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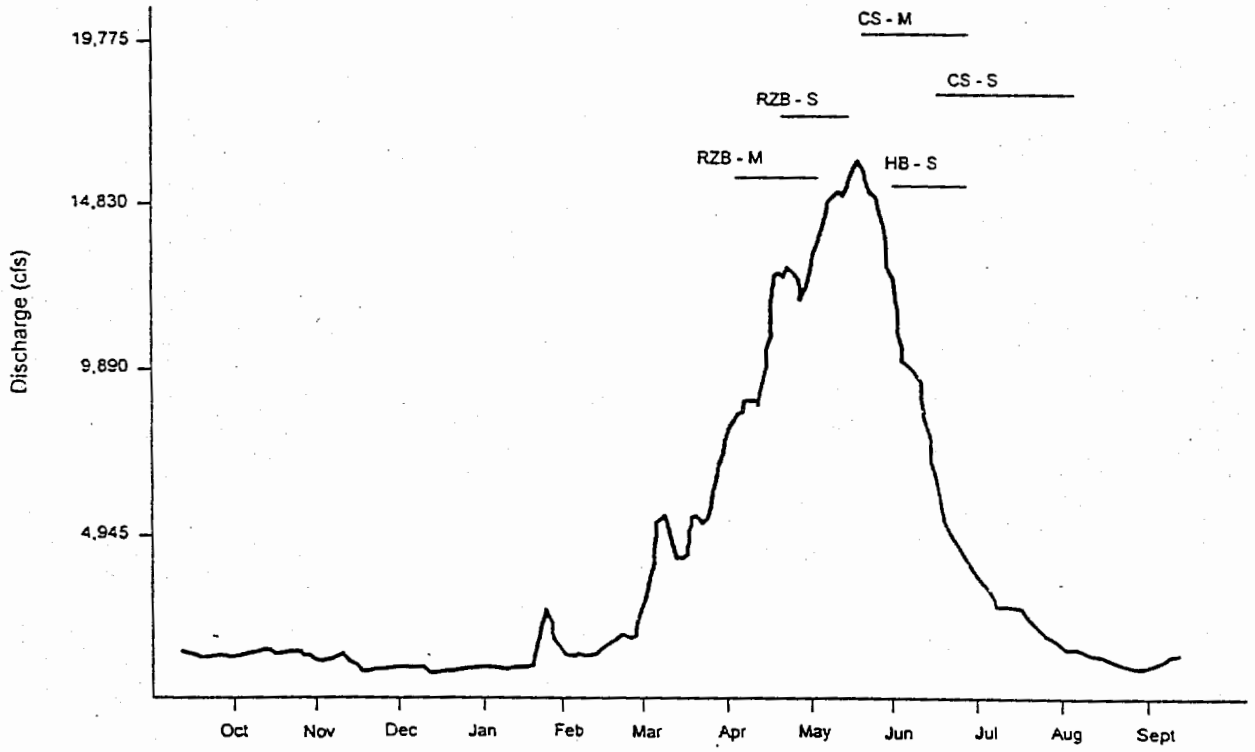
Flow Recommendations for Endangered Fishes in the Yampa River



Generalized sequence of spawning migration and spawning of endangered fishes in the Yampa River. Abbreviations represent, RZB = razorback sucker, CS = Colorado squawfish, HB = Humpback chub, M = migration, S = spawning

Final Report
November 1995
U.S. Fish and Wildlife Service

Flow Recommendations for Endangered Fishes in the Yampa River

Final Report

November 1995

Tim Modde[1]
Colorado River Fish Project

and

George Smith[2]
Water Resources

U.S. FISH AND WILDLIFE SERVICE

[1]Fisheries Biologist, U.S. Fish and Wildlife Service, 266 West 100 North, Suite 2, Vernal, Utah

[2]Hydrologist, U.S. Fish and Wildlife Service, 134 Union Blvd., Denver, Colorado

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Recovery Implementation Program for the Endangered Fishes of the Upper Colorado River Basin, U.S. Fish and Wildlife Service, P.O. Box 25486, Denver Federal Center, Denver, Colorado 80225.

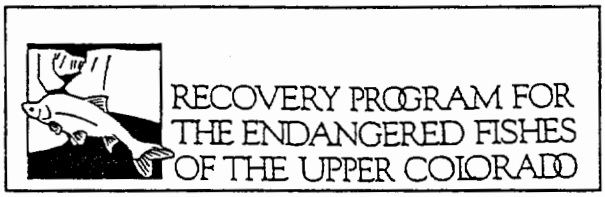

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

Existing biological information together with a comparison of historical and estimated virgin flow scenarios were synthesized following with reference to the Recovery Implementation Program instream flow review to update the U.S. Fish and Wildlife Services' interim flow recommendations for the Yampa River. Biological information on endangered fish abundance, distribution, and spawning activity, existing fish composition and migratory movement, and ecological concepts related to native fish persistence was integrated to provide the best estimate of flows necessary for the recovery and maintenance of the endangered fishes in the Yampa River and the Upper Colorado River Basin. Flow recommendations were based on the premise that natural variability is a major factor in the recruitment and survival of endangered fishes.

The major factor affecting the decline of the "large river" endangered fishes in the Upper Colorado River is a failure to recruit. This failure is due to habitat alteration and the interactions with nonnative fishes in moderated environments. The reproductive biology of Colorado squawfish, razorback sucker and humpback chub is critically linked with the hydrograph. In addition, fishes native to the Colorado River drainage are more abundant in variable environments than nonnative fishes. In this respect, flow recommendations were developed that strive to maintain annual, seasonal and daily variations. Annual variation should be maintained by allowing the recommendation for any given year to be dependent upon the flow magnitude of that year. The recommendation for seasonal variation is unchanged from the U.S. Fish and Wildlife Services' 1990 interim recommendation that spring flows be whatever occurs during the high flow period of a given year, minus the baseline depletion allowance. Daily flow variation will be achieved through the maintenance of a natural hydrograph curve, rather than a truncated, stair-stepped average based on a mean monthly flow. The flow recommendation for the baseflow months (August through March) is a range between 20% and 80% exceedance, dependent upon the magnitude of the flow year. The baseflow recommendation for any specific year would vary between the two ranges based upon the expected and observed flows.

In updating the flow recommendations, information gaps associated with biological monitoring for the lower Yampa River and fish passage were identified. Recommendations are made to address those information gaps.

BACKGROUND

Purpose

This document proposes flow recommendations (as measured at the Maybell gage) needed to recover Colorado squawfish *Ptychocheilus lucius*, humpback chub, *Gila cypha*, bonytail, *G. elegans*, and razorback sucker, *Xyrauchen texanus*, in waters influenced by Yampa River flows. In addition to the four listed species, the Yampa River drainage has some of the last abundant populations of flannelmouth sucker, *Catostomus discobolus*, and roundtail chub, *G. robusta*. As the last major, unregulated tributary in the Upper Colorado River Basin, the Yampa River provides flows that support the largest natural populations of Colorado squawfish and razorback sucker in the Colorado River Basin. The approach taken in this document is to use the best data and science available to define the hydrological needs of endangered fishes. It is not the purpose of this document to define the mechanisms to achieve the recommendations proposed, but rather, to use existing knowledge to define water needs for recovering and maintaining habitat for endangered fishes in Yampa and Green rivers. We recognize that sufficient flows to meet the following recommendations and projected water depletions may not always be available and that, at times, limitations will be placed on the implementation of the recommendations during some times of the year. A discussion of these limitations is found in the section that summarizes flow recommendations.

The recommendations proposed in this document update the 1990 interim Yampa River flow recommendations presented by the U.S. Fish and Wildlife Service (USFWS 1990). The interim recommendations were based on a review of existing biological data on endangered fishes by Tyus and Karp (1989). That approach was selected following the failure of physical habitat modeling (IFIM) to demonstrate predictive cause-and-effect relationships with the distribution and abundance of endangered fishes in the Green River Basin (Rose and Hahn 1989). The recommendations proposed in this document are heavily based on the biological information presented by Tyus and Karp (1989), but, also include information provided by the RIP (Recovery Implementation Program for the Recovery of Endangered Fishes in the Upper Colorado River Basin) instream flow review (Stanford 1994), comparison of historical and virgin flow estimates of the Yampa River (Maybell), and published ecological principles.

Study Area

Originating in the White River National Forest on the western slope of the Rocky Mountains, the Yampa River is the largest tributary of the Green River (Figure 1). The greatest abundance of endangered native fishes in the Yampa River occurs downstream of (potamon-rithron transition region of the river) Hayden, Colorado. The upper reach of the Yampa River occupied by endangered fishes flows through low gradient agricultural valleys with the exception of Juniper (RM 90.5 - 88.2) and Cross Mountain (RM 58.5 - 55.2) canyons prior to entering the high gradient Yampa Canyon (RM 46.7 - 0).

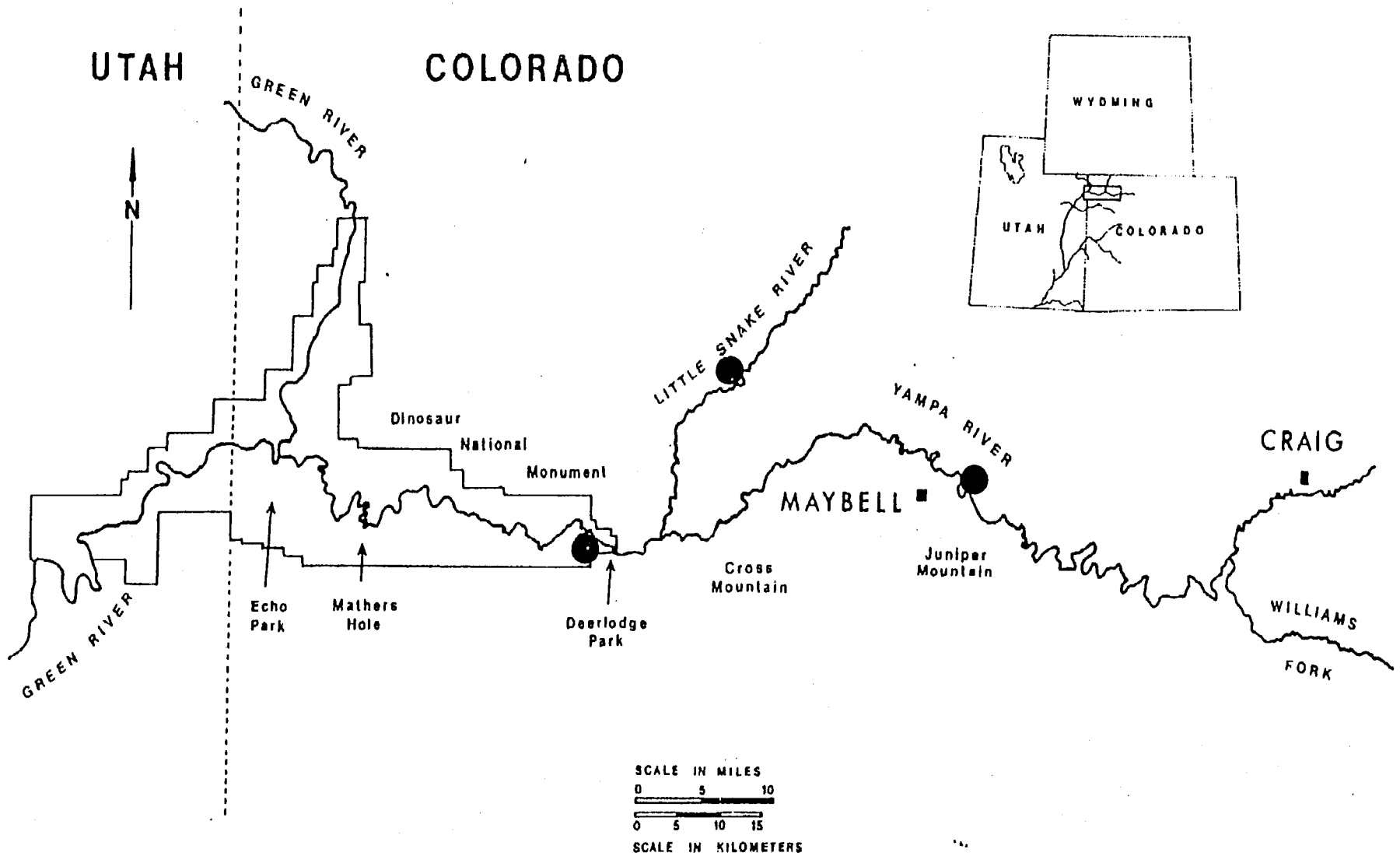

Figure 1. Yampa River study area, confluence with the Green River at Echo Park to Craig, Colorado (river kilometer 0-224), ● = locations of USGS river gauges (from Tyus and Karp 1989).

The Yampa River drains approximately 7,600 square miles and provides an average annual flow of 1.2 million acre feet of water per year, of which about 28% is contributed by the Little Snake River (Tyus and Karp 1989). Due to the lack of large storage capacity, the Yampa River has a relatively natural hydrograph (Figure 2). Flows in the Yampa River generally begin increasing in March from melting snow pack and remain high through July (Figure 2). Mean flow during spring runoff in the Yampa River is about 5,403 cfs (U.S.G.S. flow records). River discharge may widely fluctuate during spring runoff due to local warming trends and rain events. A maximum discharge of 33,200 cfs was recorded 18 May 1984 at Deerlodge Park (Ugland et al. 1987). The 50% exceedance for daily peak spring flows in the Yampa River at Deerlodge Park is about 13,738 cfs (U.S.G.S flow records). Following spring high flows the discharge of the Yampa River declines to approximately 359 cfs (50% exceedance of historic flows, U.S.G.S flow records) between the months of August and February. Despite having a natural hydrograph, the average annual water depletion of the Yampa River was estimated to be 110,000 ac ft in 1989 (Hydrosphere 1995a), with a disproportionate quantity depleted during the baseflow months. In addition to water flow, the Yampa River also transports on average 1.5 to 2.0 million tons of sediment per year, much of which is delivered by the Little Snake River which drains both northwest Colorado and southwest Wyoming (O'Brien 1984).

Biological Background

Colorado squawfish, humpback chub, bonytail, and razorback sucker were once common throughout the Upper Colorado River Basin (Quartarone 1993). All four species are currently listed as endangered species by the U.S. Fish and Wildlife Service. Previous to systematic studies initiated after the Green River rotenone effort (Holden 1991) in 1963, abundance and distribution of endangered fishes was based largely on anecdotal information (Tyus 1991). Studies following the closure of Flaming Gorge Dam reported an absence of native fishes in the Green River above the confluence of the Yampa River which was thought to be due to changes in water temperature resulting from hypolimnetic releases from Flaming Gorge Dam (Vanicek 1967, Vanicek et al. 1970). These studies reported that native fish habitat was maintained below the confluence of the Yampa River, a presumed consequence of the Yampa Rivers' ameliorating effect on water temperature.

All fishes indigenous to the potamon section (i.e. warm water region) of the Yampa River, with the possible exception of bonytail, persist today despite the introduction of at least 18 nonnative fish species (Tyus and Karp 1989). In this decade, Colorado squawfish, humpback chub and razorback sucker have been collected in the Yampa River (unpublished data, USFWS). All three species spawn in the Yampa River and reproduction is closely associated with changes in the hydrograph (Tyus and Karp 1989). One of the two largest known concentrations of spawning Colorado squawfish occurs between RM 15 and RM 30 (Tyus and Karp 1989). In addition, one of two documented spawning aggregations of razorback sucker in the Upper Colorado River Basin occurs at the mouth of the Yampa River, just above its confluence with the Green River, the other is located approximately 34

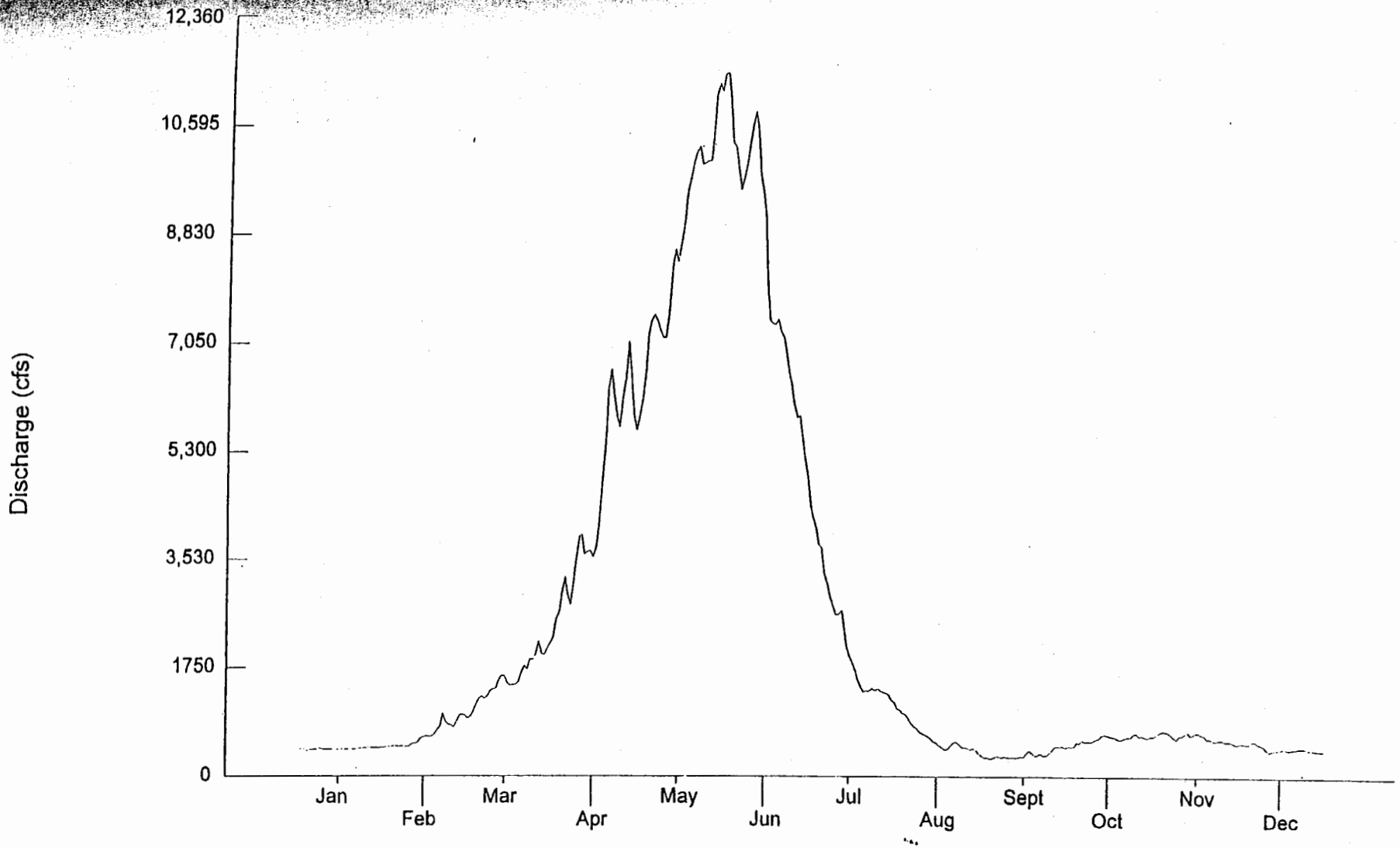

Figure 2. Average annual hydrograph of the Yampa River based on flows at Deerlodge Park between 1983 - 1990.

RM downstream in the Green River (Tyus 1987). Humpback chub are believed to spawn at several locations within Yampa Canyon (Karp and Tyus 1989). Because the Yampa River is the last major tributary of the Upper Colorado River Basin whose hydrograph has not been substantially altered by water development, it exerts a major impact on the biology of native fishes, both listed and nonlisted species. The magnitude of this impact was identified in the Biological Opinion for the operation of Flaming Gorge Dam (USFWS 1992) which requires the synchronization of dam releases with Yampa River peak flows to simulate a natural hydrograph in the Green River.

On a larger geographic scale, the decline of the "large river" fishes in the Colorado River drainage has been attributed to the failure of recruitment resulting from a number of factors, primarily habitat alteration associated with water development and interactions with nonnative fishes (e.g. Behnke and Benson 1988, Minckley et al. 1991, Tyus 1991). The magnitude and pattern of flows is the primary habitat feature influencing the reproductive success of the endangered fishes occupying the Green and Yampa rivers (Tyus and Karp 1989, 1990, Tyus and Haines 1991, Modde et al. accepted for publication). Flows cue the initiation of spawning migrations, spawning (Tyus 1987, Tyus and Karp 1989, Nesler et al. 1988), remove sediment from spawning substrate (Harvey et al. 1993) which would maximize egg survival, and transport larval fishes to nursery sites (Tyus 1991). As with many riverine species (Welcomme 1985), reproductive behavior of the "large river" fishes of the Colorado River is adapted to the seasonal hydrology and the annual, seasonal and daily variation inherent in rivers of arid landscapes. Despite the overwhelming data supporting the association of reproductive biology of endangered fishes to flow patterns, little information exists on their tolerance for change. Thus, in the absence of specific information on how native fish respond to modified environments, this report proceeds with the assumption that virgin flow conditions (those when fish were common, i.e Quartarone 1993) represent the environment most likely to allow recovery and maintenance of these species (Tyus 1986, 1994).

OBJECTIVE AND APPROACH

The objective of this report is to present and integrate existing hydrological and biological information with ecological principles to present flow recommendations that will recover and maintain endangered fishes in waters influenced by Yampa River flows (i.e. Middle Green River). Existing information on endangered fish distribution, abundance, spawning migrations and reproductive requirements (much of which was previously presented by Tyus and Karp 1989), comparisons of native and nonnative fish distribution within the Yampa River, and a synthesis of newly acquired virgin flow estimates were used as the data base on which flow recommendations were based. In addition, the RIP instream flow review (Stanford 1994) was used as a guideline in developing flow recommendations. The approach taken was to review existing information and integrate this material with the recent RIP instream flow review (Stanford 1994) and ecological literature to provide recommendations that will recover endangered fishes of the Yampa and Green rivers.

BIOLOGICAL AND HYDROLOGICAL DATABASE

Endangered Fish Distribution, Abundance and Habitat Use

Colorado squawfish

Colorado squawfish are found in the Yampa River between Craig, Colorado, and the confluence of the Green and Yampa rivers (Figure 3, from Tyus and Karp 1989). The upper Yampa River (RM 50.7 - 123.3) is considered a concentration area for overwintering adults (Archer et al. 1986), as evidenced by radio transmitter monitored fish (Tyus et al. 1987) and abundance data (Miller et al. 1982, Wick et al. 1985, data incorporated information from a high flow winter, DEC-FEB mean = 386 cfs, and low winter flow, DEC-FEB mean = 161 cfs). During winter, adult Colorado squawfish use backwaters, runs, and eddies, but are most common in shallow, ice covered shoreline areas (Wick and Hawkins 1989). Local, nonmigratory movements of adult Colorado squawfish in nonbreeding seasons may be indicative of home-range behavior among a wide range of flows (Tyus et al. 1987, Tyus 1991, Wick and Hawkins 1989). In the spring and early summer, adult Colorado squawfish were most often located in backwater habitats or flooded bottomlands in the Yampa River. Use of flooded bottomlands was most prevalent in flood years. Wick et al. (1983) observed that in 1982 (an average flow year), adult Colorado squawfish used flooded shoreline areas in spring, but, moved to backwater habitats as the river elevation dropped. During the late spring many adult Colorado squawfish underwent spawning migrations to a major spawning area located in the lower 25 miles of the Yampa River (Tyus 1986). Following spawning, adult Colorado squawfish occupied a variety of habitats in mid to late summer, but were most common in eddies, pools, runs, and shoreline backwaters over sand and silt substrates (Tyus and Karp 1989). Radio tracked fish were most often located in deeper shoreline habitats, where movements suggested heavy use of eddy-run interface (Tyus et al. 1987).

Early life stages of the Colorado squawfish reside only temporarily in the Yampa River. Larval Colorado squawfish emerge as sac fry from cobble spawning bars in the Yampa Canyon and drift downstream (Tyus et al. 1982b; Haynes et al. 1984) and relocate in shallow backwater habitats in the Green River (Tyus et al. 1982b, 1987, Ongoing research by the Larval Fish Laboratory, Colorado State University). Presumably, young fish are dispersed by river currents from upstream spawning areas to nursery habitats (Tyus and McCada 1984, Tyus 1986). Juvenile (60 - 450 mm) Colorado squawfish are rare in the Yampa River. Therefore, adult fish occupying the Yampa River represent individuals which have been reared downstream and move upstream as adults to occupy useable habitat.

