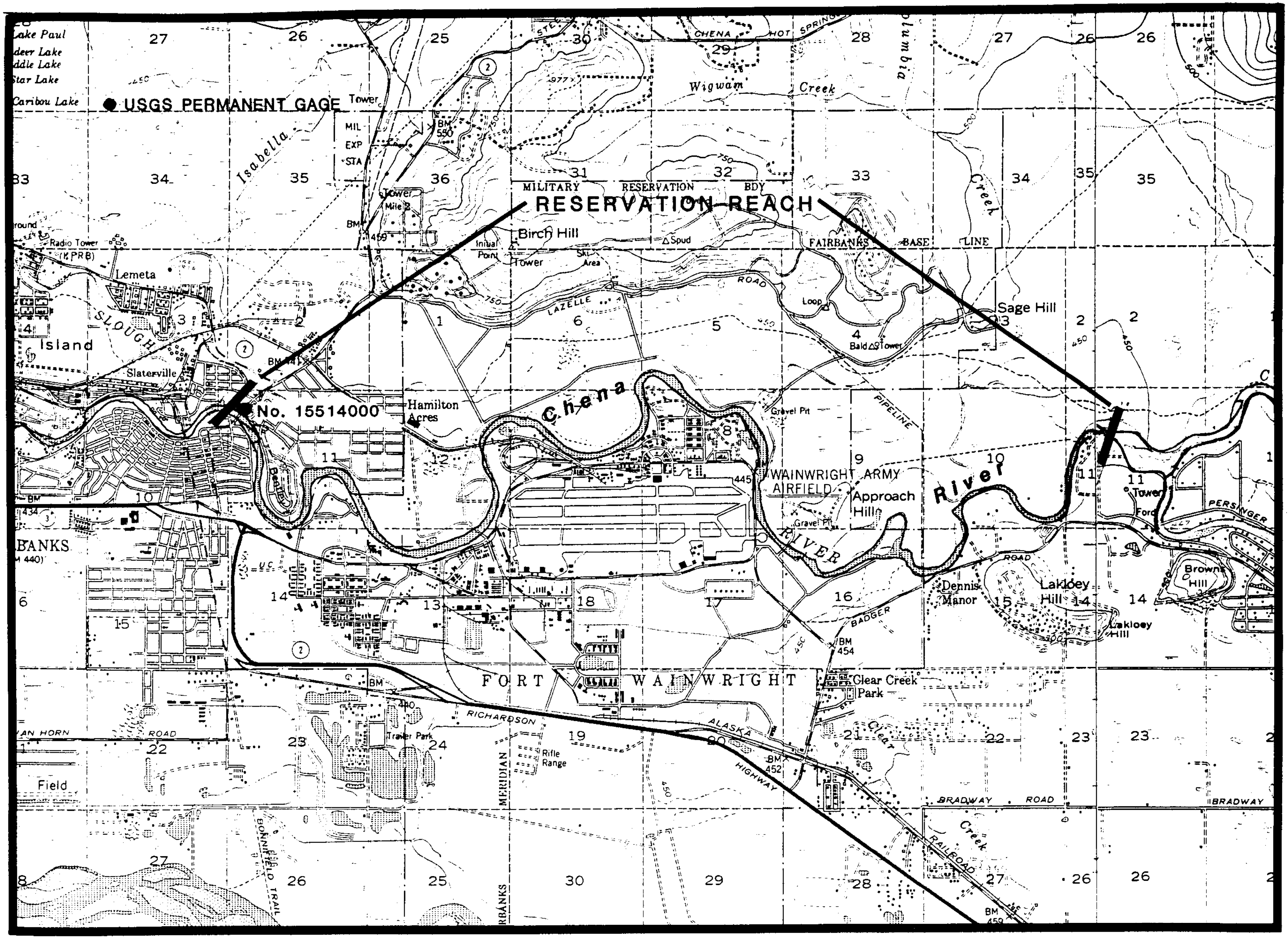
Appendix A2. Reservation reach boundaries, Eagle River.



Appendix A3. Reservation reach boundaries, Lake Creek.



Appendix A4. Reservation reach boundaries, Chilkat River Reaches A and B.



Appendix A5. Reservation reach boundaries, Chena River-Reach B.

Appendix A6. Species periodicity chart for Eagle River.