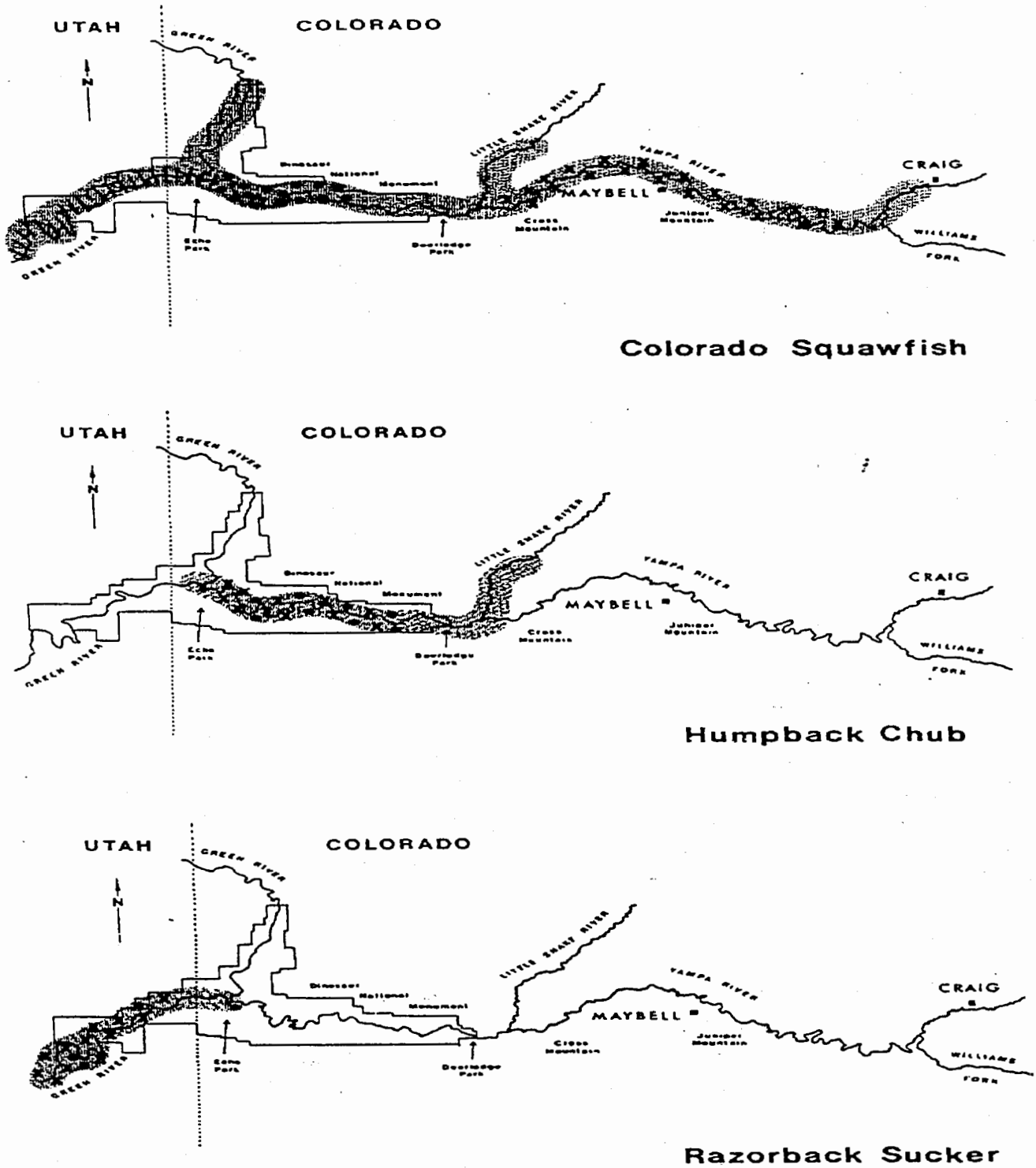

Figure 3. Important river reaches for Colorado squawfish, humpback chub, and razorback sucker in Yampa and Green rivers, Colorado and Utah. *Shading* = distribution; *dots* = spawning areas; *X*'s = winter concentration, and *//*s = larval drift (from Tyus and Karp 1989).

Humpback chub

Adult humpback chubs (230 mm) have been collected in canyon-bound areas in the lower 35 miles of the Yampa River (Figure 3, from Tyus and Karp 1989) (Tyus et al. 1982a, Karp and Tyus 1989, Fish and Wildlife Service and Colorado State University unpublished data) and in the lower Little Snake River and Upper Yampa Canyon by Fish and Wildlife Service and Colorado State University (unpublished data). Adult humpback chubs were most often collected in eddy habitat (average depth, 2 m), particularly in shoreline eddies created by large boulders and rapids (Karp and Tyus 1989). Radio telemetry monitoring of an adult humpback chub near Mathers Hole (RM 19) in 1993 indicated only localized movement during the summer months (Colorado State University, unpublished data). Two adult humpback chub implanted with radio transmitters in the lower nine miles of the Little Snake River in June 1995, moved downstream into Yampa Canyon in late July as flows in the Little Snake River declined (Fish and Wildlife Service, unpublished data).

Juvenile (less than 230 mm) humpback chub have been collected between RM 0.1 and 40 in Yampa Canyon by the Fish and Wildlife Service (Karp and Tyus 1989). Identification of juvenile *Gila* as the humpback form was based on the same complex of morphologic characters use to differentiate the adult life history stage (Karp and Tyus 1989). Most young humpback chubs were captured in shoreline eddies and runs. Problems with specific identification of small chubs has hindered the evaluation of habitat needs of small humpback chub.

Razorback sucker

Adult razorback sucker have been collected between RM 13 and RM 0.1 (Fish and Wildlife Service, unpublished data) of the Yampa River. In 1979 one adult razorback sucker was collected in Lily Park (Ed Wick and John Hawkins, Colorado State University, Personal Communication). Most fish have been collected during the spring at a documented razorback sucker spawning site located in the Yampa River just upstream from its confluence with the Green River. Telemetry data indicate that some fish spawning in the Yampa River may reside the remainder of the year in the Green River (Modde et al., in preparation). Tyus (1987) observed nonbreeding adult razorback sucker occupying shoreline runs and sites near midchannel sand bars (depths < 2 m) on the Green River, while Modde et al. (in preparation) observed razorback sucker using deeper habitats associated with deep runs and eddies as well as shallow habitats. Adult razorback suckers were observed to overwinter in Echo Park (McAda and Wydoski 1980, Valdez and Masslich 1989).

Only one juvenile razorback sucker has been collected in the Yampa River. The single fish, a 389 mm juvenile, was collected at RM 39 in June 1994 (Fish and Wildlife Service, unpublished data). Razorback sucker have been

observed spawning in the Yampa River just above the confluence of the Green River, however, larvae are presumed to drift downstream immediately following emergence where they are transported to floodplain habitat in the Green River (Modde et al. 1995, Modde et al. accepted for publication).

Bonytail

Because of the rarity of bonytail chubs, their distribution and abundance is largely unknown. Fish were fairly common in Echo Park prior to and shortly after the closure of Flaming Gorge Dam (Vanicek 1967). However, few individuals have been collected in the last decade. Holden and Crist (1981) collected one bonytail chub in the lower Yampa River in 1979, and the Fish and Wildlife Service captured a suspected juvenile in 1987.

Spawning Requirements of Endangered Fishes

Colorado squawfish

Two primary Colorado squawfish spawning sites have been identified in the Green River Basin (Tyus and McAda 1984, Wick et al. 1983, and Tyus et al. 1987), one of which is located between RM 10.5 and RM 18 in the Yampa River. Fish spawning in this area travel both upstream from the Green River and White rivers (Tyus 1985, 1986, and Irving and Modde 1994) as well as downstream from higher in the Yampa River (Tyus 1985). Seven migrating Colorado squawfish traveled over 200 river miles from the White River to the Yampa River spawning site (Irving and Modde 1994). The same fish were observed to make this extended migration in two consecutive years (Irving and Modde 1994).

The initiation of the spawning migration is an important element for the successful reproduction of the Colorado squawfish. Most fish initiated spawning migrations between late May and mid June depending on the magnitude of the water year (Tyus and Karp 1989). Spawning migrations were initiated earlier in low peak flow years (and later in higher peak flow years (Tyus and Karp 1989). Movement to spawning locations was associated with patterns of discharge and temperature (Figure 4, from Tyus and Karp 1989). Fish began moving to spawning sites during the descending limb of the hydrograph and when temperatures reached 14° C.

Timing of spawning, as was spawning migration, was associated more closely with patterns in the hydrograph rather than absolute quantity of flows. Spawning occurred earlier in low flow years and later in higher flow years. Water temperatures during spawning ranged from 14.5° and 27.5° C for all years studied (Tyus and Karp 1989). During the peak spawning period (study years of Tyus and Karp 1989), mean discharge ranged from 893 cfs (1981) to 3,814 cfs (1982).

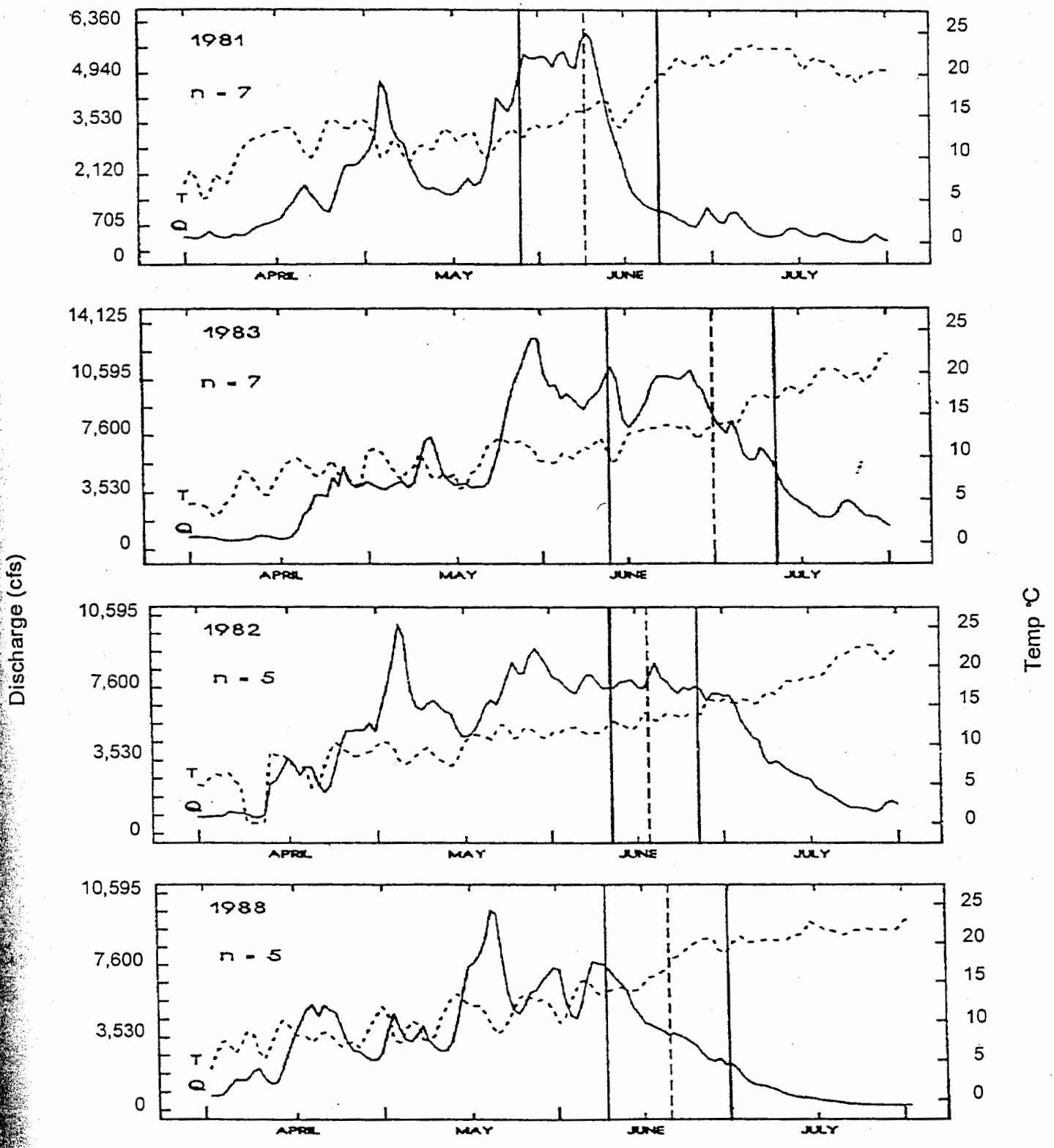

Figure 4. Relation between discharge, temperature, and initiation of spawning migration for Colorado Squawfish, Yampa River, 1981-83 and 1988. Q = average daily discharge; T = average daily temperature (USGS records, Yampa River near Maybell, Colorado). *Solid vertical lines* = dates first and last radio-tagged fish exhibited movement to spawning ground; *dashed vertical line* = average date radio-tagged fish exhibited migratory movements; *n* = number of radio tagged fish (from Tyus and Karp 1989).

Post spawning migration of the Colorado squawfish coincided with the near baseflow conditions, ranging between approximately 1,400 cfs to 325 cfs (Figure 4, from Tyus and Karp 1989, and Appendix 1). The upstream movement of squawfish during low flow conditions presents the potential problem of barriers to fish passage through Cross Mountain Canyon and the Maybell Diversion. Telemetry records of 13 fish (from a total of 165 Colorado squawfish as defined by Tyus 1990, Irving and Modde 1994, Wick et al. 1983, and Wick and Hawkins 1989) were observed to move to the spawning site in the Yampa River and migrated upstream through Cross Mountain Canyon. In addition, 8 of these 13 fish also moved above the Maybell Diversion. The actual movement of Colorado squawfish through Cross Mountain Canyon occurred at flows of 324 cfs or greater (Figure 5). Actual fish movement through the Maybell Diversion was observed at even lower flows (i.e. 177 cfs). Timing of fish movement was related more to the hydrograph than to specific calendar dates (Appendix 1). For example, during low flow years fish were more likely to spawn earlier and return earlier than during high flow years when spawning and return migrations occur later in the calendar year. Although it was possible to identify that fish could move through Cross Mountain Canyon and Maybell Diversion at flows of between approximately 350 and 200 cfs, respectively, we were unable to identify whether these in-channel obstacles were barriers to fish migration at lower flows.

Humpback chub

Spawning of humpback chub occurs during the descending limb of the hydrograph, usually during the months of May and June (Figure 6, from Tyus and Karp 1989) (Tyus et al. 1987, and Karp and Tyus 1989). As with Colorado squawfish, the relationship of spawning seemed more related to the hydrograph than specific flows or dates. Fish in spawning condition were collected between RM 12 and 40 in shoreline eddy and run habitats. Average temperature during the spawning period was 19°C, ranging between 14.5° and 23.0°C (Karp and Tyus 1990). Little evidence exists that fish in the Yampa River migrate long distances to spawning sites. However, two humpback chub were collected during the descending limb of the hydrograph in the lower 9 miles of the Little Snake River in 1995 (Fish and Wildlife Service and Colorado State University, unpublished data). Although secondary reproductive characteristics were not present on either fish (i.e. tubercles or pigmentation) at the time of capture, these fish remained in the Little Snake River until the baseflow period, after which they moved to RM 36 and RM 41 in the Yampa River. This pattern of movement is consistent with humpback chub in the Colorado River that occupy the mainstem river during the nonreproductive period and enter the Little Colorado River to spawn (Valdez and Ryel 1995).

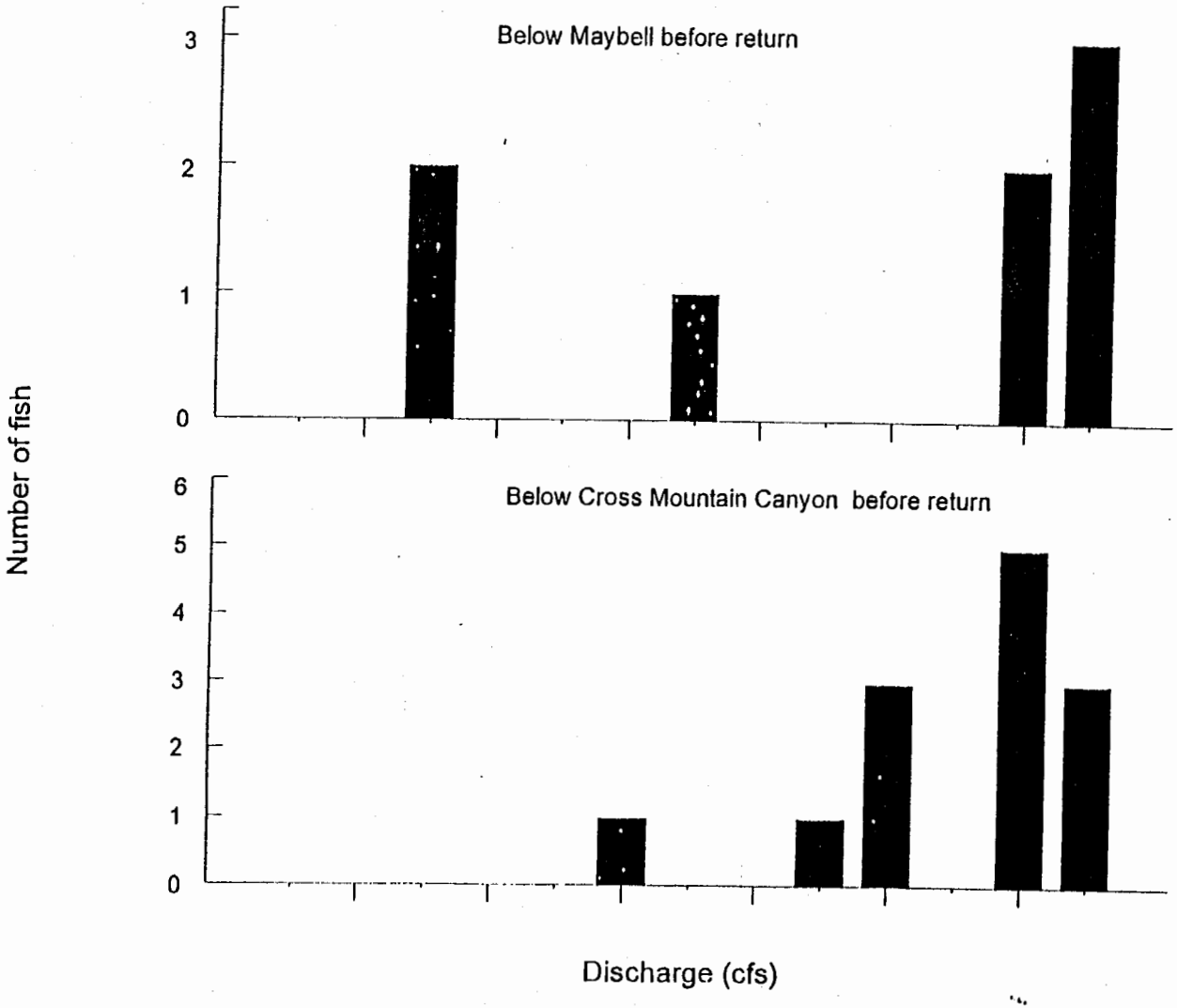

Figure 5. Summary of discharge information coinciding with fish movement in the Yampa River through Cross Mountain Canyon and the Maybell Diversion.

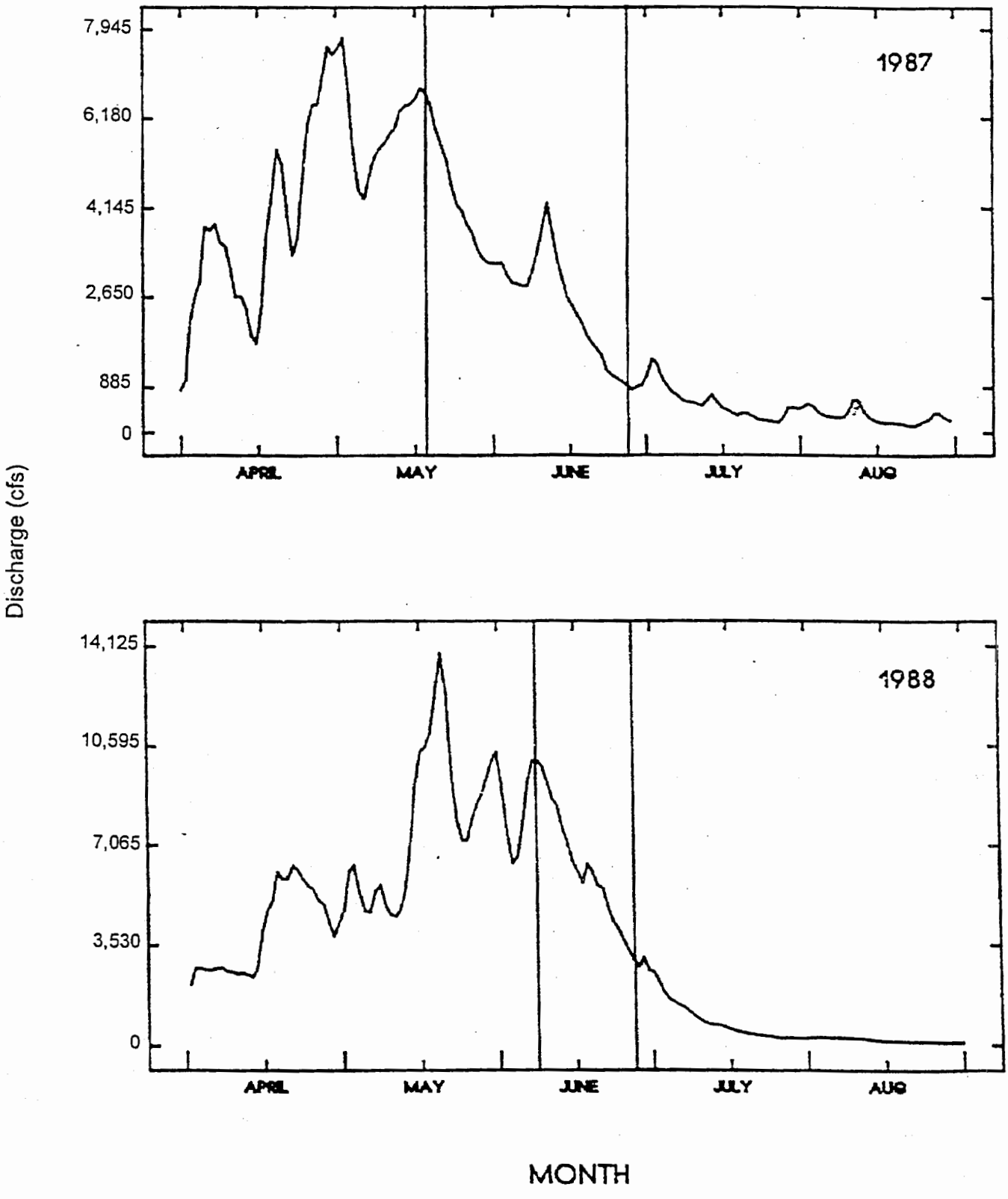

Figure 6. Relation between discharge and spawning period for humpback chub, Yampa River, 1987-88. *Vertical bars* delineate spawning period (from Tyus and Karp).

Razorback sucker

Spawning of razorback sucker, like Colorado squawfish and humpback chub is associated with changes in the hydrograph. Razorback sucker spawn on the ascending limb of the hydrograph (Figure 7, from Tyus and Karp 1989). As with the Colorado squawfish, razorback sucker are known to use two primary spawning areas, one on the Green River near RM 311 and the other in the Yampa River just above the confluence with the Green River. Individuals have been observed to move as far as 100 river miles to a specific spawning site (Tyus and Karp 1990, and Modde et al. in preparation). Movement to the spawning bar appeared more related to discharge rate than temperature (Figure 8). As with Colorado squawfish, the pattern of the hydrograph rather than absolute flows tend to initiate movement to spawning locations. However, in 1995 fish implanted with radio transmitters were observed to move to the spawning locations in late April, but, larvae were not collected downstream until June when water temperatures exceeded 14^0 C (Fish and Wildlife Service unpublished data). Thus, although adults seem to be attracted to the spawning sites by discharge, spawning may not occur until temperatures reach approximately 14^0 C (Tyus and Karp 1990).

In general, the spawning requirements of all three listed species, known to reproduce it the Yampa River is determined by the combination of flows and temperature, both of which are related. The spawning activities of these fish were influenced more by the pattern of flow, i.e. rise or drop in the hydrograph, in any given year than a specific magnitude of flow. Each species migrates and spawns at a different stage of the hydrograph (Figure 9). Therefore, the occurrence of a natural hydrograph is an important feature to the reproductive success of endangered fishes and represents a rationale as to why the largest natural populations of Colorado squawfish (Tyus 1991) and razorback sucker (Lanigan and Tyus 1989, Modde et al. accepted for publication) occur in waters influenced by the Yampa River hydrograph. It appears that temperature and the shape of the hydrograph have a greater influence on behavior relating to the initiation of spawning activity than the magnitude of the hydrograph. However, it is the magnitude of the flows which influence the geomorphology of the river and effect habitat availability. Thus, although fish appear to cue to specific patterns of the hydrograph, the magnitude of the hydrograph is responsible for creating available spawning, nursery and adult habitat.

Association of Nonnative Fishes with Native Fishes

Native fishes were reported to be more abundant than nonnative fishes in the canyon reaches of the Yampa River than in either the upper (RM > 54 or lower reaches (RM < 1.8) (Figure 10, Appendix 2). Among all Yampa Canyon (RM 1.8 to

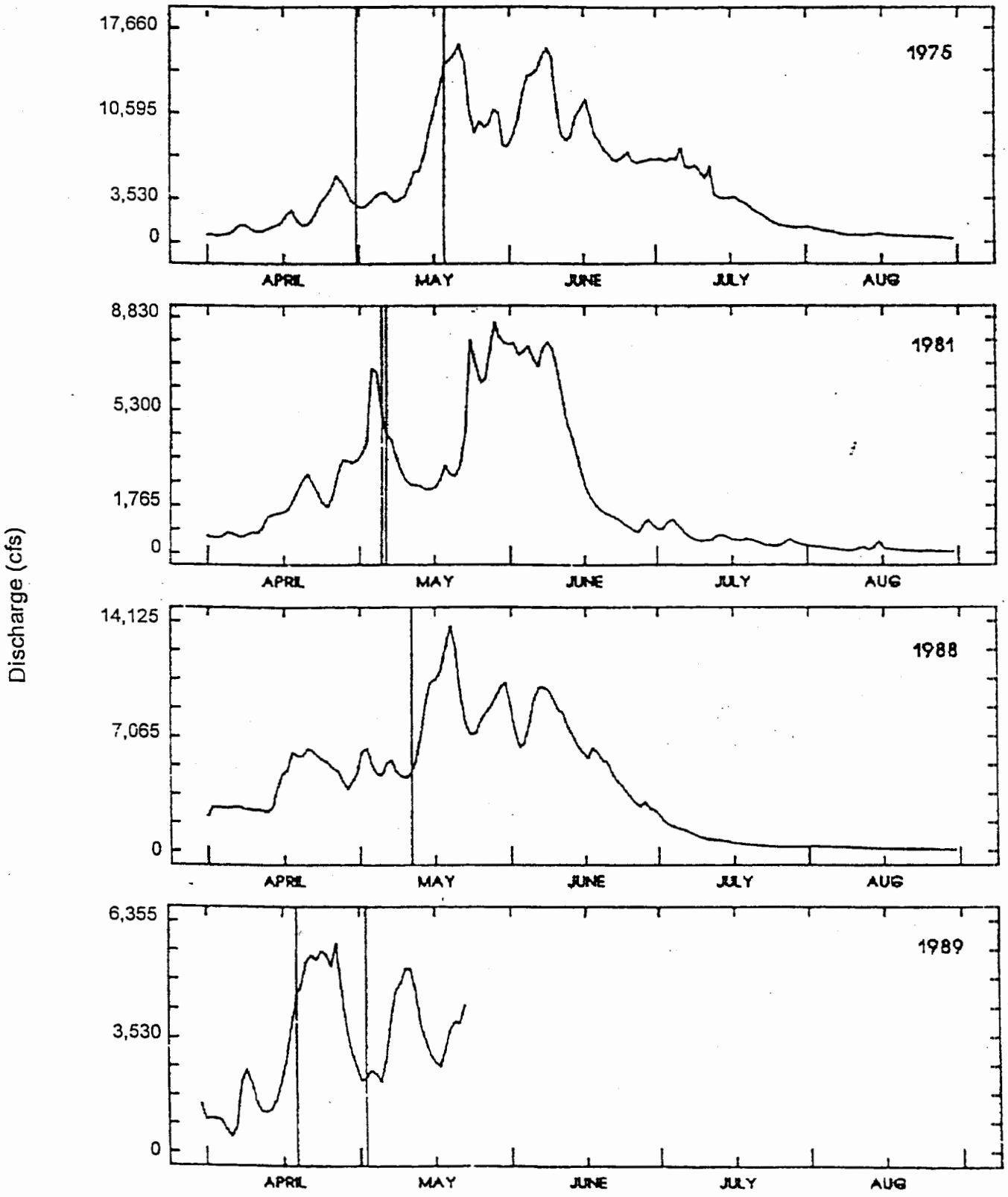

Figure 7. Relation between discharge and spawning period for razorback sucker, Yampa River, 1975, 1981, 1988, and 1989 (discharge data incomplete for 1989) (from Tyus and Karp 1989). *Vertical bars* delineate spawning period. (One collection of ripe fish in 1988).

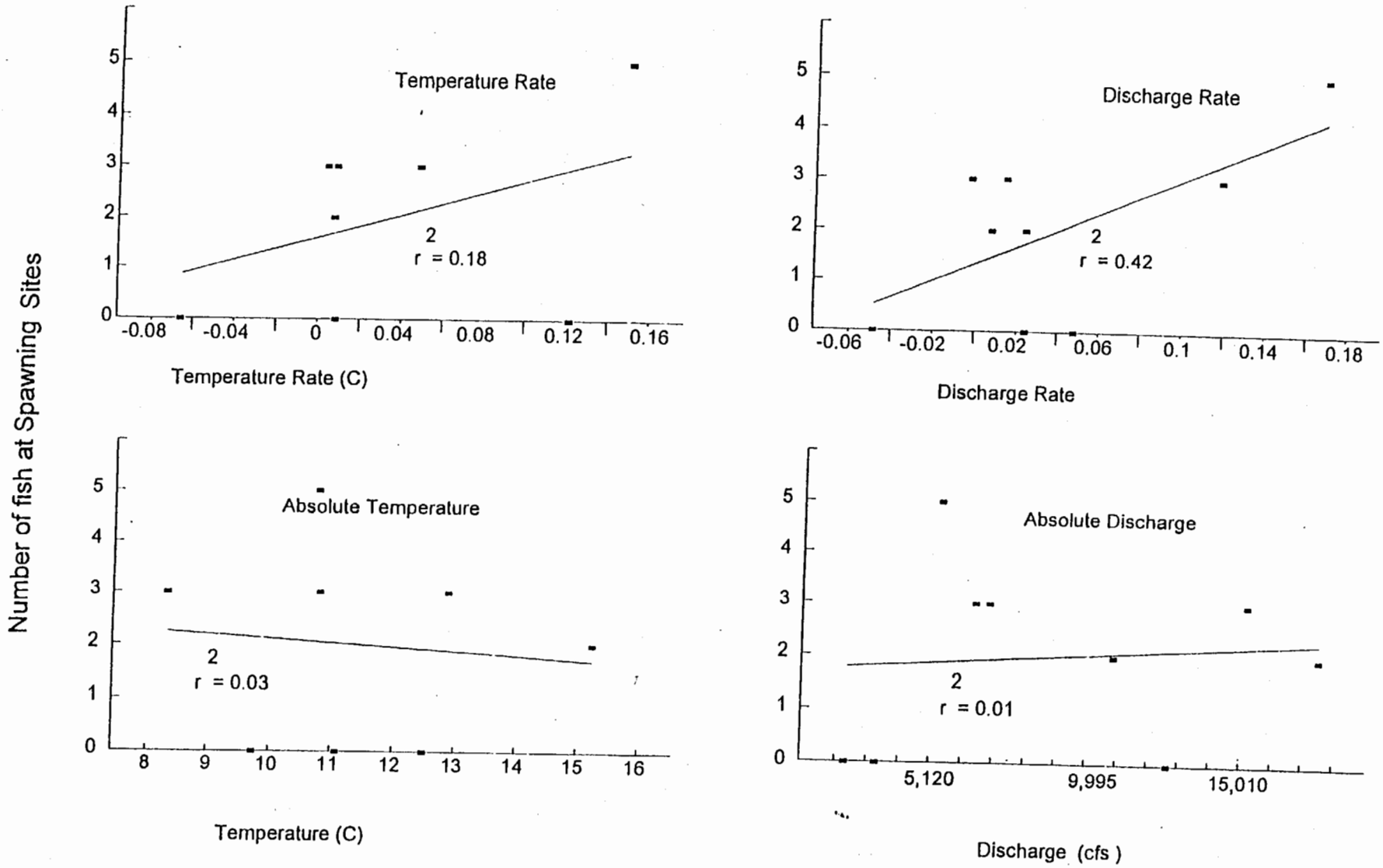

Figure 8. Comparison of the relationship of temperature and discharge with the presence of razorback sucker, Xyrauchen texanus, at spawning sites in the Green and Yampa rivers. Rates represent percent change over a five-day period preceding the observation.

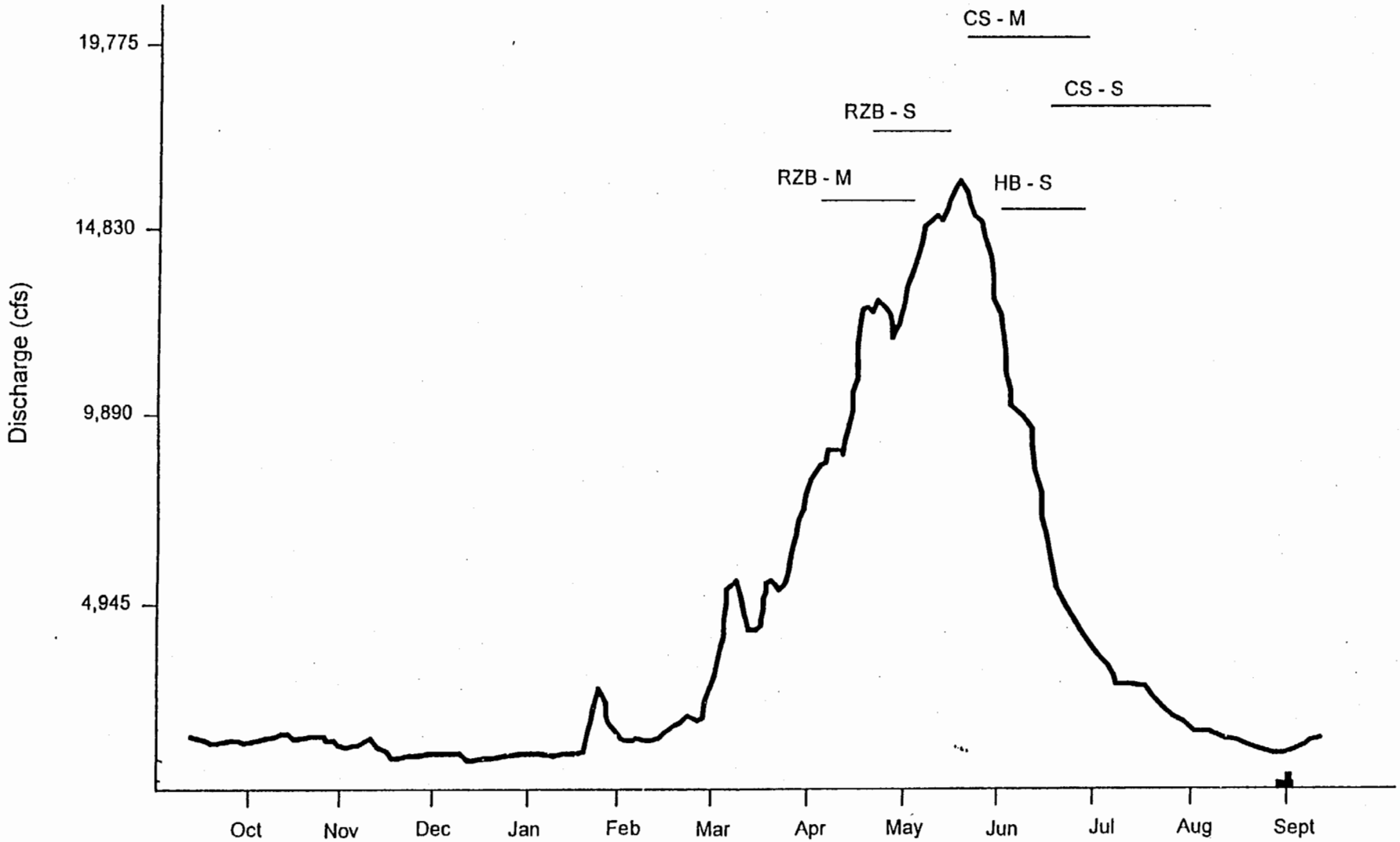

Figure 9. Generalized sequence of spawning migration and spawning of endangered fishes in the Yampa River. Abbreviations represent, RZB = razorback sucker, CS = Colorado squawfish, HB = Humpback chub, M = migration, S = spawning (modified from Tyus and Karp 1989).

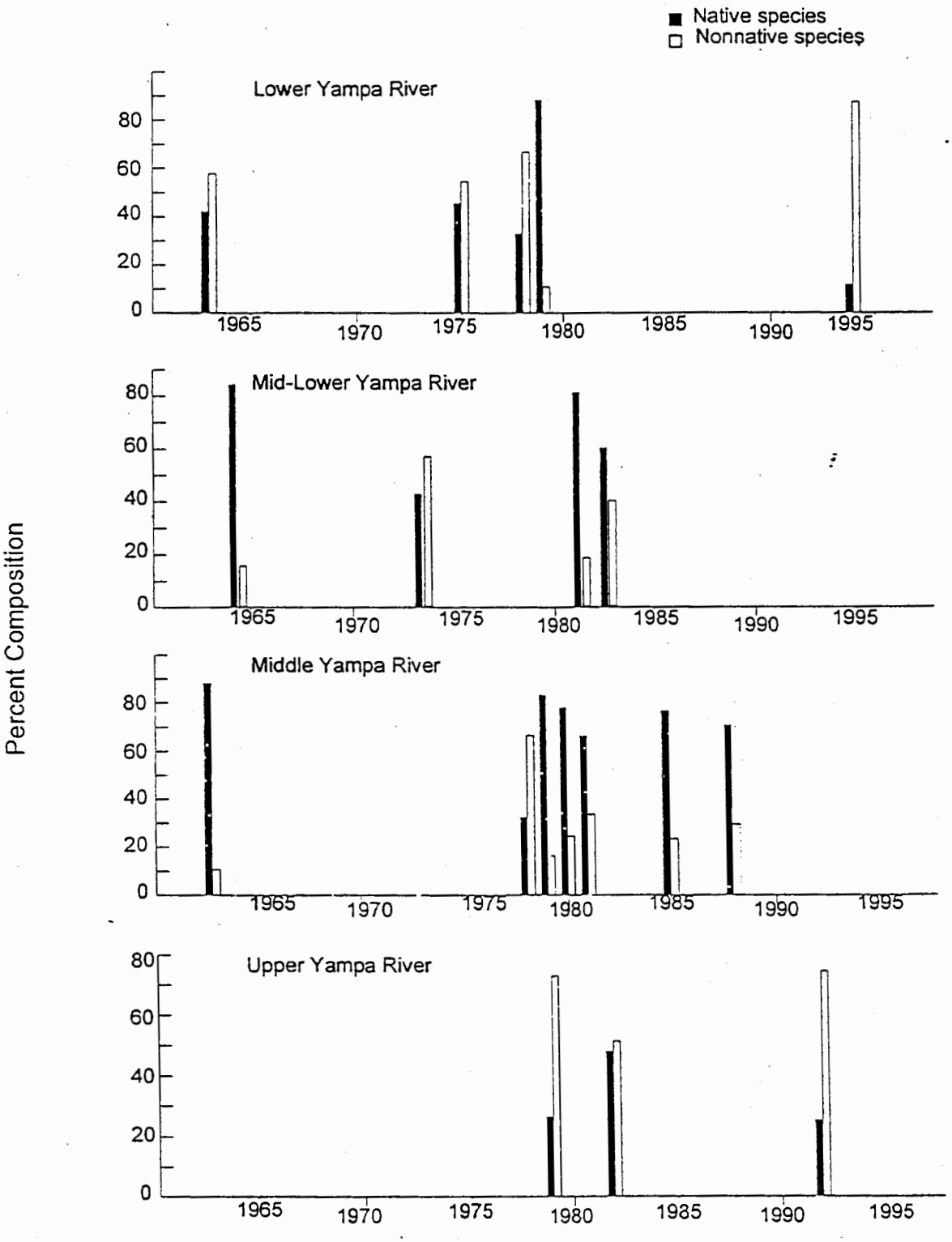

Figure 10. Percentages of native and nonnative fishes collected in the Yampa River.

approximately RM 54) studies reviewed, only one data set showed nonnative fishes to outnumber native fishes in the canyon reach of the Yampa River. In addition, three of four data sets representing both the lower and middle reaches of Yampa Canyon were characterized by a greater number of native than nonnative fishes. Fish collected in the lower reach of the Yampa River were represented more by nonnative than native fishes (80%, four of five, of the data sets). All three data sets obtained between Deerlodge and Craig indicated that nonnative fishes were more abundant than native fishes.

Another trend observed was the abundance of northern pike, *Esox lucius*, and smallmouth bass, *Micropterus dolomieui*, as sampled by the Interagency Standardized Monitoring Program above Yampa Canyon (McAda et al. 1994, and supplemental reports for years 1993 and 1994). Greatest numbers of both species in the Yampa River occurred simultaneously with the large water releases from Elkhead Reservoir in 1992 (Figure 11) and continued through 1993, prior to the high runoff. Thus, it appears that discharges from Elkhead Reservoir, a 13,700 cfs reservoir on Elkhead Creek, are capable of dispensing significant numbers of nonnative fish in the Yampa River.

The importance of native and nonnative fish distribution in the Yampa River to flows in not clear. In river reaches with the greatest range of depth and velocity (Yampa Canyon), native fishes are the dominant components. However, in areas above Yampa Canyon nonnative fish species are more abundant than native species. The influence of seasonally high runoff flows on the persistence of native fishes in Yampa Canyon is probably beneficial, however, the specific relationship in unknown.

Comparison of Historical and Virgin Hydrographs

Daily virgin flow estimates for the Yampa River were developed by Hydrosphere Resource Consultants, using methods described in their report, "Development of Estimated Daily Flows, Yampa River at Maybell" (Hydrosphere 1995a, Appendices 3 and 4). This set of estimates, hereafter referred to as virgin flows, was constructed by adding all estimated flow depletions back into the actual stream gage records for the Yampa River at Maybell, for the period 1950-82. Although we recognize a limitation in the mechanism used to generate these estimates, i.e. best estimates of depletions through time, we accept these values as the best estimate of virgin flows. The similarity of standard deviations within virgin and historical flows indicates that variation between these two data sets was nearly identical. In this regard, the estimated virgin flow regime provided a standard for comparison with historical flows. Historical flows are defined as actual, measured streamflows from 1950-82, which have been influenced by storage of small reservoirs in the Yampa River headwaters as well as agricultural, municipal, and industrial diversions that have accumulated prior to, and during, this time period.

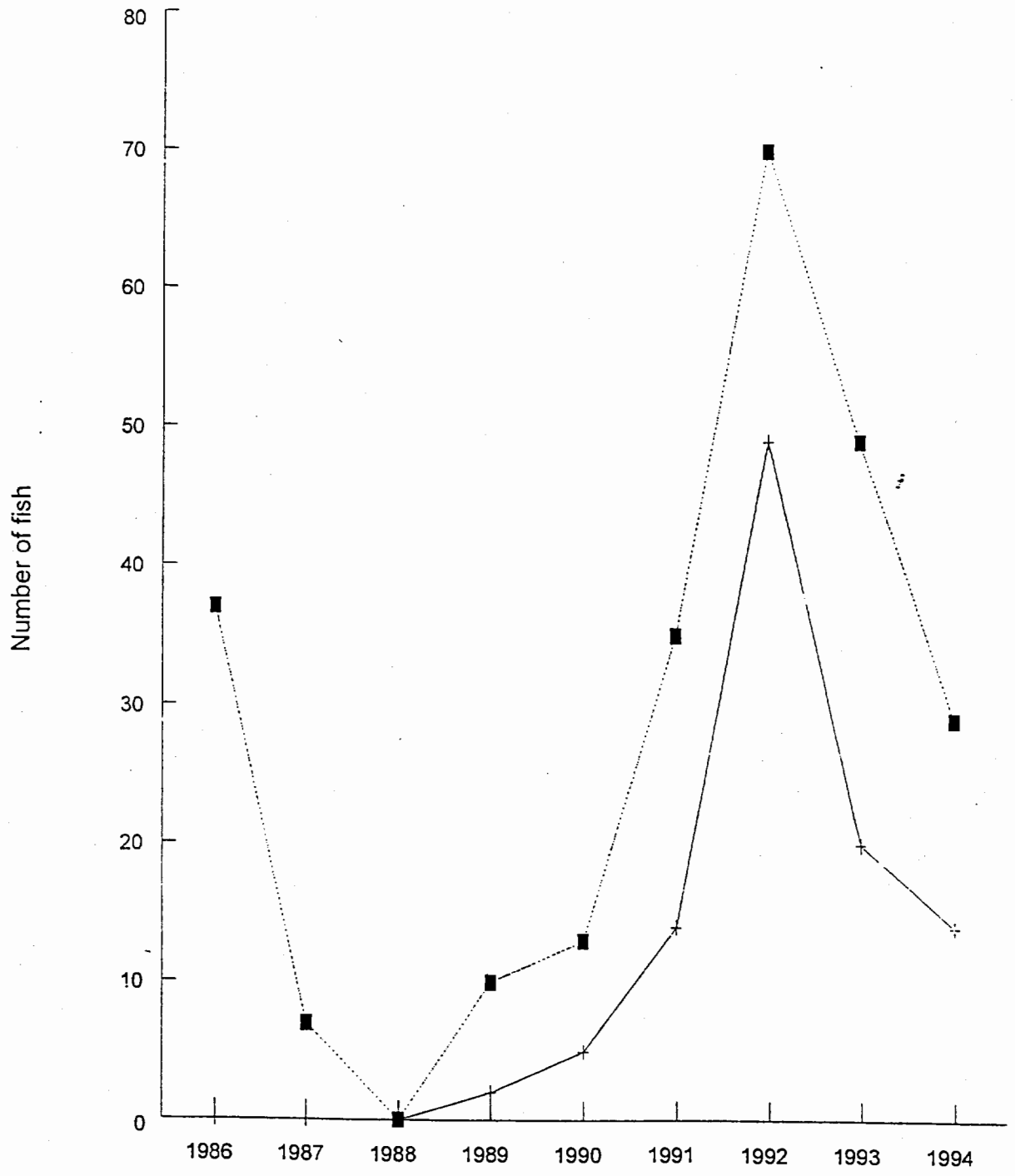

Figure 11. Number of northern pike (broken line), and smallmouth bass (solid line), collected during the RIP Interagency Standardized Monitoring Program sampling stations on the Yampa River.

Because of the evolutionary relationship of native fish biology to natural flows, virgin flows were used as a standard to compare deviations from historical records. A modified version of the Indicators of Hydrologic Alteration (IHA) (Richter et al. in review) was used to compare differences in virgin and historic hydrographs. Based on hydrological modeling, a trend exists between virgin and historic flow scenarios in which peak flows have been reduced and baseflows have increased since water development began in the Yampa basin (Figure 12 and Table 1). The difference between peak flow volumes under virgin and historic flows is seen in the monthly means for March (-5.3%), April (-15.2%), May (-13.5%), and June (-8.6%) (Table 2). During the low flow months, irrigation return flows were apparently increasing low flow volumes, as seen in monthly means for August (+4.7%), September (+25.6%), October (+34.3%), November (+16.0%), and December (+9.5%). Similar effects were seen in the 7- to 90-day high and low flow averages listed in Table 2 (for historic flows). High flow averages are reduced by 8.4% for annual one-day maximums (as described in Table 1) to 11.3% for 90-day highs. Low flow averages are increased by 79.2% for annual one-day minimums to 25.9% for 90-day lows. The slight moderation historic flows from virgin conditions was also observed in the slight reduction of low flow duration, and the increase of high flow duration. The standard deviations associated with virgin and historic flows were similar, even for low flow measures in which mean values were considerably different (i.e. Annual minimum, 7, 30, and 90 day lows).

Habitat Maintenance and Geomorphology

Although information concerning the distribution, relative abundance, and spawning requirements exist, little information exists on the habitat availability and needs of the endangered fishes of the Yampa River relative to flow. Given this shortcoming, the physical character of the Yampa River as formed by virgin flows represent the best target to meet environmental needs of endangered fishes. The physical character, and hence habitat for endangered fishes, of the Yampa River is maintained by the magnitude of the hydrograph. O'Brien (1984) estimated that the effective discharge (transportation of greatest sediment over a long period of time) of the Yampa River near Cleopatras couch (RK 28 in Yampa Canyon) was 11,500 cfs and that bankfull discharge (i.e. channel changing capability) was 21,500 cfs. The discharge that would be effective in scouring the channel to prevent encroachment of the river channel by vegetation occurs approximately every 1.5 years (O'Brien 1984). Fisher et al. (1983, in Stanford 1994) provided evidence that vegetation along the shoreline of the Yampa River has not changed substantially because of its unregulated flows. Conversely, riparian vegetation, primarily nonnative species including reed canary grass (*Phalaris arundinacea*), salt cedar (*Tamarix* spp.), and Russian olive (*Elaeagnus angustifolia*) have modified channels in regulated reaches of the Upper Colorado River Basin (Stanford 1994). The higher bankfull discharge, necessary to periodically reshape the river channel historically occurs on a frequency of about every 20 years (O'Brien 1984). Mussetter and Harvey (1994) estimated that flows necessary for bar formation at two known Colorado squawfish spawning sites, Cleopatras Couch (RM 17) and Mathers Hole (RM 18), was approximately 17,500 cfs and 25,000 cfs respectively.