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

Appendix A7. Species periodicity chart for Lake Creek.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
COHO SALMON												
Passage									XXXX	XXXX	XXXX	
Spawning										XXXX	XXXX	XXXX
Incubation	XXXX	XXXX	XXXX	XXXX	XXXX					XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
PINK SALMON												
Passage							XX	XXXX	XXXX			
Spawning							XX	XXXX	XXXX			
Incubation	XXXX	XXXX	XXXX	XXXX	XXXX		XX	XXXX	XXXX	XXXX	XXXX	XXXX
Rearing				XXXX	XXXX							
CHUM SALMON												
Passage								XXXX	XXXX			
Spawning								XXXX	XXXX			
Incubation	XXXX	XXXX	XXXX	XXXX	XX			XXXX	XXXX	XXXX	XXXX	XXXX
Rearing					XXXX	XXXX						
SOCKEYE SALMON												
Passage						XXXX	XXXX	XXXX	XXXX			
Spawning								XXXX	XXXX			
Incubation	XXXX	XXXX	XXXX	XXXX				XXXX	XXXX	XXXX	XXXX	XXXX
Rearing ?												
CUTTHROAT TROUT												
Passage							XXXX	XXXX	XXXX	XXXX		
Spawning ?				XXXX	XXXX	XXX						
Incubation ?				XXXX	XXXX	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	
Spawning									XX	XXXX	XXXX	
Incubation	XXXX	XXXX	XXXX	XXXX	XXXX				XX	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.

Appendix A8. Species periodicity chart for Chilkat River-Reach A.

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

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.

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Appendix A8. (Page 2 of 2).

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

Appendix A9. Species periodicity chart for Chilkat River-Reach B.

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

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.

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Appendix A9. (Page 2 of 2).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
DOLLY VARDEN												
Passage				XX	XXXX	XXXX		XXXX	XXXX	XXXX	XXXX	
Spawning									XXXX	XXXX	XX	
Incubation	XXXX	XXXX	XXXX						XXXX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
ROUND WHITEFISH												
Passage ?												
Spawning ?												
Incubation ?												
Rearing ?												
RIVER LAMPREY												
Passage				XXXX	XXXX			XXXX	XXXX	XXXX		
Spawning ?												
Incubation ?												
Rearing ?												
SLIMY SCULPIN												
Passage ?												
Spawning ?												
Incubation ?												
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
THREESPINE STICKLEBACK												
Passage ?												
Spawning ?												
Incubation ?												
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Appendix A10. Species periodicity chart for Chena River-Reach B.

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

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Appendix A10. (Page 2 of 2).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SHEEFISH												
Passage					XXXX	XXXX	XXXX	XXXX	XXXX	X		
Spawning												
Incubation												
Rearing					XXXX	XXXX	XXXX	XXXX	XXXX	X		
LONGNOSE SUCKER												
Passage ?												
Spawning ?				XX	XXXX	XXX						
Incubation ?				XX	XXXX	XXXX	XXXX					
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
HUMPBACK WHITEFISH												
Passage							XXXX	XXXX	XXXX	XXXX	XXX	
Spawning								XX	XXXX	XXXX		
Incubation	XXXX	XXXX	XXXX	XXXX				XX	XXXX	XXXX		
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
ARCTIC LAMPREY												
Passage												
Spawning					XXXX	XXXX	XX					
Incubation					XXXX	XXXX	XXXX	XXX				
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
LAKE CHUB												
Passage ?												
Spawning				XXX	XXXX	XXXX	XXXX					
Incubation				XXX	XXXX	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.

Appendix A11. Common and scientific names of fishes identified in periodicity charts (Appendices A6-A10).

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*
Lake chub	*Couesius plumbeus japonica*
Longnose sucker	*Catostomus catostomus*
Northern pike	*Esox lucius*
Pink salmon	*Oncorhynchus gorbuscha*
Rainbow trout	*Oncorhynchus mykiss*
River lamprey	*Lampetra ayresi*
Round whitefish	*Prosopium cylindraceum*
Sheefish	*Stenodus leucichthys*
Slimy sculpin	*Cottus cognatus*
Sockeye salmon	*Oncorhynchus nerka*
Steelhead	*Oncorhynchus mykiss*
Threespine stickleback	*Gasterosteus aculeatus*

Appendix A12. Summary of hydrologic data for 1992 instream flow reservation applications.

STREAM/REACH	USGS SITE NUMBER	YEARS OF DAILY FLOW RECORD
LAKE CREEK AT AUKE BAY	15053800	1963-1973
CHILKAT RIVER		
near Klukwan	15056500	1959-1961
at Gorge near Klukwan	15056400	1962-1968
EAGLE RIVER AT EAGLE RIVER	15277100	1965-1981
CHENA RIVER AT FAIRBANKS	15514000	1948-1979[a]

[a] Represents only years of record prior to flow regulation that are required to calculate "flushing flows" and meet instream flow application requirements.