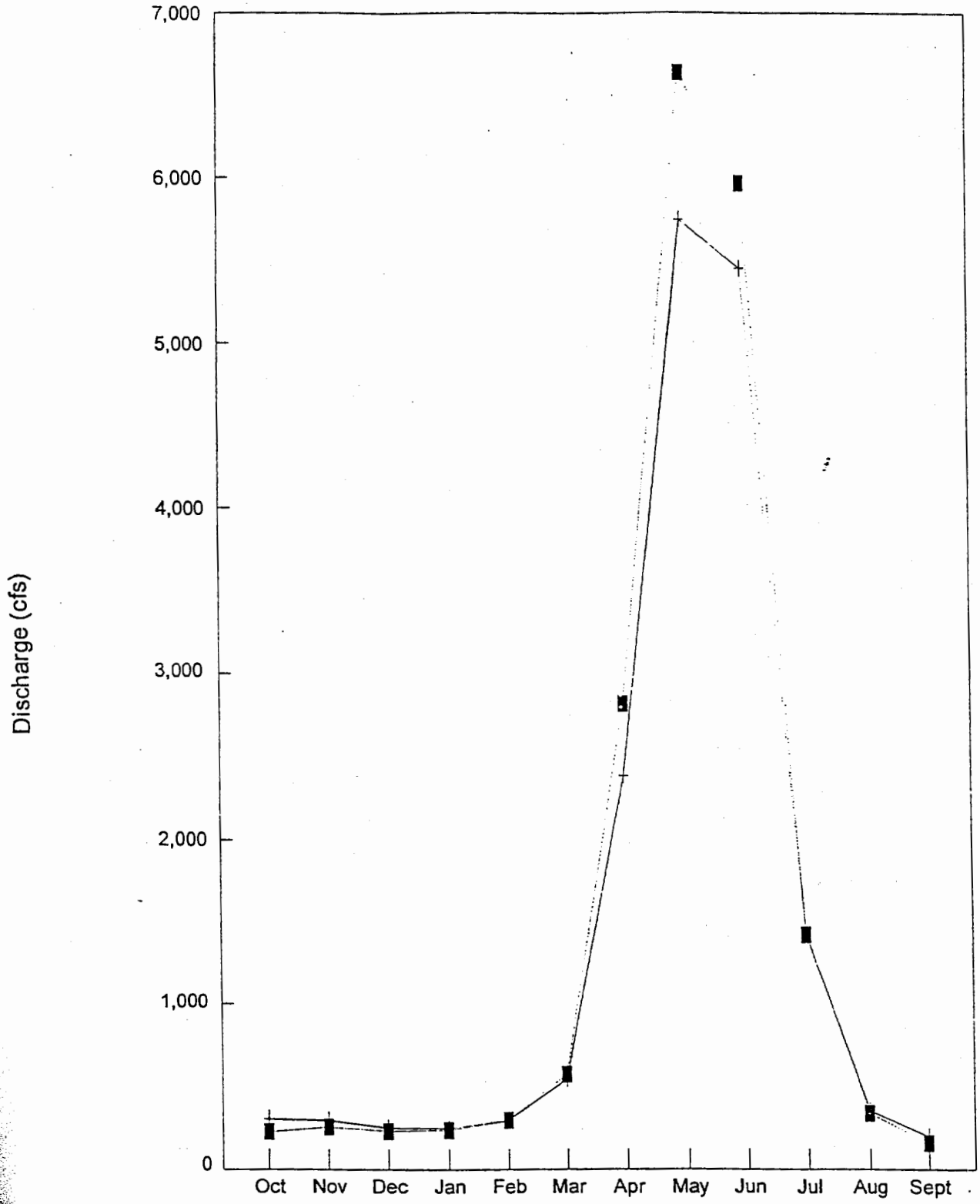

Figure 12. Comparison of historic (solid line), and virgin (broken line), flow estimates as estimated by Hydrosphere (1995) for the period between 1950 and 1982.

TABLE 1. Summary of IHA results for virgin and historic flows (cfs) from the Yampa River (based on the time period between 1950 and 1982). Std. d. = standard deviation.

	Virgin Flows		Historic Flows	
	MEAN	Std. d.	MEAN	Std. d.
October	230	186	309	182
November	262	97	304	.97
December	232	77	254	76
January	240	60	250	60
February	300	111	303	112
March	573	258	542	255
April	2810	1293	2384	1287
May	6634	1900	5742	1894
June	5959	2384	5448	2234
July	1427	1156	1429	1157
August	340	194	356	206
September	163	104	204	120
Annual Minimum	48	46	87	48
Annual Maximum	10326	3098	9460	2933
7-day Low	58	55	101	53
7-day High	9446	2928	8601	2752
30-day Low	91	71	137	62
30-day High	7818	2267	7007	2242
90-day Low	157	59.7	197	55
90-day High	5373	1666	4764	1620

TABLE 2. Summary of deviations of historic flows (cfs) from virgin flow conditions in the Yampa River (based on time period between 1950 - 1982).

	Historic Flows MEAN
October	34.3
November	16.0
December	9.5
January	4.2
February	0.7
March	-5.3
April	-15.2
May	-13.5
June	-8.6
July	0.1
August	4.7
September	25.6
Annual Minimum	79.2
Annual Maximum	-8.4
3-day Low	73.3
3-day High	-8.7
7-day Low	73.2
7-day High	-8.9
30-day Low	51.6
30-day High	-10.4
90-day Low	25.9
90-day High	-11.3

DISCUSSION

The previous Yampa River interim flow recommendations proposed by the U.S. Fish and Wildlife Service (USFWS 1990) were based largely on relationships of the hydrograph to reproductive behavior and nursery habitat needs of endangered fishes (Tyus and Karp 1989). This approach is appropriate because insufficient recruitment is the major factor in the decline of the "large river" endangered fishes in the Upper Colorado River Basin (e.g Behnke and Benson 1980, Minckley et al. 1991). The natural hydrograph is necessary to cue spawning migrations (Tyus and Karp 1989), provide habitat conditions necessary for spawning and survival of early life stages (Tyus 1986, Modde et al. accepted for publication), and the construction of habitat features (i.e. river channel geomorphology) needed to maintain quality spawning, nursery and adult habitats (O'Brien 1984, Mussetter and Harvey 1994). Despite the demonstrated relationship of natural flow patterns to the biology of the "large river" endangered fishes of the Yampa River, little information exists on the habitat available to endangered fishes among flow scenarios. Given this situation, we assume that the conditions favorable for the recovery and maintenance of the endangered fishes of the Yampa River, and affected areas of the Green River, are best estimated using virgin flow conditions (Tyus 1994) when fish were abundant (Quartarone 1993).

The comparison of Yampa River historical and virgin hydrographs indicated present peak flows tend to be lower and baseflows higher than virgin flows. These characteristics were evident in both monthly average flows and both high and low (3 d through 90 d) duration records. Deviations in high and low flows dampen natural variability. Several studies have reported that moderation of flow patterns in streams and rivers resulted in replacement of native fishes with introduced exotic fish species (e.g. Maheshwari et al. 1995, Deacon 1988, Moyle 1986, in Baltz an Moyle 1993). The fish fauna of the Upper Colorado River Basin are largely endemic (Tyus et al. 1982a) and evolved in a very harsh climate and hydrology (Miller 1961). Although tolerant to high levels of environmental variability, the largely endemic fish fauna of the Colorado River Basin have not been effective competitors with introduced nonnative fishes (Minckley and Douglas 1991, Johnson et al. 1993). Among the states of Colorado, Utah, and New Mexico (data from Arizona not provided), 53% of the listed species were considered to be largely the result of nonnative fish interactions while 71% where considered largely the result of habitat alterations (Horak 1995).

Despite the encroachment of nonnative fishes in altered western rivers and streams, native species have dominated in those systems able to maintain a relatively natural hydrograph. Hawkins and Nesler (1991) described several instances in which high spring peaks have resulted in the decline of nonnative fishes in the Upper Colorado River Basin. Native fish distribution in the Yampa River is consistent with observations of Hawkins and Nesler (1991) in that native fishes continue to dominate in the areas with the greatest environmental variation. In the Lower Colorado River Basin flow variability was observed to be the dominant factor in maintaining native fish communities in several streams and rivers (Deacon 1988, Minckley and Meffe 1987).

Poff and Ward (1990) suggested that in highly variable/unpredictable flow regimes abiotic factors dictate ecological processes, whereas, under more benign or predictable flow regimes biotic factors such as competition or predation are more influential. In this respect, species adaptable to variable environments will persist in the face of environmental heterogeneity and disturbance, whereas, others (i.e. nonnative species) may colonize but will not persist. Conversely, under moderated conditions biotic interactions become more determinate and nonnative species have a greater opportunity to persist. In California streams, Baltz and Moyle (1993) stated that the maintenance of native fish assemblages required maintaining natural flow patterns which included the high winter floods and the low summer baseflows.

Several studies support the concept that flow variation is important to the maintenance of native fishes in western rivers and streams (e.g. Hawkins and Nesler 1991, Baltz and Moyle 1993, Minckley and Meffe 1987). Much of this literature relates to the importance of peak flows to the persistence of native species. Indeed, peak flows seem to be the dominant factors influencing spawning migration, spawning, larval transport to nursery sites and adult habitat in the Yampa River (Tyus and Karp 1989). Very little information exists relative to the importance of baseflows on native fish communities. Although some studies have indicated the importance of baseflows to native species in intermittent streams (Deacon 1988, Paloumpis 1958), these studies are not applicable to the permanent flowing Yampa River. Poff and Allan (1995) evaluated fish assemblages in various flow regimes in midwestern streams and rivers and concluded that fluctuations in baseflow can influence persistence among fishes.

Data clearly demonstrate the relationship of natural flow patterns to the biology of endangered fishes in the Yampa River (Tyus and Karp 1989), however, the quantity of flows and variation necessary to maintain rare native species within and among years has not been experimentally defined. Although correlations of fish declines with changes in the hydrograph have been demonstrated (e.g. Walker and Thoms 1993, Modde et al. accepted for publication) the specific causal factors associated with native fish declines have not been clearly demonstrated. Nonetheless, the dependence of native fish assemblages on a variable hydrograph have been clearly demonstrated in arid landscape rivers and streams. As discussed by Stanford (1994), no universal quantitative method of determining specific habitat needs (i.e. flow recommendations) of fishes exists and an adaptive management approach using the best information available represents the most desirable approach. Stanford (1994) further recommended that, due to the "critical" nature of flows and habitat in the Yampa River, and its importance to the recovery of endangered fishes in the Upper Colorado River Basin, the U.S. Fish and Wildlife Service interim flows should be adopted and evaluated. However, Stanford (1994) cautioned that the environmental baseline needed to be revised and that flow recommendations not be based on monthly averages because of the need to incorporate instantaneous variation which was a "very important component of river ecology".

RECOMMENDATIONS

Flow Recommendations

Based on the review of the IHA results for the Yampa River, the RIP instream flow review (Stanford 1994) and the existing biological information in this report, the Service has reevaluated the interim flow recommendations for the Yampa River (USFWS 1990). The 1990 recommendations were based on the preservation of a natural hydrograph with base flows maintained at a constant flow (i.e. 50% exceedance) measured at Deerlodge Park. During the course of the Yampa River Alternative Feasibility study (Hydrosphere Resource Consultants 1995a), the Maybell gage was identified as the reference point for flow recommendations and the depletion set above that point was updated as shown in Table 3. Based on the modeling undertaken by the Yampa River Feasibility Study this revised depletion set was still considered to be consistent with the maintenance of a relatively natural hydrograph.

Daily, seasonal and annual variation may be the responsible factor for maintaining the abundance of native fishes in Yampa Canyon. The higher gradient in the confined channel of Yampa Canyon (Miller et al. 1982) produces greater ranges in velocity, turbulence and depth than occurs in lesser gradient channel outside the canyon where wider floodplain habitats exist which may provide refuge for nonnative fishes. The harsh environment occurring in Yampa Canyon during peak flows is most likely the reason native fishes are most abundant. Annual variation should be more favorable to native fishes the closer it resembles virgin conditions, that is, variation and magnitude around the natural hydrograph. The maintenance of constant monthly baseflows that do not vary annually is a significant departure from a natural hydrograph and such moderation of flows may be of greater advantage to nonnative than native fish species. The baseflows for the Yampa River should therefore correspond to its largely unregulated and undepleted hydrology in any given year. However, the constant and extreme fluctuation of baseflows, such as those resulting from hydroelectric generation, should also be avoided.

The recent review of the Upper Colorado River Basin flow recommendations by Stanford (1994) supported the need for the maintenance of natural variation and expressed the need for a natural hydrograph rather than a stair-stepped recommendation based on monthly averages. That report also expressed concern with the de-stabilization of daily flows by hydropower operations on the Green and Gunnison rivers, and cautioned that the daily hydropower ramping rates should not exceed pre-regulation conditions. The recommendation was to restore naturally stable summer and winter baseflows on the Green and Gunnison rivers, which would exhibit substantial daily, seasonal, and annual variation, as now occurs on the largely unregulated Yampa River. Stanford (1994) suggested that natural variation during the baseflow period could be about 5% per day.

The primary tenet of the interim Fish and Wildlife Service Yampa River flow recommendations, to maintain a relatively natural hydrograph, remains unchanged. High spring flows are necessary to support biological needs (initiates spawning

Table 3. Projects included in the Yampa River Section 7 Baseline Above Maybell, Colorado. Values represent acre feet.

	Yampa River	Depletion
Craig Thermal I, II, III	Total	19,200
Hayden Thermal I, II		7,100
	Total	26,300
Municipal/Other		3,091
Mining		1,692
	Total	4,183
Stagecoach Reservoir		
Municipal		333
Industrial		9,000
Evaporation		1,140
Yampcolo Exchange		2,400
	Total	12,473
Private Actions Reasonably Certain to Occur[1]		
Export		4,788
Reservoir Evaporation		4,638
	Total	9,426
Agriculture		
Historic Agriculture		81,669
Agricultural consumption to 1989 level		3,519
Dry Year Additional Agriculture[2]		4,250
	Total	89,438
GRAND TOTAL		142,820

[1]Private action reasonably certain to occur are actions described in the regulations which have no federal nexus and can be reasonably certain to occur.

[2]Additional Agricultural Consumption added in 10 dry years

Table 4. The U.S. Fish & Wildlife Service recommends the following flows for the Yampa River at Maybell, Colorado (September 1995). Flow recommendations vary between the exceedance levels described on this table relative to the magnitude of a specific runoff year. Exceedance numbers are based upon estimates of daily virgin flows from 1950 to 1982. A constant flat flow at these exceedance levels is not recommended, flows should be interpolated between these recommendations with portions of the month higher and portions lower (i.e. reflective of the curve of a natural hydrograph). An alternate table, not recommended by the Fish and Wildlife Service that data which excludes the minimum 10 cfs values in the estimating daily exceedance of virgin flows is found in Appendix 5.

MONTH	80%[1] Exceedance DRY	50% Exceedance AVERAGE	20% Exceedance WET
OCT	88	181	335
NOV	172	239	336
DEC	157	209	320
JAN	187	230	299
FEB	221	266	335
MAR	305	443	694
APR	Existing flows minus the depletion baseline (Table 3)		
MAY			
JUN			
JULY			
AUG	125	302	520
SEP	45	139	242

[1]Exceedances in cfs

migration, spawning, and creates nursery habitat for early life stages) and maintain the river channel geomorphology such that habitats necessary for endangered fishes continue to exist. A slight deviation in the interim recommendations for baseflows is proposed, such that, flows during successive years fluctuate according to the magnitude of the water year. The recommendations for minimum flows are that: 1) baseflows generally remain above the monthly 80% exceedance for virgin flows between August through March period as shown in Table 4, and 2) rates of daily variation throughout the year do not materially deviate from virgin conditions. The relative impacts of a minimum flow on native and nonnative fishes is unknown at this time. The U.S. Fish and Wildlife Service suggests an adaptive approach to defining baseflow recommendations by evaluating the response of native and nonnative fish interactions following low flow years, i.e., greater than 80% exceedance. The use of the 20% and 80% exceedance values has been standard practice for developing Biological Opinions in Region 6, U.S. Fish and Wildlife Service for defining high and low flows years. The same standards were proposed by Maheshwari et al. 1995.

The importance of the Yampa River's relatively natural flow magnitude and variation to the life histories of endangered fishes fully justifies that the flow recommendations be implemented and evaluated. Because daily, seasonal and annual flow variations may be essential to the life history of the endangered fishes of the Yampa River, the continuous pattern of a natural hydrograph should be maintained rather than a truncated design of constant monthly values. Below are specific rationale for U.S. Fish and Wildlife Service recommendations associated with the runoff and baseflow period.

Spring (March 21 - June 21)

Colorado squawfish

In the spring adults move into flooded or protected areas where they fed and ostensibly prepare for spawning. Annual spawning migrations are associated with the decline of the hydrograph and increasing temperatures. Between 1981-1988, spawning of Colorado squawfish occurred approximately 26 days following the start of migration movement with minimum temperatures of 19° C and maximum temperatures of 24° C. Spawning generally occurred earlier in low water years and later in high water years. Seasonal peak flows are necessary to cue movement, build and maintain gravel spawning bars, and sculpt river channels to create eddy habitats used by staging fishes.

Razorback sucker

Razorback sucker spawning migration is initiated during the increasing limb of the natural hydrograph and spawning occurs between temperatures of 12° C to 16° C. High flows are necessary to clean spawning gravel and cobbles and transport larval fish from spawning sites to nursery sites downstream in the lower gradient reaches of the Green River.

Humpback chub

Humpback chub appear to spawn following the seasonal peak flow at temperatures of about 19° C. Seasonally high flows are important in constructing and maintaining shoreline eddy habitats used by humpback chub throughout the year.

Spring Recommendations

Spring peak flows are associated with reproductive activities of all the target endangered species occupying the Yampa River. Spring peak flows of the Yampa River connect floodplain habitats thus providing seasonal bottomland use by endangered fishes in both the Yampa and Green rivers. The decline of razorback sucker may be due to the loss of floodplain habitat in the low gradient reaches of the Green River and Yampa rivers. Evidence also suggests that high flows impede establishment of exotic fish species, particularly in canyon bound reaches of the Yampa River.

Spring high flows transport sediments and that are delivered downstream to nursery habitat sites for Colorado squawfish in the middle Green River. High flows are also implicated in reducing encroachment of the introduced salt cedar, and exotic plant that competes with native riparian vegetation. Given the needs for high spring flows the Service recommends that existing flows (minus the baseline depletion) be provided for the recovery of endangered fishes in the Yampa River..

Summer (June 22 - September 22)

Colorado squawfish

A gradual decline in summer flows following spring scouring of cobble substrates provides an environment that facilitates spawning, incubation, larval emergence, and downstream drift of larvae, as well as, enhance growth and development of embryos and larvae. High spring flows help to create downstream nursery areas, but these habitats are maintained as productive fish habitats by declining flows. Sufficient flows are necessary for return migration of postspawning adults past low flow obstacles in the river channel. Variability in flow among years and months should provide greater benefits to native fishes, as observed in Yampa Canyon.

Humpback chub

Extremely low summer flows could adversely affect spawning and nursery habitat of the humpback chub in Yampa Canyon by concentrating fishes in suboptimal habitats and increasing the potential for disease, competition, predation, and hybridization. Variability in flow among years should provide greater benefits to native fishes, as observed in Yampa Canyon.

Summer recommendations

Flows during the months of August through September should be maintained between 20% and 80% exceedance based upon the flow magnitude occurring during that year. Flows should occur in a pattern reflecting a natural hydrograph with a continuous curve and not truncated or stair-stepped based on any temporal based mean.

Fall and Winter (September 23 - March 31).

Colorado squawfish

Variable Yampa River flows (20% to 80%) are desirable for adults and juveniles relative to interaction with nonnative fishes. However, under ice conditions flow should never decrease below 80% exceedance flows. Because of the transition to winter behavior, it is important to prevent unnatural variation during this period to reduce any ice break-up that may occur and the energy required by fish to move to and from preferred habitat which may cause stress.

Humpback chub

Flows lower than the 80% exceedance value are not recommended. Little is known of fall and winter habitat use of humpback chub, however, most native species are believed to compete more effectively with nonnative species when environmental conditions show natural levels of variability.

Fall and Winter Recommendations

Naturally variable flows between 20% and 80% exceedance (depending on the magnitude of the flow year) occurring in a continuous hydrograph are recommended. Regular and unnaturally high flow fluctuations should be avoided to prevent ice break-up and unnecessary energy expenditure by fishes resulting from movement associated with changes in preferred water column position.

Summary of flow recommendations

The Fish and Wildlife Service flow recommendations (Table 4) were based on calendar months to facilitate their translation into the water right decree. Due to the limitations of available water, the Fish and Wildlife Service recognizes that implementation of the above flow recommendations will involve trade-offs between seasonal needs. A discussion of the seasonal priorities and mechanisms related to implementation will be addressed in a separate report prepared by the Fish and Wildlife Service.

Baseflow Months August-March

During the non runoff months the flow recommendation is for flows between the 20% and 80% exceedance of virgin daily flow. The recommendation is meant to vary depending on the type water year and not to be construed as a single value but must vary between years and between days in the month to emulate the variability of a natural hydrograph.

High Flow Months

Flow recommendations for the high flow months, April through July, include all existing flows minus the depletion baseline allowance described in Table 3. These flows are necessary as biological cues, habitat construction (spawning and habitats necessary for all life stages), and maintenance.

Recommended Actions

The Yampa River, due to its relatively natural hydrograph and environmental variability, is a primary factor in the maintenance and potential recovery of Colorado squawfish, razorback sucker, and humpback chub in the Upper Colorado River Basin. This river supports the largest Colorado squawfish spawning aggregation, one of two known razorback sucker spawning sites and supports all life stages of humpback chub. Despite its importance and research emphasis during the past decade, little trend information exists relative to abundance or population structure of native and/or nonnative fishes below the confluence of the Little Snake River. In this respect, a long term monitoring effort for the entire Yampa River needs to be initiated. In addition, little information also exists on available habitat as it relates to flows. In the same manner, the interactions between native and nonnative fishes is unknown. As proposed by Stanford (1994) flow recommendations should be initiated as an adaptive management process. If natural low flows result in detrimental interactions between native and nonnative fishes the recommendations in this report may not be valid and would need to be revised.

Another issue identified in this report was potential disruption to postspawning Colorado squawfish migration. Flows were identified in which barriers were traversed by fish; however, if fish were unable to traverse these barriers they would not have been detected. As a consequence, further investigation as to the limitations associated with fish movement through both natural and man-made obstacles during

low flows is recommended. Identification of flows necessary for movement past potential barriers would allow greater resolution in defining a lower limit of baseflows.

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Appendix 1. Dates and flows in the Yampa River at the Maybell gage before and after radio transmitter equipped Colorado squawfish left the Yampa River spawning reach.

Colorado squawfish movement through Cross mountain Canyon.

Tag No.	Date below	Flow below
1300	07/08/81	535
1312	07/17/81	515
1327	07/21/81	467
1330	07/05/81	1060
1339	07/05/81	1060
1347	07/23/81	324
1166	08/08/83	1200
3056	08/03/83	1360
3061	08/03/83	1360
3074	08/03/83	1400
3076	08/08/83	1200

Colorado squawfish movement through the Maybell Diversion.

Tag No.	Date below	Flow below
1300	08/05/81	177
1327	07/30/81	352
1339	07/05/81	1060
1347	08/05/81	177
3056	08/03/83	1360
3061	08/03/83	1360
3074	08/02/83	1400
3282	08/07/82	804

Appendix 2. Literature compiled in constructing Figure 10.

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Appendix 3. Report by Hydrosphere Resource Consultants that estimates daily flow in the Yampa River at Maybell (attached).

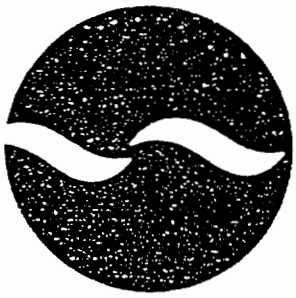
DEVELOPMENT OF ESTIMATED DAILY FLOWS

YAMPA RIVER AT MAYBELL

May 12, 1995

Prepared for:

Colorado River Water Conservation District
201 Centennial Street
P.O. Box 1120
Glenwood Springs, Colorado 81602



HYDROSPHERE

Resource Consultants
1002 Walnut · Suite 200 · Boulder, CO 80302
(303) 443-7839 · TeleFax (303) 442-0616

DEVELOPMENT OF ESTIMATED DAILY FLOWS YAMPA RIVER AT MAYBELL

OVERALL DESCRIPTION OF WORK

This work was undertaken to assist the Colorado River Fish Project of the U.S. Fish and Wildlife Service ("Fish Project") by providing certain hydrologic data it requires to investigate the potential benefits and disadvantages of summer low flow augmentation in the Yampa River using storage water made available by the enlargement of Elkhead Reservoir. Funding for this work was provided through the Colorado River Water Conservation District.

Three hydrologic data sets were developed in this effort, including: 1) estimated daily virgin flows in the Yampa River at the Maybell gage; 2) estimated daily flows at the Maybell gage in the year 2040 without the Elkhead Reservoir enlargement project; and 3) estimated daily flows at Maybell in the year 2040 with an enlarged Elkhead Reservoir operating to provide augmentation flow in the Yampa River. Development of the data sets relied heavily on previous work accomplished as part of the Yampa River Basin Recommended Alternative Detailed Feasibility Study ("Phase 2 Study") and its predecessor, the Yampa River Basin Alternatives Feasibility Study ("Phase 1 Study"). In particular, data sets of current and future water demands and modeled scenarios of river flow conditions developed in those studies were used directly and indirectly to estimate daily flows at Maybell.

ESTIMATED DAILY VIRGIN FLOWS AT MAYBELL

Estimated daily virgin flows at the Maybell gage site (USGS gage # 09251000) were developed by adding estimated depletions associated with historical upstream water uses back into the gaged flow for each day of the study period. The estimated depletions added back into the gage values were those associated with: 1) the municipalities of Steamboat Springs, Hayden and Craig, 2) the Hayden and Craig Generating Stations, 3) irrigation of upstream agricultural lands, 4) the diversions of the Maybell Canal immediately upstream of the gage, 5) diversions for export from the basin, and 6) the first-fill of and subsequent evaporation from principal upstream reservoirs.