Appendix A13. Tennant Method analysis for Eagle 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	Eagle River	
	% of QAA	Flow (cfs)
Month	Oct.- Apr.	
QAA	100	528
Flushing or Maximum	200	1056
Optimum Range	60-100	317-528
Outstanding	40	211
Excellent	30	158
Good	20	106
Fair or Degrading	10	53
Poor or Minimum	10	53
Severe Degradation	<10	<53
Month	May - Sep.	
QAA	100	528
Flushing or Maximum	200	1056
Optimum Range	60-100	317-528
Outstanding	60	317
Excellent	50	264
Good	40	211
Fair or Degrading	30	158
Poor or Minimum	10	53
Severe Degradation	<10	<53

Monthly Flow Characteristics

Month	Long-term Mean Monthly Flow (cfs)
Jan	78
Feb	67
Mar	58
Apr	78
May	261
Jun	981
Jul	1734
Aug	1635
Sep	876
Oct	350
Nov	136
Dec	92

Appendix A14. Tennant Method analysis for Lake Creek.

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	Lake Creek	
	% of QAA	Flow (cfs)
Month	Oct.- Apr.	
QAA	100	13
Flushing or Maximum	200	26
Optimum Range	60-100	8-13
Outstanding	40	5
Excellent	30	4
Good	20	3
Fair or Degrading	10	1
Poor or Minimum	10	1
Severe Degradation	<10	<1
Month	May - Sep.	
QAA	100	13
Flushing or Maximum	200	26
Optimum Range	60-100	8-13
Outstanding	60	8
Excellent	50	7
Good	40	5
Fair or Degrading	30	4
Poor or Minimum	10	1
Severe Degradation	<10	<1

Monthly Flow Characteristics

Month	Long-term Mean Monthly Flow (cfs)
Jan	4
Feb	3
Mar	6
Apr	9
May	29
Jun	19
Jul	12
Aug	21
Sep	20
Oct	15
Nov	10
Dec	3

Appendix A15. Tennant Method analysis for Chilkat River-Reach A.

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	Chilkat River-Reach A	
	% of QAA	Flow (cfs)
Month	Oct.- Apr.	
QAA	100	3262
Flushing or Maximum	200	6524
Optimum Range	60-100	1957-3262
Outstanding	40	1305
Excellent	30	979
Good	20	652
Fair or Degrading	10	326
Poor or Minimum	10	326
Severe Degradation	<10	<326
Month	May - Sep.	
QAA	100	3262
Flushing or Maximum	200	6524
Optimum Range	60-100	1957-3262
Outstanding	60	1957
Excellent	50	1631
Good	40	1305
Fair or Degrading	30	979
Poor or Minimum	10	326
Severe Degradation	<10	<326

Monthly Flow Characteristics

Month	Long-term Mean Monthly Flow (cfs)
Jan	444
Feb	272
Mar	905
Apr	764
May	3968
Jun	8282
Jul	9023
Aug	7372
Sep	3323
Oct	1666
Nov	1002
Dec	822

Appendix A16. Tennant Method analysis for Chilkat River-Reach B.

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	Chilkat River-Reach A	
	% of QAA	Flow (cfs)
Month	Oct.- Apr.	
QAA	100	528
Flushing or Maximum	200	1056
Optimum Range	60-100	317-528
Outstanding	40	211
Excellent	30	158
Good	20	106
Fair or Degrading	10	53
Poor or Minimum	10	53
Severe Degradation	<10	<53
Month	May - Sep.	
QAA	100	528
Flushing or Maximum	200	1056
Optimum Range	60-100	317-528
Outstanding	60	317
Excellent	50	264
Good	40	211
Fair or Degrading	30	158
Poor or Minimum	10	53
Severe Degradation	<10	<53

Monthly Flow Characteristics

Month	Long-term Mean Monthly Flow (cfs)
Jan	78
Feb	67
Mar	58
Apr	78
May	261
Jun	981
Jul	1734
Aug	1635
Sep	876
Oct	350
Nov	136
Dec	92

Appendix A17. Tennant Method analysis for Chena River-Reach B.

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	Chena River-Reach B	
	% of QAA	Flow (cfs)
Month	Oct.- Apr.	
QAA	100	1403
Flushing or Maximum	200	2806
Optimum Range	60-100	842-1403
Outstanding	40	561
Excellent	30	421
Good	20	281
Fair or Degrading	10	140
Poor or Minimum	10	140
Severe Degradation	<10	<140
Month	May - Sep.	
QAA	100	1403
Flushing or Maximum	200	2806
Optimum Range	60-100	842-1403
Outstanding	60	842
Excellent	50	702
Good	40	561
Fair or Degrading	30	421
Poor or Minimum	10	140
Severe Degradation	<10	<140

Monthly Flow Characteristics

	Long-term Mean Monthly Flow (cfs)		Maximum One in Two Year Flow (cfs)	
Month	Unregulated	Regulated	3-Day Average	7-Day Average
Jan	325	348		
Feb	272	277		
Mar	251	265		
Apr	390	383		
May	4153	2878		
Jun	2734	2395		
Jul	2081	2651		
Aug	2658	2249	8960	7100
Sep	2146	2261		
Oct	1172	1279		
Nov	557	641		
Dec	412	492		