Historical records needed to carry out the work were obtained from a variety of sources. The principal data sources included the Division 6 Office of the State Engineer, which provided records on diversions and irrigated acreage, and water and wastewater managers of the larger municipalities in the basin. Related documents and information which shed light on historical data or provided means of independently verifying it were also obtained and reviewed. Historical data necessary for the work included: gaged flow at Maybell; daily diversions of the Maybell Canal; daily diversions of the generating stations and municipalities; wastewater flows from the municipalities; populations of the municipalities; historically irrigated acreage;

historical climatic data for estimation of evapotranspiration; types of crops grown in the basin; diversions of irrigation ditches; evaporation rates; dates and patterns of first-fill of reservoirs; and reservoir operations of consequence.

Related documents obtained and reviewed included: annual reports of the Division 6 Engineer; irrigated acreage from the Consumptive Uses and Losses Reports prepared by the Bureau of Reclamation; the recent water availability study done for the Colorado Water Conservation Board; and reports of the Colorado Department of Agriculture and Bureau of Census. The work also relied on information developed through numerous conversations with the Division 6 Engineer and other water managers in the basin.

Definition of Study Period

The term "study period" here refers to the historical period of time over which daily flow data sets were developed. While it is desirable to have as long study period as possible, constraints imposed by the availability of both historical and modeled data sets limited it to an interval from approximately 1950 to the present. Gaged Maybell flows were examined to determine precisely which starting and ending years in this general time period should be used to insure that all included dry spells are contained entirely within the study period. The study period was then defined as extending from October 1, 1949 to September 30, 1982 (water years 1950-1982)

Daily Municipal Depletions

Daily municipal depletions were estimated by first establishing statistical relationships between recent annual historical records of diversions and wastewater flows at the municipalities, and recent population data. The relationships were then used to estimate annual depletions from 1950 to 1982 using population data over the study period. The depletions were then disaggregated into monthly values using an average monthly pattern observed in recent historical records, and the monthly depletion computed as the difference between monthly diversions and wastewater return flows. Finally, the monthly depletions were disaggregated into daily values using a spline interpolation scheme that preserved the total flow volume in each month. Daily municipal depletions were estimated for the municipalities of Steamboat Springs and Mt. Werner, Hayden, and Craig.

Steamboat Springs and Mt. Werner Water and Sanitation District

Total annual depletion data between 1985 and 1991 were related to population over the same period. The annual depletions were obtained from the aggregated monthly depletions in recent years. Monthly depletions were computed as diversions minus wastewater effluent. The diversion data were obtained from the Fish Creek Reservoir Expansion EIS Water Resources Technical Report (ACZ, Inc., 1992), which provides the monthly water usage by the City of Steamboat and the Mt. Werner district. Data on total annual wastewater flow from the treatment plant over the 1985 through 1991 period were obtained from the City and were reduced by 5.39% to remove contributions by Steamboat II, Sleepy Bear and Ski Town (since diversion data were not available for these small domestic systems). This data was then also related to population data over the study period.

In those months when the monthly depletion was less than five percent of the monthly diversion, the depletion for the month was taken as five percent of the diversion. Depletions less than five percent sometimes occur during the winter and early spring months and are likely a result of seepage inflow to the wastewater collection system.

The relationship developed between annual depletion and population was then used to estimate annual depletions over the period 1950- 1982 using population data over the study period. Population figures were obtained from the demographic section of the Division of Local Government, Department of Local Affairs. Because population data were only available every ten years in the earlier part of the study period, the intervening years were filled in using a straight line interpolation scheme. Annual values were then disaggregated into monthly values using the average monthly diversion or wastewater flow over the 1985 through 1991 period expressed as a percentage of the average annual value over the same period. Monthly depletions were then estimated by subtracting the monthly wastewater flows from the diversions. The monthly depletions were then disaggregated into daily values using a quadratic spline interpolation scheme. Daily values were then routed to the Maybell gage based on the travel times discussed below.

Town of Hayden

A similar approach was used to estimate daily depletions for the Town of Hayden. Monthly diversion records for Hayden's municipal water use were obtained from the Town over the period 1991 through 1994. Effluent from the wastewater treatment plant was estimated to average 200,000 gallons/day (Jack Rickman, Public Works Director, Town of Hayden). Annual depletions (diversion minus wastewater effluent) were computed over the recent historical record, and related to the population data over the same period. The relationship was then used to calculate annual depletions over the study period from 1950 through 1982. The annual depletions were then disaggregated into monthly values using the average monthly depletion pattern expressed as a percentage of the annual value over the recent historical period. Daily depletion estimates were then derived from the monthly depletions using a quadratic spline interpolation scheme. Daily values were then routed to the Maybell gage based on the travel times discussed below.

City of Craig

The approach used to estimate historical depletions at Steamboat Springs and Hayden was also used for the City of Craig. Annual flow from the water and wastewater treatment plants over the period from 1984 through 1990 were related to the population over the same period. The relationships were then used to estimate the corresponding annual flows over the 1950 through 1982 study period using population data from the period. Annual flows estimated in the study period were then disaggregated into monthly values based on the average monthly flow pattern expressed as a percentage of the average annual flow over the historical period from 1984 through 1990. The monthly depletions were then calculated as the monthly flows from the water treatment plant minus the effluent from the wastewater treatment plant. Daily depletion estimates were then obtained from the monthly depletions using a quadratic spline interpolation scheme. Daily values were then routed to the Maybell gage based on the travel times discussed below.

Daily Power Generation Depletions

Historical depletions associated with the Hayden and Craig Generating Stations were determined from daily records of actual diversions over the study period. These records were supplied by the Office of the State Engineer, Division of Water Resources. All diversions by the Hayden and Craig Stations were assumed to be 100 percent consumptive with respect to the flow measurement gage on the Yampa River at Maybell. The effects of these diversions were then routed to the Maybell gage using the travel times discussed below.

Daily Irrigation Depletions

Irrigation results in the most significant depletions that are imbedded in the historical gaged flow at Maybell. Accordingly, this "correction" to the gaged Maybell flow was given the greatest attention. Historical irrigation depletions were, in general, estimated from potential crop consumptive use adjusted for the effects of water supply shortages, groundwater return flows, and river travel times. The agricultural depletion analysis was conducted on a monthly basis. Estimated depletions were then converted to daily values using a spline interpolation scheme.

Historically Irrigated Lands

Estimates of historically irrigated lands are available since the mid-1970's from the Division 6 office of the State Engineer. Since this time, irrigated lands have average roughly 70,000 acres in the Yampa River Basin in Water Districts 44, 57 and 58, and acreage has shown little variability from year to year. The Division 6 Engineer has suggested that this same approximate level of irrigated lands likely occurred over the period 1950 through 1982. Information provided on irrigated acreage from the U.S. Department of Agriculture and the U.S. Bureau of Reclamation also showed no time trends in the amount of irrigated lands since the 1930's..

To estimate historical agricultural depletions over the study period, records of irrigated lands were examined from a 1994 tabulation developed by the Division 6 Engineer. This information was provided in electronic DBase format which listed each irrigation ditch and the number of acres it supplied. This information was then sorted by general geographic location and filtered to exclude any acreage below the Maybell gage (a portion of District 44 extends to the west of Maybell). This process resulted in an estimated 68,700 acres of irrigated lands upstream of the gage. The area of irrigated lands was assumed constant over the study period.

Potential Consumptive Use

Monthly potential crop consumptive use rates were estimated, using the Blaney-Criddle method and historical precipitation and temperature data, for the irrigated crop types determined to be relevant over the study period (primarily pasture hay and alfalfa). Potential consumptive use (PCU) was estimated for each crop type at each of four climate stations in the basin which were in operation during the study period (Yampa, Steamboat Springs, Hayden, and Craig). PCU rates (feet) were developed for each month of the study period.

Aggregation of Irrigated Areas

The current distribution of irrigated land in the basin was examined from the perspective of climatic zone, distance from the Maybell gage, and irrigation practice. From these considerations, eight groupings of lands were defined for consumptive use estimation purposes (Table 1). All lands within each group were treated as if they constituted a single parcel of irrigated land. Potential consumptive use rates for each of the eight land groupings were developed in consideration of each area's proximity to one of the four climate stations. Furthermore, cropping type was considered to appropriately weight PCU for differences in crop proportions between land groups. The PCU rates were then applied to the number of acres in each grouping to estimate monthly potential consumptive use, in acre-feet, over the study period.

Table 1
Designation of Irrigated Land Groupings for Estimation of Agricultural Depletions

Group	Irrigated Area Included in Grouping	Climate Station
1	Yampa River/Tribs. ab. Steamboat and Elk River/Tribs. ab. Mad Creek	Yampa
2	Yampa River/Tribs. between Milner and Steamboat Springs	Steamboat
3	Yampa River/Tribs. between Mount Harris and Milner	Steamboat
4	Trout Creek/Tribs. and Williams Fork ab. Hamilton	Steamboat
5	Yampa River/Tribs. between Mount Harris and Elkhead Creek	Hayden
6	Elkhead Creek/Tribs.	Hayden
7	Yampa River/Tribs. between Elkhead Creek and Williams Fork	Craig
8	Yampa River/Tribs. bel. Craig and Morapos Creek	Craig

Historical Diversions

Records of historical diversions by all irrigation ditches in the Yampa River Basin were supplied by the Office of the State Engineer, Division of Water Resources. This data was available in both daily format and as monthly totals for each diversion structure. With the exception of the Maybell Canal, only monthly totals were examined.

Diversion data was provided in electronic DBase format and was systematically filtered to develop a set of diversion records for only those ditches upstream of the Maybell Gage. The Maybell Canal was excluded from this subset (discussed below). The data were then cross referenced with data on irrigated lands to develop eight sets of diversion data which were geographically consistent with the geographic groupings shown in Table 1. Each of the data sets consisted of 33 years of monthly diversion volumes (acre-feet).

Irrigation Depletion Analysis

Potential consumptive use is an upper-bound estimate of actual consumptive use. Actual consumptive use will generally be less than potential consumptive use because of water supply shortages and irrigation and harvesting practices. Furthermore, the temporal pattern of actual stream depletion is different from that of actual consumptive use because of the lagging of

groundwater return flows (stream depletion on any given day is the net of diversions and return flows on that day).

In order to estimate historical depletions due to irrigation, an EXCEL spreadsheet was created to calculate actual consumptive use and return flows to the Yampa River. This analysis was conducted for each of the eight land groupings identified. Input to this calculation included 1) irrigated area; 2) historical diversions to those lands; 3) potential consumptive use; and 4) assumptions relating to ditch losses, application efficiencies, and return flow characteristics. Return flow characteristics reflected distance from the irrigated lands to the river and hydraulic conductivities of the underlying soils. These characteristics were used in a Glover analysis to determine monthly groundwater return flow lag factors.

Input data on irrigated lands, diversions and potential consumptive use were determined as previously described. Values for ditch loss rates, application efficiencies and return flow characteristics were assumed based on engineering judgment. We believe these assumptions are generally consistent with the methods of irrigation in the Yampa River Basin and the location of irrigated lands (Table 2).

Table 2
Land Grouping Characteristics Used in Glover Analysis of Return Flows

Group	Irrigated Area (ac.)	Ditch Loss (%)	Application Efficiency (%)	Valley Width (ft.)	Hydraulic Conductivity (ft./d)	Specific Yield	Saturated Thickness (ft.)
1	21,500	10	45	4,000	400	0.2	20
2	14,100	10	45	4,000	300	0.2	20
3	500	10	45	2,000	200	0.2	20
4	8,000	10	45	2,000	300	0.2	20
5	6,600	10	45	4,000	200	0.2	20
6	2,200	10	45	2,000	200	0.2	20
7	5,600	10	45	3,000	200	0.2	20
8	10,200	10	45	2,000	175	0.2	20

The agricultural depletion analysis generated eight sets of monthly depletion values. Generally speaking, depletions are positive (diversions are greater return flows in each month) during the months of April through July. During the remaining months of the year, depletions are generally negative (return flows are greater than diversions in each month). Monthly depletion volumes were then converted to daily values using a spline interpolation scheme. Each of the eight daily data sets were then routed downstream based on the average distance of each land grouping from the Maybell gage and the travel time estimates discussed below.

Estimated monthly depletions generated through the analysis were then compared to similar estimates by Division 6 for the period 1976 to 1982. On average the comparison was quite close. However, the Division 6 estimates tended to show somewhat more variability from year to year. Agricultural depletions estimated through this study averaged roughly 78,000 acre-feet per year and ranged from a high of over 97,000 acre-feet (1978) to a low of 46,500

acre-feet (1965). Division 6 has estimated depletions of over 100,000 acre-feet in recent years, although this estimate includes some agricultural depletions occurring below the Maybell gage.

Maybell Canal Depletions

The Maybell Canal diverts water from the Yampa River approximately four miles upstream of the Maybell gage. Water diverted by the Canal serves lands located several miles downstream. For purposes of this study, it was assumed that diversions by the Maybell Canal were 100 percent consumptive with respect to the gage. With this assumption, the adjustment to gage flows at Maybell was made simply by adding back in the daily diversions observed from 1950 to 1982. No routing correction was applied to these diversions because of the close proximity of the Canal to the Maybell gage.

Daily Basin Export Depletions

Several ditches within the Yampa River Basin divert water for export to another basin. Three of these exports occur upstream of the Maybell Gage. For purposes of this study, it was assumed that these diversions are 100 percent consumptive with respect to the Maybell gage. With this assumption, the adjustment made to reflect these depletions was simply to account for observed historical diversions by these ditches and route this effect based on travel time estimates. Diversion records were obtained from the Division 6 Office of the State Engineer.

Daily Reservoir Depletions

Three types of reservoir depletions were accounted for in the estimation of virgin flows: (1) depletions from evaporation, (2) depletions from first fill, and (3) depletions from reservoir operations. Calculations explicitly accounted for depletions from five reservoirs: Steamboat Lake, Lake Catamount, Yamcolo Reservoir, Stillwater Reservoir and Elkhead Reservoir. Reservoir depletions from other reservoirs and open water bodies (e.g., stock ponds) above the Maybell gage were aggregated in each of the three water districts. Depletions were computed on a monthly basis and then disaggregated into daily values using a quadratic spline interpolation scheme that preserved the total depletions in each month.

Evaporation and first fill depletions were calculated for Steamboat Lake. The reservoir was assumed to remain full after it filled for the first time in the spring of 1963. The monthly evaporation depletion was computed as the average surface area from the current and previous months multiplied by the net evaporation rate for the month. Evaporation rates were taken from the Phase 1 study. The first fill depletion was computed as the capacity of the reservoir, and was assumed to take place in April of 1963. The monthly evaporation and first fill depletions were then disaggregated into daily values using a quadratic spline interpolation scheme that preserved the total depletions in each month.

Evaporation and first fill depletions were also calculated for Elkhead Reservoir and Lake Catamount in the same manner as described above for Steamboat Reservoir. However, the first fill for Elkhead Reservoir was assumed to take place in April of 1974. The first fill for Lake Catamount was assumed to take place in April of 1977.

Evaporation, first fill and reservoir operation depletions were calculated for Yamcolo Reservoir. The reservoir was built in 1980 and historical end-of-month storage records are available starting from January of 1981. The evaporation depletion was computed as the average surface area multiplied by the net evaporation rate. The first fill depletion was assumed to be equal to the end-of-month content for January, 1981, i.e., it was assumed that the reservoir began storing water in January, 1981. Depletions from reservoir operation for the month were computed as the current end-of-month content minus the previous end-of-month content. Hence, the depletion is positive when the reservoir is storing water, and is negative when the reservoir is releasing water. Monthly depletions from evaporation, first fill and reservoir operations were then added together and dissagregated into daily values using the quadratic spline interpolation scheme.

Evaporation and reservoir operation depletions were calculated for Stillwater Reservoir. The first fill depletion was not considered in this case because the reservoir was built before our study period began in 1950. An average pattern of end-of-month contents was obtained from the recent historical end-of-month records from 1979 through 1990. This pattern was then applied over the entire study period. The daily evaporation and reservoir operation depletions were then calculated as described above.

Evaporation and first fill depletions were computed for all stock ponds in Districts 44, 57 and 58 in existence during the study period. The surface areas and the date of appropriation of the stock ponds were obtained from the Division 6 Office of the State Engineer. From these, a time series indicating how the surface areas increased over the study period from 1950 through 1982 was constructed based upon the assumption that the stock pond was built in the year of water rights appropriation. Evaporation depletions for each month of the study period were then computed as the net evaporation rate for the month multiplied by the surface area for the year. First fill depletions were assumed to take place in the month of April when the surface area increased from one year to the next. The first fill depletion amount was computed as the reservoir volume corresponding to the increase in surface area using the area-volume relationship for Stillwater Reservoir (this was considered representative of typical reservoirs). The monthly evaporation and first fill depletions for the stock ponds were dissagregated into daily depletion values, and then routed to the Maybell gage using the appropriate travel times.

River Flow Travel Times

The effects of river travel times are significant when daily depletions at points upstream in the basin must be translated to the Maybell gage. Average travel times between selected points in the basin and the gage reach were estimated for each month of the year using a uniform flow assumption, channel geometries and slopes estimated from USGS quad maps, and average monthly gaged flows at the Steamboat Springs and Maybell gages. The resulting estimates were then used to develop daily routing factors to be used in translating estimated depletions from their locations of occurrence to the Maybell gage.

Average travel times were estimated between: (1) the USGS gage on Yampa River at Craig and the USGS gage on Yampa River near Maybell; (2) the USGS gage on Yampa River near Steamboat and the USGS gage on Yampa River at Craig; (3) the USGS gage on Elk River at Clark and the confluence of the Elk River and Yampa River; and (4) the USGS gage on Yampa River above Stagecoach Reservoir and the USGS gage on Yampa River near

Steamboat. From these, travel time contours were drawn, and the travel time from any basin location to the Maybell gage was then estimated using the contours.

Average velocities between the selected locations were estimated using a uniform flow, channel geometry and slope assumptions. The channel geometries were estimated from USGS 7.5 minute quadrangle maps. Slopes were estimated from the elevations recorded in the USGS Water Resources Data report for the gages, and the river mile information provided by Division 6. The Manning equation was used for computing the average velocity as:

$$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$

where n = Manning's coefficient
S = average slope = (elevation difference/distance)
R = hydraulic radius = (Area/Wetted Perimeter)

The travel time between two locations was then estimated as the river distance divided by the average velocity. Parameters used for estimating the average velocity in the four reaches defined are given in Table 3.

Table 3
Parameters Used for Computing Average Travel Times

	Yampa River Craig to Maybell	Yampa River Steamboat to Craig	Elk River Clark to Confluence	Yampa River Stagecoach to Steamboat
Manning's coefficient	0.05	0.05	0.05	0.05
Change in Elevation (ft)	199.77	595.47	747.75	544.53
Distance (miles)	55.75	54.75	22.40	19.50
Average slope	0.0007	0.0021	0.0063	0.0053
Average flow area (ft^2)	500	279	100	225
Average wetted perimeter (ft)	230	186	80	150
Hydraulic radius (ft)	2.17	1.50	1.25	1.50
Average flow velocity (ft/sec)	1.30	1.77	2.75	2.84
Average travel time (days)	**2.62**	**1.89**	**0.50**	**0.42**

Daily Virgin Flows at Maybell

Estimated daily virgin flows at Maybell were calculated according to the following general formula:

Daily virgin flow equals:

daily gaged flow, plus
routed daily depletions at Steamboat Springs, Hayden and Craig, plus
routed daily diversions at the Craig and Hayden Stations, plus
routed daily depletions for each of the eight irrigated lands groupings, plus
routed daily diversions for transbasin export, plus
routed daily reservoir depletions, plus
daily diversions at the Maybell Canal.

Adjustments to Virgin Flows

Estimated daily virgin flow at Maybell over the 33 year study period were examined to check for the presence of negative values in the calculation results. Negative virgin flows, while not possible from a physical standpoint, can result due to the adjustment applied for agricultural depletions. As previously described, depletions from irrigation are typically negative during all but a few months as groundwater flow returns to the river in a lagged fashion. Adjustment for a negative historical depletion results in a virgin flow that is less than gage flows (i.e. the return flow would not have happened without irrigation activity).

The review of estimated virgin flows revealed several days with negative calculated values generally ranging from -10 cfs to -20 cfs. The fact that these values exclusively occurred during the months of September and October suggested that estimates of return flow characteristics could be improved. In an attempt to eliminate these occurrences, assumptions on hydraulic conductivity were modified in the calculation of agricultural depletions and new virgin flows estimated (final return flow parameters are shown in Table 2). Although these changes reduced the number of occurrences, negative values still resulted in approximately 50 days of the roughly 12,000 daily flow calculations. Rather than further modifying assumed return flow characteristics, these negative values were set equal to 10 cfs. Given the large drainage area above the Maybell gage and the geology of the area in the vicinity of the gage, we believe it unlikely that flow levels would drop below this level under virgin conditions.

DAILY MAYBELL FLOWS: FUTURE CONDITIONS WITHOUT-PROJECT

Estimated daily flows at Maybell reflecting future (year 2040) without-project conditions were developed by subtracting estimated daily depletions associated with year 2040 water uses from the estimated daily virgin flows. Year 2040 water uses were generally those defined and used in the Phase 1 and Phase 2 studies. Future daily depletion estimates were developed, in general, by factoring the daily depletion estimates developed in estimating virgin flows to year 2040 use levels, "backcasting" them over the entire study period, and subtracting them from the virgin flow estimates.

The daily factors applied for these adjustments were calculated as the daily percentage of total volume for each year of the study period. Where the estimated historical daily depletions showed a time trend, the factors from more recent periods were used over the entire study period. These daily factors were then multiplied by the assumed constant 2040 level of depletion (from the Phase 1 and Phase 2 studies) for each day of the year. Table 4 provides the resulting approximate level of 2040 depletion by general category.

Table 4
Approximate 2040 Level Depletion Adjustments Applied to Virgin Flows (af)

Depletion Category	Adjustment to 2040 Level Depletion
Municipal	15,517
Agricultural	84,588
Thermoelectric	31,644
Coal Gas Plant	8,000
Mining	7,245
Export	3,402
Res. Evap. and Ops.	11,235
Maybell Canal	10,048
Total	**171,679**

Estimated daily depleted Maybell flows reflective of year 2040 conditions were calculated by subtracting the estimated daily depletions of from the estimated daily virgin flows. As with calculations of virgin flows, negative daily flow values were calculated in several years of the study period. In these instances, any negative values were reset to zero values.

The total 2040 depletion level adjustment averaged 171,700 acre-feet per year. This is somewhat higher than the assumed 2040 levels described in the Phase 1 and 2 studies for several reasons. First and most importantly, it should be noted that the 2040 depletion estimates presented in the Phase 1 and 2 studies were for the basin above the Little Snake River confluence, which is downstream of the Maybell gage; return flows from the Maybell Canal (which accrue to the river above the Little Snake) would probably reduce the 171,700 acre-foot average by roughly 5,000 to 7,000 acre-feet per year. Secondly, the depletion estimates in the Phase 1 and 2 studies were derived in a different manner than the depletion estimates made for this analysis; for the earlier studies, all but a few depletions estimated by adding depletion increments to assumptions about depletions implicit in the gage data. In the present analysis, we have attempted to estimate all depletions in explicit terms from basic data.

DAILY MAYBELL FLOWS: FUTURE CONDITIONS WITH-PROJECT

Estimated daily Maybell flows under future (year 2040) demand conditions with the enlargement of Elkhead Reservoir were developed by applying a set of differences to the daily depleted flows estimated for year 2040. This set of differences reflect the change in Maybell flow conditions, over the without-project case, caused by operation of the enlarged Elkhead Reservoir. The general pattern of these differences is that of storage (less flow) in the early spring and releases (more flow) in late July and early August. These monthly differences were derived using results from the Yampa River Basin Model developed in the Phase 2 study.

Monthly differences in Maybell flows under the with- and without-Elkhead-enlargement model scenarios were converted to a set of daily differences using a simplified step function scheme. This scheme was designed to reflect that Elkhead Reservoir typically captures the majority of its annual storage volume from the early runoff of Elkhead Creek in April and the first part of May. During typical storage periods (April and May), the total monthly volume stored (as determined from model scenarios in the Phase 2 study) was distributed on a weekly basis as shown in Table 5. If storage occurred during the months of June and July, the total monthly volume stored was assumed to be a constant rate in the first two weeks of the month. Weekly volumes were then distributed uniformly into daily values. Any storage occurring in the remaining months of the year was distributed on a daily basis evenly throughout the month.

Table 5
Weekly Distribution of Monthly Storage Volumes from the Phase 2 Study

	Week 1	Week 2	Week 3	Week 4
April	0%	0%	20%	80%
May	70%	20%	5%	5%
June	70%	20%	5%	5%
July	90%	10%	0%	0%

Releases from the enlarged Elkhead Reservoir were handled in a slightly different manner. The majority of releases from the enlargement pool to meet assumed flow targets at Maybell typically occur in the later part of July and the early part of August as flow levels in the Yampa River decline. For these two months, the estimated daily 2040 flows without the project were compared to the flow targets assumed in the Phase 2 study (Table 6) to provide an indication of when daily "shortages" to the flow target occurred and when releases would be needed. A daily factor was then calculated as the difference between the estimated daily flow and the flow target, divided by the total shortage for the month. The daily factor was then multiplied by the monthly release volume determined from the Phase 2 study. In this way, total monthly release volumes from the Phase 2 study were preserved while the estimated 2040 daily flows without the project provided an indication of the daily distribution of the releases.

During other months of the year, monthly release volumes from the Phase 2 study were generally distributed evenly over each day of the month.

Table 6
Elkhead Reservoir Operational Flow Targets for the Yampa River at Maybell (cfs)

October	204
November	255
December	228
January	217
February	256
March	498
April	*
May	*
June	*
July	400
August	220
September	200

* Percentile which occurs naturally in any given year.

The procedures to convert monthly flow differences at Maybell with and without the reservoir enlargement to daily flow values, and to impose these differences on the year 2040 daily flows without the enlargement, were automated to facilitate later analyses of alternative reservoir operating strategies. Following the conversion, the set of daily flow differences at Maybell were added to the estimated depleted 2040 daily flows to arrive at estimated future daily flows reflective of operation of the enlarged Elkhead Reservoir.

Appendix 4. Estimates of daily virgin flow for the Yampa River at Maybell, Colorado, 1950 to 1982 based upon Hydrosphere report (1995b)

Rank	October	November	Decemb	January	Februar	March	April	May	June	July	August	September
										UNITS CFS		
1	10	73	78	70	131	173	369	1482	244	10	10	10
2	10	74	88	71	133	176	389	1591	298	10	10	10
3	10	74	89	71	137	176	407	1998	342	10	10	10
4	10	75	92	72	141	176	410	2009	395	10	10	10
5	10	75	92	74	142	177	414	2018	419	13	10	10
6	10	75	92	85	142	177	432	2028	477	14	10	10
7	10	76	93	85	144	177	443	2072	561	15	10	10
8	10	75	93	85	144	177	445	2080	643	15	10	10
9	10	75	93	88	144	177	462	2083	670	16	10	10
10	10	76	93	94	145	177	466	2098	712	17	10	10
11	10	77	93	98	145	178	506	2102	737	19	10	10
12	10	80	95	102	149	183	507	2118	778	23	10	10
13	10	82	98	102	150	194	509	2120	799	23	10	10
14	10	85	99	104	151	198	510	2128	817	24	10	10
15	10	87	99	110	151	198	518	2168	865	24	10	10
16	10	92	100	112	152	198	519	2205	867	25	10	10
17	10	93	101	113	152	199	526	2268	900	25	10	10
18	10	94	103	114	153	199	526	2274	930	25	10	10
19	10	94	103	118	154	200	528	2294	942	28	10	10
20	10	97	103	118	154	202	534	2303	951	28	10	10
21	10	101	104	119	154	204	535	2322	953	30	10	10
22	10	102	104	120	155	205	542	2344	1005	38	10	10
23	10	106	104	120	155	209	543	2353	1022	38	10	10
24	10	106	106	120	155	210	546	2368	1060	41	10	10
25	10	107	109	121	155	211	551	2383	1062	42	10	10
26	10	109	109	122	157	211	555	2383	1085	46	10	10
27	10	110	109	124	158	212	558	2401	1073	52	10	10
28	10	110	109	126	160	212	567	2407	1075	53	10	10
29	10	111	110	127	161	212	568	2417	1095	55	10	10
30	10	111	110	127	162	215	570	2421	1116	56	11	10
31	10	113	110	127	163	219	570	2432	1132	65	12	10
32	10	113	110	128	163	219	582	2462	1155	70	17	10
33	10	115	111	128	163	220	590	2476	1165	71	18	10
34	10	116	113	129	163	220	592	2500	1168	72	21	10
35	10	116	113	129	163	220	596	2507	1178	72	22	10
36	10	117	113	129	165	220	607	2515	1182	72	22	10
37	10	117	115	129	165	221	620	2516	1207	73	23	10
38	10	118	115	129	165	222	627	2519	1236	77	26	10
39	10	118	115	130	165	224	642	2528	1239	79	26	10
40	10	118	115	130	166	226	643	2543	1258	81	28	10
41	10	119	115	130	165	227	644	2562	1290	82	30	10
42	10	119	117	131	165	227	645	2563	1293	84	32	10
43	10	121	117	131	166	228	650	2570	1314	84	32	10
44	10	122	117	132	166	229	659	2573	1319	84	35	10
45	10	122	117	132	166	235	659	2584	1321	86	37	10
46	10	122	117	132	166	235	663	2585	1350	87	38	10
47	10	123	118	133	166	237	669	2607	1388	93	39	10
48	10	123	118	133	166	237	671	2615	1390	93	41	10
49	10	123	118	133	166	237	673	2639	1406	95	43	10
50	10	124	118	134	167	237	673	2641	1410	102	44	10
51	10	125	118	136	167	238	675	2644	1422	103	46	10
52	10	125	118	136	168	239	676	2655	1450	103	47	10
53	10	126	118	138	168	239	685	2672	1458	108	47	10
54	10	126	118	138	169	239	692	2675	1483	108	48	10
55	10	126	118	138	171	239	704	2686	1503	113	49	10
56	10	127	119	139	171	240	705	2693	1508	115	50	10
57	10	127	119	139	174	240	711	2716	1520	118	52	10
58	10	128	119	140	176	241	721	2721	1523	119	52	10
59	10	128	120	141	176	241	730	2721	1572	120	53	10
60	10	128	120	142	176	241	734	2727	1591	122	53	10
61	10	129	120	142	178	241	742	2764	1601	123	53	10
62	10	130	120	143	178	242	742	2778	1615	124	54	10
63	10	131	120	143	179	242	744	2781	1616	124	55	10
64	10	132	120	143	182	242	745	2783	1625	125	55	10
65	10	133	121	143	183	243	747	2800	1649	126	55	10
66	10	133	121	143	184	245	762	2824	1664	127	56	10
67	10	134	122	143	184	247	764	2834	1666	128	57	10
68	10	134	122	145	184	247	769	2834	1671	129	57	10
69	10	135	123	146	184	248	771	2836	1674	130	57	10
70	10	135	123	146	184	248	775	2847	1686	130	57	10
71	11	136	123	148	185	248	779	2848	1711	130	57	10
72	12	136	123	151	185	248	783	2856	1712	130	58	10
73	12	136	123	151	186	249	784	2863	1746	131	62	10
74	13	136	124	152	187	249	785	2876	1754	133	63	10
75	13	136	124	152	188	249	785	2884	1762	135	63	10
76	13	137	124	152	189	249	787	2887	1789	139	64	10
77	14	137	124	152	189	250	790	2925	1797	139	64	10
78	15	137	124	153	189	250	797	2928	1803	139	65	10
79	16	138	125	153	191	250	798	2934	1813	141	65	10
80	17	138	125	154	191	251	800	2943	1826	144	66	10
81	18	138	125	154	191	251	804	2947	1829	144	67	10

APPENDIX 4

TABLE 2

Estimates of Daily Virgin Flow for the Yampa River at Maybell Colorado
1950 to 1982 based upon Hydrosphere Report (1956)

UNITS CFS

Rank	October	November	Decemb	January	Februar	March	April	May	June	July	August	September
1	10	73	78	70	131	173	309	1482	244	10	10	10
2	10	74	89	71	133	176	389	1891	298	10	10	10
3	10	74	89	71	137	178	407	1994	342	10	10	10
4	10	75	92	72	141	176	410	2009	365	10	10	10
5	10	76	92	74	142	177	414	2018	419	13	10	10
6	10	75	92	85	142	177	432	2028	477	14	10	10
7	10	75	93	85	144	177	443	2072	561	15	10	10
8	10	75	93	85	144	177	446	2080	643	15	10	10
9	10	75	93	89	144	177	462	2083	670	16	10	10
10	10	76	93	94	143	177	488	2098	712	17	10	10
11	10	77	93	98	145	178	508	2109	737	19	10	10
12	10	80	95	102	149	183	507	2118	778	22	10	10
13	10	82	98	102	150	194	509	2120	799	23	10	10
14	10	85	99	104	151	196	510	2128	817	24	10	10
15	10	87	99	110	151	198	518	2168	865	24	10	10
16	10	92	100	112	152	198	519	2205	867	25	10	10
17	10	93	101	113	152	199	526	2258	900	25	10	10
18	10	94	103	114	153	199	526	2274	930	25	10	10
19	10	94	103	116	154	200	528	2294	942	28	10	10
20	10	97	103	118	154	202	534	2309	951	29	10	10
21	10	101	104	119	154	204	535	2322	953	30	10	10
22	10	102	104	120	155	205	542	2344	1005	38	10	10
23	10	106	104	120	155	209	543	2353	1022	38	10	10
24	10	106	106	120	155	210	546	2368	1060	41	10	10
25	10	107	109	121	155	211	551	2383	1062	42	10	10
26	10	109	109	122	157	211	555	2383	1065	45	10	10
27	10	110	109	124	158	212	558	2401	1073	52	10	10
28	10	110	109	126	160	212	567	2407	1075	53	10	10
29	10	111	110	127	161	212	568	2417	1095	55	10	10
30	10	111	110	127	162	215	570	2421	1116	56	11	10
31	10	113	110	127	163	219	570	2432	1132	65	12	10
32	10	113	110	128	163	219	582	2462	1155	70	17	10
33	10	115	111	128	163	220	590	2476	1185	71	18	10
34	10	116	113	129	163	220	592	2500	1186	72	21	10
35	10	116	113	129	163	220	596	2507	1178	72	22	10
36	10	117	113	129	165	220	607	2515	1192	72	22	10
37	10	117	115	129	165	221	620	2516	1207	78	23	10
38	10	118	115	129	165	222	627	2519	1238	77	26	10
39	10	118	115	130	165	224	642	2528	1239	79	28	10
40	10	116	115	130	166	226	643	2543	1258	81	28	10
41	10	119	115	130	165	227	644	2562	1290	82	30	10
42	10	119	117	131	165	227	645	2563	1293	84	32	10
43	10	121	117	131	166	228	650	2570	1314	84	32	10
44	10	122	117	132	165	229	659	2573	1319	84	35	10
45	10	122	117	132	166	235	659	2594	1341	85	37	10
46	10	122	117	132	166	235	663	2595	1358	87	38	10
47	10	123	118	133	166	237	669	2607	1366	93	39	10
48	10	123	118	133	166	237	671	2613	1395	93	41	10
49	10	123	118	133	168	237	673	2639	1406	95	43	10
50	10	124	118	134	167	237	673	2641	1410	102	44	10
51	10	125	118	136	167	238	675	2644	1422	103	46	10
52	10	125	118	136	168	239	676	2655	1450	103	47	10
53	10	126	118	138	168	239	685	2672	1468	106	47	10
54	10	126	118	138	169	239	698	2675	1493	108	48	10
55	10	126	118	138	171	239	704	2686	1503	113	49	10
56	10	127	119	139	171	240	705	2693	1508	115	50	10
57	10	127	119	139	174	240	711	2716	1520	118	52	10
58	10	128	119	140	176	241	721	2721	1523	119	52	10
59	10	128	120	141	176	241	730	2721	1572	120	53	10
60	10	128	120	142	176	241	734	2737	1591	122	53	10
61	10	129	120	142	176	241	742	2764	1601	123	53	10
62	10	130	120	143	178	242	742	2778	1615	124	54	10
63	10	131	120	143	179	242	744	2781	1616	124	55	10
64	10	132	120	143	182	242	745	2793	1625	125	55	10
65	10	133	121	143	183	243	747	2800	1649	126	55	10
66	10	133	121	143	184	245	762	2824	1664	127	58	10
67	10	134	122	143	184	247	764	2834	1665	128	57	10
68	10	134	122	145	184	247	768	2834	1671	129	57	10
69	10	135	123	146	184	248	771	2836	1674	130	57	10
70	10	135	123	146	184	248	775	2847	1686	130	57	10
71	11	136	123	148	185	248	779	2848	1711	130	57	10
72	12	136	123	151	185	248	783	2856	1712	130	58	10
73	12	136	123	151	188	249	784	2863	1746	131	62	10
74	13	136	124	152	187	249	785	2875	1754	133	63	10
75	13	136	124	152	188	249	785	2884	1762	135	63	10
76	13	137	124	152	189	249	787	2887	1789	139	64	10
77	14	137	124	152	189	250	790	2925	1797	139	64	10
78	15	137	124	153	189	250	797	2928	1803	139	65	10
79	16	138	125	153	191	250	798	2934	1813	141	65	10
80	17	138	125	154	191	251	800	2943	1828	144	66	10
81	18	138	125	154	191	251	804	2947	1829	144	67	10

Rank	October	November	Decemb	January	Februar	March	April	May	June	July	August	September
82	18	139	125	154	192	252	808	2948	1845	144	67	10
83	19	140	125	154	192	252	809	2955	1850	145	68	10
84	20	140	125	154	192	252	811	2966	1879	145	70	10
85	21	140	126	154	192	253	812	2972	1879	146	70	10
86	22	140	126	154	192	255	812	2980	1887	147	71	10
87	22	140	127	155	193	255	814	2982	1891	147	72	10
88	23	140	127	155	194	255	815	2990	1891	149	73	10
89	23	141	127	156	194	257	817	2992	1906	149	74	10
90	26	141	127	156	194	257	818	3005	1907	154	75	10
91	26	141	127	157	194	258	818	3010	1915	155	76	10
92	27	142	127	157	195	258	819	3024	1918	156	77	10
93	28	142	128	157	196	258	820	3025	1935	158	77	10
94	28	144	128	158	196	258	833	3025	1936	164	78	10
95	30	144	128	161	196	259	836	3028	1948	164	78	10
96	31	144	129	161	196	259	837	3029	1969	168	78	10
97	34	145	129	161	197	259	838	3031	1971	166	80	10
98	34	145	129	162	198	260	841	3042	1975	167	80	10
100	35	146	129	163	198	260	844	3053	1976	168	80	10
101	36	146	129	163	198	260	848	3059	1979	169	81	10
102	36	146	130	163	199	260	848	3073	1987	170	82	10
103	37	146	130	163	199	260	852	3078	2051	170	83	10
104	37	147	130	163	199	261	858	3082	2070	170	83	10
105	37	147	130	163	199	261	860	3107	2089	171	84	10
106	38	147	130	163	199	261	862	3115	2091	172	85	10
107	38	148	131	163	199	261	864	3118	2125	172	85	10
108	38	148	131	164	199	262	864	3137	2142	172	86	10
109	38	148	132	164	200	263	866	3139	2152	174	87	10
110	38	148	132	164	200	263	869	3175	2160	174	88	10
111	39	149	132	164	200	264	871	3183	2178	178	88	10
112	40	149	132	164	200	265	876	3187	2184	176	90	10
113	42	149	132	164	200	265	882	3201	2208	178	90	10
114	42	150	133	164	201	265	883	3204	2214	178	90	10
115	43	150	133	165	201	266	887	3205	2239	180	90	10
116	43	150	134	165	202	267	888	3220	2257	181	91	10
117	43	150	134	165	202	267	894	3226	2318	181	91	10
118	43	150	134	165	203	268	895	3233	2323	182	91	12
119	43	151	134	165	204	268	897	3237	2356	183	91	13
120	43	151	134	166	204	270	898	3243	2357	185	92	13
121	44	152	134	168	204	270	901	3256	2371	186	92	13
122	44	152	135	169	205	270	904	3256	2434	187	93	14
123	46	152	135	169	205	271	906	3261	2439	188	93	15
124	46	152	135	169	205	272	913	3265	2439	191	93	15
125	46	152	135	170	206	272	917	3277	2472	191	93	15
126	46	152	136	170	206	272	925	3288	2483	192	93	15
127	46	152	136	170	206	272	926	3291	2494	196	93	16
128	46	153	136	170	207	273	927	3309	2498	198	94	16
129	46	153	137	170	207	273	929	3364	2501	202	94	17
130	49	154	137	171	207	274	929	3366	2503	205	94	18
131	49	154	137	172	208	274	929	3375	2509	211	94	18
132	49	154	137	172	208	274	937	3388	2511	218	94	19
133	50	154	138	173	209	275	939	3429	2516	217	94	19
134	50	154	138	173	209	275	942	3436	2523	219	94	19
135	51	155	139	173	210	277	943	3436	2541	220	94	19
136	51	155	139	173	210	277	946	3449	2565	222	95	20
137	51	155	139	173	210	277	958	3454	2575	222	95	21
138	52	156	139	173	211	277	960	3461	2642	224	96	22
139	52	156	139	173	211	277	975	3462	2658	224	98	23
140	52	156	139	174	211	279	987	3473	2672	225	99	23
141	53	156	140	174	211	279	987	3488	2707	225	99	24
142	53	157	140	174	211	279	989	3520	2716	230	99	25
143	53	157	140	174	212	279	991	3545	2738	232	99	25
144	54	157	140	174	212	279	992	3548	2768	235	100	25
145	55	157	140	174	212	279	993	3549	2797	236	100	26
146	55	158	141	174	212	280	998	3555	2817	239	101	26
147	56	158	141	174	213	280	998	3581	2817	241	101	26
148	58	158	141	174	213	281	999	3585	2819	241	102	27
149	57	160	142	175	213	281	1004	3601	2823	243	102	28
150	58	160	142	175	214	281	1006	3613	2831	247	102	28
151	58	161	143	175	214	281	1008	3651	2842	249	102	29
152	58	162	143	175	214	281	1008	3663	2842	250	102	29
153	58	162	143	176	214	282	1012	3665	2854	251	102	29
154	60	162	143	176	214	282	1015	3671	2884	252	102	30
155	60	162	143	176	215	282	1016	3688	2907	252	102	30
156	60	162	144	176	215	283	1017	3691	2914	253	102	31
157	60	163	144	178	216	283	1019	3696	2921	256	103	31
158	61	163	145	178	216	284	1028	3702	2954	257	103	31
159	62	163	145	179	216	284	1028	3709	2958	258	104	32
160	62	163	145	179	216	284	1028	3712	2967	258	104	32
161	62	164	145	180	216	285	1027	3740	2981	259	106	33

UNITS CFS

Rank	October	November	December	January	February	March	April	May	June	July	August	September
162	83	164	146	180	216	286	1027	3747	2985	258	106	34
163	83	165	146	180	216	286	1030	3780	2992	263	108	34
164	84	166	146	180	216	287	1037	3788	3027	263	108	34
165	84	166	146	181	217	288	1046	3815	3029	270	108	34
166	84	166	146	181	217	288	1046	3821	3051	270	108	34
167	85	166	146	181	217	290	1053	3828	3056	270	110	34
168	85	166	146	181	217	290	1056	3835	3059	271	110	35
169	85	166	146	181	218	290	1057	3846	3071	271	111	36
170	85	167	146	182	218	290	1062	3874	3074	273	111	36
171	85	167	146	182	218	291	1063	3874	3088	274	111	37
172	86	167	147	182	218	291	1065	3885	3111	276	111	37
173	86	167	147	182	218	292	1067	3886	3130	276	111	37
174	86	167	148	182	218	292	1067	3888	3131	277	112	37
175	86	167	148	182	218	292	1069	3889	3132	281	112	37
176	87	167	148	182	218	295	1070	3893	3155	281	113	37
177	88	168	148	183	219	295	1071	3893	3159	283	113	37
178	89	168	148	184	219	295	1075	3912	3162	283	113	38
179	70	168	148	184	219	296	1080	3921	3164	285	114	38
180	70	169	148	184	220	297	1082	3959	3165	286	114	38
181	71	169	148	184	220	297	1084	3962	3179	287	115	39
182	71	169	149	184	221	297	1088	3974	3181	291	115	40
183	73	169	150	184	221	297	1093	3975	3193	292	115	40
184	73	170	150	184	221	298	1098	3984	3198	293	116	41
185	76	170	151	185	221	299	1102	4013	3198	295	116	41
186	78	170	151	185	221	299	1109	4015	3199	295	118	42
187	77	170	151	185	222	299	1109	4022	3231	297	118	42
188	77	170	152	185	222	299	1111	4023	3237	297	118	42
189	78	170	152	185	222	300	1117	4024	3243	299	118	43
190	79	171	153	185	223	300	1124	4039	3245	300	118	43
191	80	171	153	188	223	300	1129	4051	3264	302	119	43
192	80	171	153	186	223	301	1129	4053	3273	302	119	44
193	81	171	154	186	223	301	1133	4055	3280	305	120	44
194	81	171	154	186	223	302	1135	4060	3283	306	120	44
195	82	172	154	186	223	303	1137	4068	3297	307	120	45
196	82	172	154	186	224	303	1140	4090	3330	310	120	45
197	82	172	155	186	224	303	1143	4095	3330	310	121	45
198	83	172	155	186	225	304	1150	4108	3336	313	121	46
199	83	172	155	186	225	304	1158	4119	3351	315	121	46
200	83	173	156	187	225	304	1160	4120	3374	317	122	46
201	83	173	158	187	225	305	1162	4132	3389	318	122	46
202	83	174	158	187	225	305	1163	4150	3391	321	123	46
203	85	174	157	188	225	305	1164	4151	3393	323	123	47
204	85	174	157	188	226	305	1170	4153	3404	324	124	47
205	86	174	157	188	226	305	1173	4161	3406	324	124	48
206	87	174	157	188	226	305	1174	4163	3410	334	124	48
207	88	175	157	188	226	306	1175	4163	3423	334	125	48
208	88	175	157	188	227	306	1181	4175	3432	338	125	48
209	88	175	157	188	227	307	1181	4178	3436	339	125	49
210	88	175	158	188	227	307	1183	4183	3441	348	125	49
211	88	175	158	188	227	307	1187	4190	3444	349	126	49
212	89	175	158	189	228	307	1189	4192	3448	349	126	49
213	90	176	158	189	228	307	1191	4199	3450	354	127	50
214	90	176	159	189	228	308	1192	4207	3453	355	127	51
215	91	176	159	189	228	308	1194	4212	3462	356	128	51
216	91	176	159	190	228	309	1194	4216	3484	358	128	52
217	91	176	159	190	228	309	1203	4221	3492	360	128	52
218	91	176	159	191	228	309	1205	4228	3525	365	129	52
219	92	176	160	191	228	309	1216	4241	3550	368	129	52
220	92	176	160	191	228	309	1218	4241	3559	370	130	53
221	92	176	160	191	228	309	1226	4248	3563	371	131	53
222	92	176	161	192	229	311	1230	4250	3585	371	132	54
223	93	180	161	193	229	311	1231	4251	3573	373	134	54
224	94	180	161	193	229	311	1236	4254	3588	374	134	54
225	95	180	161	193	229	312	1238	4268	3600	374	134	55
226	95	180	161	193	229	313	1238	4296	3646	377	135	55
227	95	180	162	194	229	313	1241	4312	3647	378	135	56
228	95	181	163	194	230	313	1242	4316	3651	380	135	57
229	95	181	163	194	230	313	1243	4321	3662	381	135	57
230	96	181	163	194	231	313	1249	4325	3677	386	135	58
231	96	181	164	194	231	314	1252	4329	3695	388	136	58
232	96	181	164	195	231	315	1257	4333	3712	387	138	59
233	97	181	164	195	232	316	1260	4355	3716	391	140	59
234	97	182	165	195	232	316	1269	4375	3722	397	141	60
235	98	182	165	195	232	317	1269	4380	3724	398	142	61
236	98	183	165	195	232	318	1276	4383	3726	398	142	63
237	98	183	166	195	232	318	1278	4385	3731	402	142	63
238	99	183	166	195	233	318	1280	4385	3741	408	143	64
239	99	183	166	195	233	318	1281	4394	3753	409	144	64
240	99	183	168	195	233	318	1290	4394	3757	411	144	65

UNITS CFS

Rank	October	November	Decemb	January	Februar	March	April	May	June	July	August	September
241	101	183	166	195	233	318	1294	4404	3759	415	145	65
242	101	183	166	195	233	319	1315	4425	3765	416	146	65
243	101	184	166	196	233	320	1317	4436	3767	418	146	66
244	101	184	166	196	234	320	1319	4448	3780	418	146	67
245	102	184	167	196	234	320	1325	4464	3817	420	146	67
246	102	184	167	196	234	323	1327	4464	3819	421	147	68
247	103	185	167	196	234	323	1328	4471	3829	425	147	68
248	103	185	167	196	234	324	1338	4478	3832	425	147	68
249	103	185	167	196	234	325	1340	4498	3842	428	148	68
250	103	186	168	196	234	326	1340	4498	3845	428	148	69
251	104	186	168	196	235	327	1341	4501	3861	430	149	70
252	104	187	168	197	235	327	1346	4504	3868	432	150	70
253	104	188	168	197	235	328	1369	4508	3871	433	151	71
254	104	188	168	197	235	328	1370	4531	3881	434	151	71
255	105	189	168	197	235	328	1372	4538	3910	434	152	72
256	105	189	169	197	235	329	1379	4552	3915	438	152	72
257	105	189	169	197	235	329	1389	4575	3919	443	152	72
258	106	189	170	198	236	330	1391	4589	3927	444	153	73
259	106	189	170	198	237	330	1399	4591	3951	445	154	73
260	106	189	171	198	237	331	1405	4600	3979	446	154	73
261	106	190	171	198	237	331	1410	4603	3981	450	154	73
262	107	190	171	198	237	332	1417	4617	3986	452	155	74
263	107	190	171	198	237	332	1417	4635	3989	452	155	75
264	107	190	172	199	237	332	1429	4645	3991	453	155	75
265	107	190	172	199	237	332	1434	4679	3995	455	157	75
266	107	191	172	199	238	332	1434	4681	3996	456	158	75
267	107	191	172	199	238	333	1438	4689	4020	457	158	75
268	108	191	172	200	238	333	1441	4705	4020	458	158	77
269	108	192	172	200	238	333	1443	4707	4030	459	159	77
270	108	192	172	200	238	333	1449	4709	4035	460	160	77
271	108	192	172	200	238	334	1450	4715	4052	460	161	77
272	109	193	172	200	238	334	1451	4718	4068	462	161	77
273	109	193	173	200	239	334	1452	4732	4079	462	162	77
274	109	194	173	200	239	336	1458	4732	4080	463	163	78
275	109	194	173	201	239	336	1466	4756	4095	465	163	79
276	109	194	174	201	239	336	1467	4765	4106	466	164	79
277	110	194	175	201	239	337	1469	4768	4123	466	164	79
278	110	194	175	201	240	337	1474	4796	4129	468	166	79
279	110	194	175	202	240	338	1483	4797	4151	469	167	80
280	110	194	175	202	240	338	1484	4799	4152	471	168	80
281	111	194	175	202	240	338	1485	4803	4161	475	168	80
282	111	194	175	202	240	338	1487	4803	4162	476	169	80
283	111	194	175	202	240	340	1490	4807	4186	480	169	81
284	112	195	175	202	240	341	1498	4808	4195	483	170	82
285	112	195	176	202	240	341	1498	4813	4201	483	170	82
286	112	195	176	203	240	342	1499	4823	4217	487	171	82
287	112	196	176	203	240	342	1501	4838	4220	487	171	82
288	112	196	176	203	240	342	1502	4842	4222	491	172	83
289	112	196	176	203	240	344	1504	4853	4242	492	172	83
290	112	196	176	203	240	344	1506	4853	4244	494	172	83
291	113	196	176	204	240	344	1508	4863	4252	496	175	83
292	113	196	176	204	240	345	1509	4866	4261	497	175	83
293	113	196	176	204	240	345	1510	4892	4279	497	176	83
294	113	197	176	204	241	345	1512	4895	4304	498	177	84
295	114	197	176	204	241	346	1518	4910	4306	498	177	84
296	114	197	177	204	241	347	1520	4922	4320	499	177	84
297	115	197	177	204	241	347	1523	4937	4322	500	177	85
298	115	197	178	204	241	347	1528	4938	4332	500	177	85
299	115	197	178	204	241	347	1528	4940	4338	500	177	85
300	115	197	178	204	241	347	1528	4948	4352	504	177	85
301	116	197	178	205	241	348	1533	4955	4353	504	177	85
302	116	198	179	205	241	349	1535	4965	4356	507	178	85
303	117	198	179	205	241	349	1541	4978	4362	508	179	86
304	117	198	179	205	242	349	1545	4979	4364	510	179	86
305	117	198	179	205	242	350	1548	4980	4368	511	179	86
306	118	199	180	205	242	350	1551	4991	4376	514	179	87
307	118	199	180	205	242	351	1557	5000	4378	515	181	87
308	118	199	180	205	242	351	1558	5010	4378	519	182	87
309	118	199	181	205	242	352	1560	5016	4393	519	182	87
310	119	199	181	205	243	352	1562	5030	4397	523	182	87
311	119	199	181	205	243	352	1565	5031	4408	523	182	88
312	119	200	181	205	243	352	1573	5032	4412	524	183	88
313	119	200	181	205	243	353	1579	5033	4414	527	184	89
314	119	200	181	205	243	353	1579	5040	4419	529	185	89
315	119	200	181	205	243	355	1585	5043	4426	530	186	89
316	120	200	182	206	243	355	1586	5056	4427	530	187	89
317	120	200	182	206	243	355	1590	5062	4434	531	188	90
318	120	201	182	206	244	356	1602	5062	4438	531	188	90
319	120	201	182	206	244	356	1603	5064	4438	531	188	90
320	120	202	183	206	244	356	1606	5062	4448	532	188	90
321	121	202	183	206	244	356	1609	5062	4456	535	188	90

UNITS CFS

Rank	October	November	Decemb	January	Februar	March	April	May	June	July	August	September
322	121	202	183	206	244	358	1610	5082	4458	535	190	91
323	121	202	183	206	245	357	1611	5085	4459	536	190	91
324	121	202	183	206	245	357	1614	5088	4462	537	191	91
325	122	202	184	206	245	358	1618	5090	4466	538	191	92
326	122	202	184	206	245	358	1619	5096	4493	540	191	92
327	123	203	184	206	245	359	1621	5102	4501	541	192	92
328	124	203	184	206	246	359	1626	5105	4510	541	192	92
329	124	204	184	207	246	360	1641	5106	4521	541	192	93
330	124	204	184	207	246	360	1641	5108	4535	544	193	93
331	125	204	184	208	246	360	1644	5131	4562	544	194	93
332	126	204	185	208	246	362	1649	5135	4577	548	194	93
333	126	205	185	208	246	362	1651	5153	4586	548	195	93
334	126	205	185	208	246	362	1652	5159	4597	549	196	94
335	126	205	185	208	246	362	1653	5172	4598	551	197	94
336	127	205	185	208	246	363	1654	5178	4606	558	197	94
337	127	205	185	208	246	364	1662	5183	4616	559	197	94
338	127	206	185	208	247	364	1668	5185	4629	559	197	94
339	127	205	185	208	247	365	1668	5187	4633	560	197	94
340	127	205	185	208	247	365	1671	5189	4643	563	197	95
341	127	206	185	208	247	365	1679	5190	4649	563	198	95
342	128	206	185	208	248	365	1690	5191	4665	565	199	95
343	128	206	186	209	248	366	1691	5195	4679	568	199	95
344	128	206	186	209	248	366	1692	5195	4696	568	200	95
345	128	207	186	209	248	366	1693	5196	4702	571	201	95
346	130	207	186	209	249	367	1693	5221	4716	571	201	97
347	130	207	186	209	249	367	1697	5223	4721	571	203	97
348	130	208	186	209	249	368	1702	5231	4728	572	203	97
349	131	208	186	209	249	368	1703	5242	4730	573	203	97
350	131	208	186	209	249	368	1709	5245	4745	574	203	97
351	131	208	186	208	249	369	1717	5255	4748	575	203	97
352	132	208	187	210	250	369	1717	5256	4752	576	204	97
353	132	209	187	210	250	369	1717	5258	4756	583	204	98
354	132	209	187	210	250	370	1721	5264	4759	587	204	98
355	133	209	187	210	250	370	1729	5265	4759	588	205	98
356	133	209	187	210	250	370	1730	5283	4767	595	207	99
357	134	209	187	210	250	372	1731	5290	4771	597	210	99
358	134	210	187	210	250	372	1734	5295	4779	598	210	100
359	134	210	188	210	250	373	1741	5316	4782	599	210	100
360	134	210	188	211	250	373	1742	5320	4787	602	211	101
361	134	210	188	211	250	373	1749	5321	4787	606	211	101
362	135	210	188	211	250	374	1750	5330	4789	606	211	101
363	136	210	188	211	251	375	1750	5334	4799	607	212	101
364	136	211	188	211	251	377	1752	5338	4801	608	212	102
365	137	211	188	212	251	378	1753	5347	4804	608	215	103
366	137	211	188	212	251	379	1755	5355	4809	609	218	103
367	137	211	188	212	251	379	1759	5362	4826	612	218	103
368	137	211	189	212	251	379	1762	5368	4835	613	218	104
369	137	211	189	212	251	379	1763	5369	4836	615	218	104
370	138	212	189	213	251	380	1764	5391	4842	616	217	105
371	138	212	189	213	251	380	1769	5405	4862	616	218	105
372	138	212	189	213	252	380	1778	5409	4894	621	218	105
373	138	212	189	213	252	381	1779	5413	4901	622	219	105
374	140	212	189	213	252	382	1779	5418	4903	623	219	105
375	140	212	189	213	252	382	1781	5418	4903	625	220	106
376	140	212	189	214	252	383	1786	5427	4904	627	221	106
377	140	213	189	214	252	383	1787	5430	4905	628	221	106
378	140	213	190	214	252	384	1792	5433	4926	628	222	107
379	141	213	190	214	252	384	1798	5438	4935	630	222	107
380	141	213	190	215	252	384	1804	5443	4935	635	222	107
381	141	213	190	215	253	384	1805	5447	4935	638	222	107
382	141	214	190	215	253	384	1810	5477	4938	638	223	107
383	141	214	190	215	253	384	1812	5488	4943	640	223	107
384	141	214	190	215	253	386	1812	5490	4950	641	223	107
385	141	214	191	215	253	386	1813	5494	4952	644	223	107
386	142	214	191	215	253	386	1816	5511	4957	647	224	107
387	142	214	191	215	254	386	1818	5521	4968	652	224	107
388	142	215	191	215	254	386	1819	5527	4970	653	224	107
389	142	215	191	218	254	386	1822	5532	4975	653	225	107
390	142	215	191	218	254	387	1827	5534	4980	653	225	108
391	143	215	191	215	254	388	1830	5542	4989	655	226	108
392	143	215	191	215	255	388	1830	5549	4994	657	230	108
393	143	218	191	215	255	388	1831	5566	5008	659	230	108
394	143	218	191	218	255	389	1835	5569	5010	660	231	108
395	144	216	191	218	255	390	1840	5569	5011	663	232	109
396	145	216	191	218	256	390	1841	5570	5029	664	232	109
397	145	217	192	218	256	391	1848	5573	5036	664	233	109
398	146	217	192	218	256	391	1849	5584	5040	666	233	109
399	146	218	192	216	256	391	1853	5597	5043	668	234	109
400	146	218	192	218	256	392	1856	5605	5048	669	235	110
401	146	218	192	216	256	392	1858	5606	5055	670	236	110

UNITS CFS

Rank	October	November	Decemb	January	Februar	March	April	May	June	July	August	September
402	146	218	192	217	256	393	1861	5618	5078	671	238	111
403	146	218	192	217	256	393	1868	5622	5080	672	236	111
404	147	219	192	217	256	394	1876	5626	5080	672	239	111
405	147	219	192	217	257	396	1868	5629	5083	673	239	111
406	147	219	193	217	257	396	1893	5639	5085	675	239	111
407	148	220	193	217	257	397	1894	5647	5093	682	239	111
408	148	220	193	217	257	398	1904	5652	5104	685	239	112
409	148	220	193	217	257	399	1905	5663	5109	686	240	112
410	150	220	193	217	257	399	1906	5698	5114	690	240	112
411	150	220	193	217	257	399	1907	5691	5115	690	241	112
412	150	221	193	217	257	399	1908	5692	5122	691	241	112
413	150	221	193	217	257	399	1909	5697	5126	698	243	113
414	151	222	193	218	258	400	1912	5712	5127	701	244	113
415	151	222	193	218	258	400	1914	5718	5129	704	245	113
416	151	222	193	218	258	400	1918	5737	5136	704	245	113
417	152	222	193	218	258	401	1925	5740	5138	707	246	114
418	152	222	193	218	258	401	1937	5746	5142	718	247	114
419	153	223	194	219	259	402	1941	5747	5154	718	247	114
420	153	223	194	219	259	402	1952	5750	5156	719	247	114
421	153	223	194	219	259	402	1953	5754	5187	719	249	115
422	153	223	194	220	259	403	1963	5766	5203	719	249	115
423	153	224	194	220	259	403	1968	5769	5228	720	250	116
424	154	224	194	220	259	403	1978	5770	5229	720	251	116
425	154	224	194	220	259	403	1980	5772	5231	721	254	117
426	154	225	194	220	259	403	1980	5776	5236	726	255	117
427	154	225	194	220	259	404	1988	5777	5244	726	255	117
428	154	225	194	220	260	404	1988	5786	5254	731	255	117
429	154	225	194	220	260	405	1989	5813	5265	732	255	118
430	155	225	195	220	260	406	1991	5814	5278	734	256	118
431	155	225	195	221	260	407	1992	5830	5279	736	256	118
432	155	225	195	221	260	407	1996	5831	5289	739	257	119
433	156	225	195	221	261	407	2002	5832	5308	742	257	119
434	157	225	195	221	261	408	2003	5843	5324	745	258	119
435	157	226	195	222	261	408	2005	5845	5328	745	258	119
436	158	226	196	222	261	409	2009	5847	5339	747	258	120
437	159	226	196	222	261	410	2013	5854	5341	747	258	120
438	159	226	196	222	261	410	2014	5866	5348	750	259	121
439	159	227	196	222	261	411	2015	5872	5349	756	259	122
440	159	227	196	222	261	411	2015	5883	5352	756	261	122
441	159	227	196	222	262	411	2016	5886	5355	758	261	122
442	160	227	196	222	262	411	2017	5897	5394	758	262	122
443	160	228	197	222	262	412	2019	5898	5412	758	263	122
444	161	228	197	222	262	412	2026	5898	5415	759	263	122
445	161	228	197	223	262	413	2029	5899	5416	765	264	123
446	162	228	197	223	262	413	2043	5908	5419	766	264	123
447	162	228	197	223	263	413	2045	5917	5420	770	264	123
448	162	228	197	223	263	413	2047	5919	5423	770	264	123
449	163	230	197	223	263	414	2051	5922	5423	774	265	124
450	163	230	198	223	263	416	2057	5927	5423	774	265	124
451	163	230	198	223	264	416	2058	5931	5426	774	266	124
452	164	231	198	223	264	416	2058	5932	5426	776	266	125
453	164	231	198	223	264	417	2062	5936	5436	778	267	125
454	165	231	199	224	264	419	2065	5937	5439	778	267	125
455	165	231	199	224	264	419	2072	5947	5439	781	267	125
456	165	231	199	225	264	420	2074	5948	5441	782	267	126
457	165	231	200	225	265	421	2074	5950	5446	782	268	127
458	166	232	200	225	265	422	2078	5954	5452	782	268	127
459	166	232	200	225	265	422	2081	5967	5459	783	269	127
460	166	232	200	225	265	422	2089	5973	5463	784	269	127
461	166	232	200	225	265	423	2091	5989	5470	785	269	128
462	166	232	200	226	266	423	2109	5991	5478	788	270	128
463	167	232	201	226	266	424	2113	6008	5490	796	270	128
464	167	233	201	226	266	427	2120	6030	5498	802	274	128
465	168	233	201	226	266	428	2125	6042	5509	805	274	128
466	168	233	201	226	266	428	2127	6043	5523	808	275	128
467	168	233	201	226	266	428	2129	6043	5531	809	276	129
468	168	233	201	226	267	428	2131	6045	5535	810	276	129
469	169	233	201	226	267	429	2134	6053	5540	815	278	129
470	169	233	201	226	267	429	2135	6072	5550	815	280	130
471	169	233	202	226	267	429	2137	6072	5551	815	280	130
472	169	234	202	226	267	429	2137	6073	5556	816	281	130
473	169	234	202	226	267	430	2144	6080	5564	819	282	130
474	170	235	202	226	267	430	2148	6081	5572	819	282	130
475	170	235	202	226	267	431	2151	6083	5588	820	282	130
476	170	235	202	226	267	431	2162	6091	5604	821	283	131
477	170	235	202	226	268	431	2168	6095	5604	822	283	131
478	170	236	202	226	268	431	2175	6117	5623	822	283	132
479	170	236	203	227	268	432	2181	6122	5637	826	284	132
480	170	236	203	227	268	433	2181	6122	5655	826	284	132
481	171	236	203	227	269	433	2181	6128	5660	828	284	132

UNITS CFS

Rank	October	November	Decemb	January	Februar	March	April	May	June	July	August	September
482	171	236	203	227	269	433	2187	6150	5871	833	285	133
483	171	236	203	227	269	434	2188	6134	5678	834	285	133
484	171	237	204	227	269	434	2189	6136	5682	834	286	134
485	171	237	204	227	269	435	2195	6145	5695	834	286	135
486	171	237	204	227	270	435	2196	6146	5696	835	287	135
487	172	237	204	227	270	435	2197	6147	5719	837	287	136
488	172	237	204	227	270	435	2198	6156	5730	838	288	136
489	173	237	204	227	270	435	2212	6156	5733	843	289	136
490	173	237	204	227	270	436	2215	6160	5741	845	291	137
491	173	237	204	228	270	436	2226	6164	5748	848	291	137
492	174	238	205	228	270	436	2228	6167	5754	854	292	137
493	174	238	205	228	270	437	2229	6170	5758	855	292	138
494	175	238	205	228	270	437	2232	6171	5769	858	293	139
495	175	239	205	228	270	437	2233	6186	5774	858	293	139
496	176	240	205	228	271	437	2235	6189	5784	859	293	140
497	176	240	206	228	271	438	2243	6189	5787	868	294	140
498	177	240	206	228	271	439	2248	6193	5794	868	296	140
499	177	240	206	229	271	440	2253	6198	5805	870	296	141
500	177	241	206	229	271	440	2257	6211	5808	872	297	141
501	178	241	206	229	271	441	2286	6214	5812	880	297	141
502	178	241	206	229	272	441	2287	6221	5818	882	299	141
503	178	241	207	229	272	441	2282	6221	5858	882	299	142
504	178	241	207	229	272	442	2287	6224	5863	882	300	142
505	178	241	207	229	272	442	2304	6225	5844	883	300	142
506	179	241	208	229	272	442	2310	6228	5845	885	301	142
507	180	242	209	229	272	442	2317	6228	5859	886	301	142
508	180	242	209	229	272	443	2322	6231	5866	891	301	143
509	180	242	209	229	273	443	2322	6233	5874	892	301	143
510	180	242	209	229	273	443	2323	6234	5891	893	302	143
511	181	242	209	230	273	443	2330	6239	5899	893	302	143
512	181	242	209	230	273	443	2340	6239	5909	894	303	146
513	182	242	209	230	273	444	2347	6258	5920	897	303	146
514	182	243	210	230	273	445	2355	6262	5928	899	304	147
515	182	243	210	230	273	445	2370	6270	5939	899	304	147
516	182	244	210	230	273	445	2370	6275	5948	900	304	147
517	183	244	210	230	273	445	2371	6280	5950	900	305	147
518	183	244	210	230	273	446	2374	6288	5955	902	305	149
519	183	244	210	230	273	447	2378	6295	5968	903	306	149
520	183	244	210	230	274	447	2378	6297	5971	903	307	149
521	183	244	211	230	274	448	2381	6328	5978	904	307	149
522	183	245	211	230	274	449	2385	6333	6006	908	307	149
523	184	245	211	231	274	451	2388	6337	6018	910	307	150
524	184	245	211	231	274	451	2389	6338	6019	910	308	150
525	184	245	211	231	274	452	2394	6347	6021	911	308	150
526	184	245	211	231	274	452	2398	6348	6023	916	309	151
527	186	245	211	231	274	452	2398	6372	6026	916	310	151
528	187	245	212	231	274	453	2405	6379	6029	916	310	152
529	187	245	212	231	274	453	2408	6379	6034	917	310	153
530	187	248	212	231	275	453	2408	6380	6043	922	310	153
531	188	248	212	232	275	453	2416	6393	6053	923	311	153
532	188	246	212	232	275	453	2420	6395	6062	936	311	153
533	189	246	212	233	276	453	2422	6396	6093	938	311	153
534	190	248	212	233	276	453	2423	6409	6095	941	312	154
535	190	248	212	233	276	454	2425	6423	6111	942	312	155
536	191	248	213	233	276	454	2426	6426	6121	942	313	156
537	191	247	213	234	276	454	2428	6431	6122	942	313	156
538	191	247	213	234	276	454	2432	6442	6124	945	313	156
539	191	247	213	234	276	454	2433	6455	6131	948	313	158
540	191	247	213	234	276	455	2433	6464	6138	948	313	158
541	191	247	213	234	276	456	2444	6471	6141	948	315	158
542	191	247	213	234	276	457	2458	6474	6154	950	315	158
543	191	248	214	235	277	458	2460	6474	6168	950	315	157
544	192	248	214	235	277	459	2465	6475	6171	951	316	158
545	192	248	214	235	277	460	2466	6477	6176	953	316	158
546	192	248	215	235	277	460	2469	6486	6181	954	317	158
547	193	248	215	235	277	460	2478	6499	6184	957	317	158
548	193	248	215	236	277	461	2479	6522	6192	959	318	158
549	193	249	215	236	277	461	2482	6536	6193	963	318	159
550	194	249	215	236	277	461	2488	6560	6230	965	318	159
551	194	249	215	236	277	461	2494	6562	6241	966	319	160
552	195	249	215	236	277	462	2497	6566	6243	967	319	160
553	195	250	216	236	278	463	2498	6571	6244	968	320	161
554	195	250	216	236	278	463	2511	6573	6248	969	320	161
555	196	250	216	236	278	463	2520	6575	6277	969	321	161
556	196	251	218	236	278	464	2521	6588	6278	970	322	161
557	196	251	218	236	278	464	2527	6591	6280	979	323	162
558	196	251	219	236	278	465	2528	6612	6282	980	324	162
559	196	251	219	236	278	465	2532	6616	6298	984	325	162
560	196	251	219	236	278	466	2533	6618	6298	985	326	163

UNITS CFS

Rank	October	November	Decemb	January	Februar	March	April	May	June	July	August	September
561	196	251	219	237	279	468	2538	6624	5305	985	328	163
562	197	251	219	237	279	468	2539	6627	6300	987	328	163
563	197	252	219	237	280	468	2542	6627	6349	991	327	164
564	197	252	219	237	280	469	2547	6632	6350	992	327	164
565	197	252	220	237	280	469	2547	6635	6350	993	327	164
566	197	252	220	237	280	469	2562	6638	6350	993	328	165
567	198	253	220	237	280	469	2554	6639	6374	993	329	165
568	198	253	220	237	280	471	2564	6649	6394	1002	330	166
569	199	253	221	237	281	471	2573	6651	6399	1007	330	167
570	199	253	221	237	281	471	2576	6655	6404	1007	331	168
571	199	253	222	238	281	472	2579	6664	6422	1009	332	168
572	200	253	222	238	281	472	2580	6666	6424	1011	332	168
573	200	253	222	238	281	472	2581	6667	6456	1018	333	168
574	200	254	222	238	281	473	2582	6669	6457	1019	334	168
575	200	254	223	238	281	473	2601	6692	6458	1022	334	168
576	200	254	223	238	281	474	2601	6692	6461	1023	334	169
577	200	254	223	238	281	474	2602	6703	6476	1025	335	169
578	200	255	224	238	281	474	2602	6714	6480	1028	336	170
579	201	255	224	238	281	474	2613	6720	6482	1028	337	170
580	201	255	224	238	282	475	2620	6721	6484	1028	337	170
581	201	255	225	238	282	475	2625	6728	6496	1031	337	170
582	201	256	225	239	283	476	2631	6728	6501	1031	338	171
583	202	256	225	239	283	476	2633	6746	6502	1032	338	171
584	202	257	225	239	284	476	2693	6747	6510	1033	339	171
585	202	257	225	239	284	476	2666	6757	6532	1036	339	171
586	202	257	226	239	284	477	2670	6759	6532	1039	339	171
587	202	257	226	239	284	477	2671	6789	6545	1040	341	172
588	203	257	226	239	285	477	2674	6790	6553	1040	341	172
589	203	257	227	239	285	478	2677	6802	6566	1043	342	173
590	203	258	227	239	286	479	2680	6805	6569	1044	342	173
591	203	258	227	239	286	480	2680	6808	6570	1044	342	173
592	204	258	228	240	286	480	2683	6830	6575	1045	342	173
593	204	258	228	240	288	481	2694	6830	6583	1049	343	174
594	204	258	228	240	286	481	2696	6832	6599	1060	343	174
595	204	259	228	240	287	481	2696	6837	6604	1063	344	175
596	204	259	229	240	287	482	2707	6838	6639	1063	344	175
597	204	259	229	240	287	484	2717	6848	6644	1067	345	175
598	205	259	229	240	287	484	2728	6853	6647	1067	345	175
599	205	259	229	240	287	484	2730	6858	6648	1070	345	176
600	205	259	230	240	288	484	2750	6878	6650	1075	348	176
601	205	259	230	240	288	484	2756	6877	6650	1082	348	176
602	206	260	230	240	288	484	2757	6893	6668	1088	346	177
603	206	260	230	241	288	484	2770	6897	6674	1094	347	177
604	206	260	230	241	288	485	2770	6902	6677	1096	348	177
605	206	260	231	241	289	486	2770	6910	6678	1096	349	177
606	206	261	231	242	289	486	2775	6914	6685	1097	351	179
607	206	261	231	242	289	486	2778	6918	6712	1098	351	179
608	206	261	231	242	289	486	2778	6906	6740	1107	351	179
609	207	262	231	242	289	488	2785	6945	6751	1109	351	179
610	207	263	232	242	290	489	2787	6968	6761	1112	351	179
611	207	263	232	242	290	489	2788	6968	6773	1114	352	180
612	207	263	232	243	290	491	2800	6972	6776	1115	353	180
613	207	264	232	243	290	491	2811	6976	6777	1120	353	180
614	207	264	233	243	290	491	2814	6984	6779	1122	354	180
615	208	264	234	243	291	492	2816	7008	6794	1123	354	181
616	208	264	236	243	291	492	2816	7016	6797	1124	354	181
617	208	265	237	244	291	492	2820	7017	6797	1129	356	181
618	209	265	237	244	291	492	2821	7017	6813	1134	356	181
619	209	265	238	244	291	493	2824	7034	6822	1137	356	182
620	210	266	238	244	292	493	2829	7047	6847	1138	356	182
621	210	266	238	244	292	494	2833	7077	6853	1145	356	182
622	210	266	238	245	292	495	2836	7088	6867	1153	357	183
623	210	266	238	245	292	495	2840	7094	6878	1155	357	183
624	210	266	239	245	292	495	2843	7095	6882	1161	357	183
625	210	266	239	245	293	496	2858	7109	6911	1161	358	183
626	211	267	240	245	293	497	2861	7115	6914	1164	358	183
627	211	267	240	245	293	498	2861	7129	6915	1166	358	184
628	212	267	240	245	294	498	2862	7130	6930	1169	359	184
629	212	267	241	246	294	499	2863	7134	6946	1170	360	185
630	213	268	241	246	294	503	2871	7139	6956	1172	360	185
631	213	268	241	246	294	503	2873	7143	6958	1173	361	186
632	214	268	242	246	294	505	2876	7144	6959	1182	364	186
633	214	268	242	246	295	505	2882	7147	6975	1214	366	186
634	215	268	243	246	295	506	2899	7147	6997	1216	369	188
635	215	268	243	246	295	507	2904	7152	7000	1218	371	188
636	215	268	243	246	296	507	2913	7156	7009	1220	372	188
637	216	268	243	247	296	507	2922	7160	7036	1220	373	189
638	216	270	243	247	296	508	2924	7167	7036	1222	375	189
639	216	270	244	247	296	508	2953	7180	7056	1228	375	189
640	218	270	244	247	296	509	2957	7183	7052	1228	375	190

UNITS CFS

Rank	October	November	Decemb	January	Februar	March	April	May	June	July	August	September
641	217	270	244	247	297	509	2960	7185	7072	1229	376	190
642	217	271	245	247	297	510	2961	7217	7074	1234	377	190
643	217	271	246	247	297	512	2962	7228	7079	1236	377	191
644	218	271	247	247	298	512	2966	7229	7083	1242	377	191
645	218	272	247	247	298	512	2968	7237	7090	1243	377	191
646	218	272	247	247	299	512	2972	7270	7095	1244	377	192
647	218	272	248	247	299	513	2975	7271	7096	1247	378	192
648	219	272	248	248	299	514	2975	7272	7103	1251	378	193
649	219	272	248	248	299	514	2993	7274	7111	1252	379	193
650	219	272	249	248	299	514	3001	7293	7133	1257	380	193
651	220	273	249	248	299	514	3002	7299	7134	1257	381	193
652	220	273	250	248	299	514	3015	7302	7138	1258	381	194
653	220	273	250	248	299	514	3017	7328	7145	1260	381	194
654	220	274	251	248	300	515	3018	7337	7163	1262	383	194
655	220	274	251	249	300	517	3020	7341	7184	1262	386	194
656	221	274	252	249	300	519	3037	7345	7177	1263	386	195
657	222	274	252	249	300	521	3049	7348	7179	1264	386	195
658	222	274	252	249	300	521	3050	7361	7182	1265	387	197
659	222	275	252	249	300	521	3055	7388	7182	1276	390	197
660	222	275	252	249	301	522	3070	7422	7192	1277	390	197
661	223	275	253	249	301	522	3070	7423	7219	1278	392	198
662	223	276	254	249	301	522	3092	7428	7231	1319	392	198
663	224	276	254	249	301	523	3098	7435	7236	1321	392	198
664	224	276	255	249	301	524	3098	7461	7237	1328	392	199
665	225	276	257	249	301	525	3102	7461	7238	1328	393	199
666	226	278	257	250	301	525	3111	7461	7249	1330	393	200
667	226	278	258	250	301	526	3128	7466	7250	1331	393	200
668	227	278	258	250	302	527	3135	7474	7256	1331	393	201
669	228	277	259	250	302	528	3140	7475	7257	1332	396	201
670	229	277	259	251	302	528	3144	7482	7263	1333	396	201
671	228	278	259	251	302	528	3146	7486	7265	1344	397	201
672	230	278	260	251	303	531	3150	7492	7271	1345	398	201
673	230	278	260	252	303	531	3159	7502	7275	1359	400	202
674	231	279	261	255	303	532	3159	7506	7282	1368	401	202
675	231	279	261	255	305	532	3183	7513	7283	1375	401	202
676	232	279	261	256	305	534	3185	7518	7299	1378	403	202
677	232	281	261	256	305	535	3187	7532	7311	1378	405	202
678	232	282	261	256	305	536	3172	7555	7323	1387	406	202
679	233	282	262	258	307	537	3177	7557	7325	1394	406	203
680	233	282	262	258	307	537	3179	7569	7330	1395	407	203
681	234	285	263	258	308	538	3180	7569	7350	1398	407	203
682	234	285	264	259	308	539	3181	7577	7353	1399	408	203
683	234	285	264	259	309	540	2138	7584	7364	1403	409	204
684	234	285	264	259	310	540	3197	7589	7378	1405	409	204
685	235	285	265	260	310	541	3201	7594	7379	1406	410	204
686	236	286	265	260	311	542	3201	7600	7380	1406	410	205
687	236	286	265	260	311	542	3209	7605	7381	1412	410	205
688	236	286	266	260	311	543	3221	7606	7389	1418	411	205
689	236	288	266	260	311	544	3226	7609	7409	1425	411	205
690	237	287	266	260	312	545	3237	7619	7413	1433	411	205
691	237	288	266	260	313	546	3248	7619	7418	1433	412	205
692	238	288	267	261	313	547	3248	7625	7425	1434	413	206
693	239	289	267	261	313	547	3256	7627	7434	1443	415	206
694	240	288	267	262	314	547	3269	7628	7448	1452	415	206
695	241	289	268	262	314	548	3276	7635	7450	1458	416	206
696	241	289	269	262	315	548	3287	7644	7469	1465	416	206
697	242	290	269	262	317	548	3287	7647	7474	1470	417	207
698	242	290	269	262	317	549	3299	7652	7496	1471	417	207
699	245	290	269	262	318	549	3300	7653	7501	1471	417	208
700	246	291	270	262	318	553	3302	7653	7506	1474	418	208
701	246	291	270	262	318	554	3304	7658	7516	1482	419	208
702	248	291	271	263	318	555	3313	7706	7535	1493	419	208
703	248	291	272	263	318	558	3315	7714	7578	1501	420	209
704	248	291	272	263	319	557	3318	7730	7577	1510	420	210
705	248	292	274	264	319	557	3318	7733	7577	1512	421	210
706	250	294	274	264	319	560	3319	7736	7579	1515	423	210
707	250	294	274	264	319	560	3323	7738	7586	1522	423	211
708	250	295	276	264	320	562	3337	7760	7595	1531	423	211
709	251	295	276	265	320	562	3341	7761	7595	1533	424	211
710	252	295	276	265	320	562	3347	7764	7609	1535	424	212
711	253	296	277	265	321	563	3354	7770	7615	1538	424	212
712	253	296	277	266	321	563	3359	7774	7622	1545	424	213
713	254	296	278	266	321	564	3370	7778	7627	1553	425	213
714	254	296	279	266	322	565	3378	7782	7632	1564	425	213
715	254	296	281	267	322	566	3384	7784	7706	1574	427	213
716	255	298	282	267	322	567	3389	7790	7708	1585	428	213
717	256	296	283	267	322	567	3391	7791	7736	1585	431	214
718	256	298	283	267	322	567	3392	7802	7750	1598	431	214
719	256	299	283	267	322	568	3399	7811	7750	1599	432	215
720	257	299	283	268	322	569	3407	7853	7751	1602	433	215

UNITS CFS

Rank	October	November	Decemb	January	Februar	March	April	May	June	July	August	September
721	258	300	284	268	322	570	3428	7858	7765	1606	433	215
722	259	300	284	269	323	570	3451	7861	7770	1619	435	216
723	259	300	284	269	323	571	3458	7880	7789	1622	436	217
724	262	301	285	270	324	571	3462	7892	7806	1628	436	217
725	262	301	285	270	324	572	3464	7905	7811	1634	437	217
726	263	301	285	271	325	573	3470	7908	7817	1634	437	218
727	263	301	285	271	325	573	3496	7915	7819	1646	438	218
728	264	302	285	272	325	573	3503	7924	7825	1666	439	219
729	264	302	285	272	326	575	3504	7938	7843	1674	440	219
730	264	303	286	272	329	577	3505	7949	7846	1679	440	219
731	265	303	286	273	329	578	3510	7952	7853	1682	441	219
732	265	303	287	273	329	578	3540	7953	7860	1692	441	219
733	266	303	287	273	330	582	3542	7963	7866	1694	442	220
734	266	304	287	274	330	584	3551	7963	7874	1694	443	220
735	267	305	287	275	330	586	3554	7986	7898	1698	443	220
736	268	305	288	275	331	587	3564	7988	7907	1707	445	220
737	268	306	288	276	331	587	3563	8001	7914	1717	448	221
738	269	307	288	277	331	588	3585	8005	7920	1716	446	222
739	269	307	289	277	332	590	3598	8012	7926	1753	447	222
740	269	307	290	277	332	591	3603	8024	7935	1757	448	222
741	270	307	290	277	333	591	3614	8026	7940	1760	449	222
742	271	308	290	277	335	591	3617	8043	7956	1762	450	222
743	271	308	291	277	335	591	3617	8043	7959	1763	450	223
744	272	308	292	277	336	591	3624	8044	7963	1766	451	223
745	274	309	292	278	336	593	3633	8045	7972	1768	451	223
746	275	310	292	278	336	596	3662	8054	7988	1780	451	223
747	277	310	292	278	337	598	3666	8056	7990	1784	451	224
748	277	312	292	278	337	600	3690	8077	8015	1784	452	224
749	278	312	293	279	338	602	3691	8092	8024	1794	452	225
750	278	313	293	280	338	602	3693	8099	8025	1799	454	225
751	280	313	294	280	339	602	3693	8101	8030	1799	455	225
752	281	314	294	281	339	603	3709	8154	8045	1807	457	225
753	282	314	294	281	339	604	3709	8185	8048	1808	461	226
754	285	315	295	281	340	604	3723	8209	8092	1822	462	226
755	285	316	295	281	340	608	3738	8213	8093	1823	462	227
756	285	316	295	281	340	609	3753	8214	8123	1835	463	227
757	285	318	295	281	340	609	3759	8219	8136	1847	463	227
758	286	317	296	282	342	610	3765	8244	8149	1867	464	227
759	286	317	296	282	343	611	3772	8248	8175	1871	466	228
760	288	318	297	283	343	612	3780	8256	8181	1875	468	228
761	290	318	297	284	343	614	3797	8291	8191	1879	468	229
762	290	319	297	284	343	614	3802	8295	8194	1901	471	229
763	292	319	297	285	345	615	3813	8312	8195	1906	472	229
764	293	321	297	286	345	615	3812	8314	8195	1909	472	230
765	295	321	297	285	346	616	3825	8332	8199	1916	473	230
766	295	322	297	285	346	617	3825	8340	8199	1935	474	231
767	296	323	297	285	346	619	3828	8356	8205	1951	476	232
768	297	323	298	285	346	619	3838	8359	8206	1959	476	232
769	297	323	298	286	346	622	3841	8390	8214	1981	477	233
770	298	324	299	286	347	624	3861	8391	8217	1982	480	233
771	300	324	299	286	348	625	3876	8396	8224	1986	482	233
772	300	324	299	287	348	625	3887	8454	8228	1989	482	234
773	301	325	300	287	348	628	3903	8458	8238	1991	483	235
774	301	326	300	288	348	626	3908	8467	8252	2021	483	235
775	303	327	300	288	349	627	3910	8473	8266	2025	483	235
776	304	327	300	288	349	628	3919	8495	8270	2026	485	235
777	304	327	300	288	349	631	3930	8510	8275	2030	486	236
778	305	327	300	288	350	632	3935	8519	8277	2032	488	237
779	305	328	301	288	350	633	3948	8533	8287	2037	490	238
780	305	328	301	289	350	637	3961	8538	8297	2046	491	238
781	306	328	302	289	350	641	3970	8541	8303	2051	493	239
782	307	329	302	289	350	642	3983	8574	8315	2057	496	239
783	307	329	302	289	350	643	3985	8579	8323	2070	497	239
784	307	331	302	290	352	645	3999	8580	8348	2079	497	240
785	307	333	303	291	353	645	4003	8605	8353	2080	496	240
786	308	333	303	291	353	645	4007	8614	8360	2087	498	240
787	308	333	304	291	353	646	4021	8623	8365	2090	499	241
788	310	334	305	291	353	646	4023	8623	8387	2096	500	241
789	310	335	306	291	354	648	4032	8624	8388	2106	501	242
790	310	336	306	292	356	651	4032	8635	8388	2109	501	242
791	310	336	306	292	356	651	4039	8650	8437	2115	502	242
792	312	336	306	292	356	653	4042	8688	8438	2129	502	242
793	312	337	306	292	356	654	4045	8693	8459	2138	502	242
794	312	338	307	292	356	655	4070	8694	8468	2158	503	243
795	312	338	307	292	357	658	4073	8696	8510	2161	503	244
796	313	338	308	292	357	659	4127	8696	8510	2175	505	244
797	314	341	308	292	358	660	4134	8711	8512	2182	505	244
798	314	342	309	292	358	663	4136	8735	8543	2188	505	244
799	315	342	310	293	358	664	4137	8741	8547	2199	506	244
800	318	343	311	293	360	666	4144	8768	8558	2211	508	245

UNITS CFS

Rank	October	November	December	January	February	March	April	May	June	July	August	September
801	319	343	311	293	361	656	4150	8770	8582	2212	508	245
802	319	344	311	293	362	609	4156	8772	8606	2234	508	245
803	320	345	311	293	362	669	4167	8773	8613	2237	508	245
804	322	345	312	293	363	672	4177	8807	8626	2244	508	246
805	322	345	313	294	363	673	4180	8821	8634	2261	509	247
806	323	346	314	294	365	676	4197	8827	8653	2267	510	249
807	323	346	316	294	365	678	4224	8854	8678	2273	510	249
808	324	348	316	294	365	684	4227	8868	8680	2286	512	249
809	327	351	316	296	366	684	4249	8877	8683	2288	512	249
810	329	353	317	296	367	685	4249	8879	8684	2302	513	251
811	329	353	318	296	367	688	4250	8879	8687	2306	514	252
812	330	354	318	296	367	688	4284	8891	8690	2307	514	252
813	330	355	318	297	367	688	4298	8906	8690	2312	515	252
814	330	358	319	298	368	689	4354	8914	8699	2318	516	253
815	331	357	319	298	369	689	4358	8916	8702	2321	518	253
816	331	359	319	298	369	692	4369	8920	8703	2322	519	253
817	334	360	320	298	369	693	4381	8921	8713	2323	520	253
818	335	360	320	298	369	693	4396	8928	8729	2338	520	253
819	335	360	320	298	371	695	4425	8957	8738	2339	521	254
820	337	361	321	300	373	696	4441	8970	8762	2341	522	255
821	338	361	321	300	374	697	4448	9037	8768	2348	522	255
822	339	361	322	300	374	697	4469	9050	8776	2348	522	256
823	340	362	322	301	374	698	4469	9070	8776	2371	523	258
824	342	364	322	301	376	698	4481	9072	8778	2377	523	259
825	345	365	322	301	377	699	4516	9076	8783	2381	523	259
826	346	365	323	301	378	703	4532	9100	8804	2385	525	259
827	347	366	323	301	380	709	4549	9125	8815	2406	525	261
828	348	367	323	301	380	710	4558	9143	8815	2434	526	261
829	349	368	323	301	383	710	4580	9145	8830	2441	526	262
830	349	369	323	302	384	711	4607	9153	8834	2442	526	262
831	349	370	325	302	388	713	4610	9183	8844	2453	529	262
832	350	370	324	302	389	716	4642	9188	8846	2455	531	262
833	351	370	324	302	390	716	4658	9200	8850	2457	532	263
834	352	371	324	302	390	717	4661	9240	8855	2468	533	263
835	353	372	324	302	391	720	4678	9242	8878	2482	534	264
836	353	372	325	302	391	721	4698	9244	8891	2492	534	264
837	353	372	325	302	394	723	4729	9255	8905	2494	535	264
838	356	373	325	303	394	724	4733	9288	8908	2505	538	264
839	356	373	326	303	397	726	4771	9297	8913	2535	540	265
840	357	374	327	303	398	728	4773	9297	8927	2536	540	265
841	358	374	327	304	399	729	4778	9330	8931	2537	540	265
842	358	377	328	305	399	729	4779	9338	8940	2540	542	268
843	358	378	328	305	400	730	4799	9359	8953	2541	543	268
844	359	378	328	305	401	731	4802	9362	8956	2552	543	267
845	361	378	328	305	408	736	4815	9368	8968	2557	544	267
846	362	379	328	306	410	737	4818	9368	8969	2601	545	268
847	367	379	329	306	412	743	4834	9389	8973	2604	545	268
848	369	380	329	306	419	756	4838	9396	8991	2608	548	269
849	373	380	329	306	421	759	4913	9406	9020	2618	549	270
850	375	384	330	307	424	766	4929	9428	9022	2621	553	270
851	377	389	330	307	424	772	4946	9427	9043	2627	554	270
852	377	390	330	308	424	773	4960	9463	9051	2628	555	272
853	378	390	331	309	425	773	4962	9475	9070	2629	555	273
854	379	390	331	309	426	777	5000	9487	9072	2631	555	273
855	379	390	332	309	428	781	5005	9515	9104	2631	557	273
856	380	392	332	310	428	784	5022	9521	9122	2636	558	273
857	380	392	332	310	430	785	5036	9528	9135	2638	559	273
858	382	393	333	310	434	785	5037	9554	9155	2654	561	273
859	384	397	333	310	444	785	5099	9579	9169	2666	563	274
860	385	397	333	310	446	787	5113	9585	9211	2670	563	276
861	386	398	333	311	447	790	5119	9596	9224	2670	565	276
862	386	398	333	311	447	794	5123	9623	9226	2677	566	277
863	386	398	333	311	448	797	5132	9668	9228	2685	567	277
864	388	398	333	312	448	801	5158	9685	9252	2692	567	277
865	388	399	334	312	451	804	5162	9695	9261	2723	568	277
866	388	399	334	312	451	806	5270	9700	9263	2736	573	278
867	389	400	334	312	452	807	5277	9712	9268	2763	574	279
868	391	401	334	312	453	812	5277	9716	9347	2771	577	282
869	392	402	334	313	456	815	5287	9718	9371	2772	578	286
870	396	403	335	313	459	819	5292	9729	9380	2773	578	286
871	405	404	335	313	462	822	5293	9734	9402	2793	579	288
872	407	407	335	313	462	824	5315	9753	9407	2796	580	288
873	409	408	335	313	463	824	5324	9772	9414	2807	581	288
874	416	410	335	313	464	824	5331	9798	9440	2817	581	288
875	422	412	335	314	464	830	5368	9808	9462	2845	581	292
876	422	413	336	314	466	830	5374	9812	9465	2850	584	292
877	422	413	336	314	467	836	5383	9813	9497	2854	584	294
878	423	413	337	314	475	837	5421	9827	9498	2855	586	295
879	431	413	337	315	475	840	5422	9828	9506	2856	587	295
880	434	413	339	315	486	843	5468	9851	9512	2870	591	295

UNITS CFS

Rank	October	November	December	January	February	March	April	May	June	July	August	September
881	435	414	339	316	486	844	6478	9859	9541	2888	591	296
882	435	414	339	316	498	844	5499	9863	9543	2890	591	296
883	436	414	340	317	505	852	5511	9905	9557	2892	591	298
884	438	415	340	317	513	852	5515	9920	9558	2906	592	297
885	438	415	341	317	515	853	5534	9225	9559	2907	592	298
886	439	417	341	318	516	856	5555	9936	9571	2915	592	298
887	440	418	341	318	518	858	5583	9939	9575	2920	593	298
888	441	418	342	319	535	861	5608	9944	9586	2945	594	299
889	441	418	342	320	538	889	5629	9947	9604	2951	594	298
890	442	419	343	321	539	873	5648	9952	9631	2954	595	300
891	442	419	343	321	544	875	5650	9956	9639	2965	597	300
892	442	420	345	321	551	876	5668	10004	9641	2965	597	300
893	443	420	345	321	565	880	5675	10013	9658	2966	601	302
894	444	421	344	322	569	884	5677	10056	9678	2970	603	303
895	445	421	345	322	575	885	6708	10058	9699	2984	607	303
896	447	424	345	322	585	886	5708	10059	9704	3001	608	303
897	449	424	346	322	586	887	5734	10079	9721	3010	610	307
898	449	426	347	323	591	896	5750	10080	9726	3026	610	308
899	450	425	348	323	594	899	5757	10098	9755	3032	611	308
900	453	426	348	323	596	902	5771	10144	9779	3047	612	309
901	453	428	348	323	597	905	5789	10145	9793	3075	618	310
902	454	428	349	323	602	913	5805	10155	9828	3088	619	311
903	456	427	349	324	604	914	5838	10184	9831	3088	619	311
904	458	427	349	324	604	917	5837	10198	9853	3093	620	311
905	457	428	350	324	606	927	5845	10220	9882	3113	621	312
906	458	429	350	324	610	932	5858	10279	9856	3141	623	313
907	458	429	350	324	620	933	5874	10356	9965	3145	625	313
908	459	430	350	324	647	935	5897	10371	9966	3150	625	314
909	460	430	350	324	658	938	5908	10402	9975	3179	627	314
910	462	430	351	325	672	942	5917	10441	9998	3181	628	314
911	463	433	352	326	704	943	5935	10444	10007	3227	629	315
912	464	434	352	327	707	946	5963	10464	10014	3275	631	316
913	464	434	352	327	736	948	5967	10487	10097	3283	634	318
914	468	436	352	327	747	947	5982	10502	10188	3291	637	318
915	470	436	353	328	751	949	6016	10505	10204	3300	645	321
916	470	436	354	328	777	957	6045	10514	10229	3323	645	326
917	473	436	354	328	798	980	6074	10533	10236	3331	647	328
918	474	439	354	329	803	984	6115	10538	10269	3345	648	328
919	474	439	354	329	839	985	6141	10553	10311	3348	648	327
920	475	444	254	329	888	987	6157	10562	10331	3353	648	330
921	477	447	355	329	900	976	6174	10571	10332	3367	650	340
922	478	448	355	329	962	989	6188	10575	10344	3384	652	340
923	478	450	365	330	981	994	6190	10578	10348	3402	659	341
924	479	450	256	331	1006	995	6294	10587	10371	3419	660	345
925	483	451	357	332	1006	996	6305	10605	10400	3431	663	346
926	483	452	359	332	1035	997	6365	10619	10473	3431	666	349
927	486	454	359	333	1206	998	6373	10621	10474	3458	669	350
928	486	458	360	333	1286	1014	6393	10651	10478	3457	669	350
929	487	459	360	333	1506	1032	6415	10672	10513	3460	672	353
930	488	461	362	333	2075	1033	6434	10712	10588	3472	672	353
931	488	461	362	333	2535	1035	6442	10773	10589	3493	675	354
932	490	465	362	334	3225	1040	6451	10779	10657	3517	678	356
933	490	468	364	334		1040	6494	10797	10668	3521	679	358
934	491	469	364	336		1049	6653	10814	10672	3523	682	358
935	493	470	364	336		1055	6656	10835	10737	3545	683	359
936	496	470	365	336		1059	6665	10858	10776	3557	683	361
937	498	470	365	337		1062	6719	10877	10809	3603	686	365
938	499	476	367	337		1067	6801	10887	10819	3634	687	370
939	499	480	367	337		1070	6821	10896	10833	3647	688	371
940	500	482	368	337		1072	6851	10938	10868	3653	698	375
941	500	483	368	338		1093	6853	10945	10914	3748	690	377
942	501	485	368	338		1100	6888	10946	10950	3773	692	381
943	502	488	368	338		1124	6903	11006	11008	3774	692	382
944	507	489	368	338		1128	6897	11012	11064	3776	696	385
945	508	490	370	338		1143	6901	11045	11128	3784	697	387
946	514	492	370	341		1148	6906	11085	11171	3797	700	391
947	516	494	370	341		1167	6922	11077	11200	3811	700	391
948	519	497	371	341		1178	6947	11086	11307	3825	703	392
949	521	503	371	342		1192	6953	11122	11321	3838	707	398
950	523	506	371	342		1213	6962	11161	11334	3857	708	395
951	524	508	372	342		1214	7063	11179	11358	3873	708	401
952	532	512	373	343		1217	7115	11213	11381	3886	709	407
953	533	515	373	343		1225	7142	11233	11462	3932	710	422
954	536	520	373	343		1226	7178	11282	11565	3972	717	428
955	536	529	373	343		1229	7254	11348	11573	3977	720	429
956	541	528	374	344		1235	7282	11358	11627	4017	724	436
957	543	540	374	344		1238	7352	11435	11675	4017	727	447
958	543	543	374	345		1245	7368	11437	11732	4040	730	449
959	544	547	374	345		1250	7540	11447	11778	4108	732	452
960	548	562	375	345		1268	7540	11463	11783	4117	734	453

UNITS CFS

Rank	October	November	Decemb	January	Februar	March	April	May	June	July	August	September
961	548	552	375	345		1275	7824	11473	11793	4131	735	488
962	552	556	377	345		1280	7845	11503	11847	4150	736	477
963	553	556	377	346		1282	7710	11518	11849	4169	738	504
964	554	557	378	346		1286	7891	11580	11902	4190	728	506
965	556	556	379	347		1309	8079	11592	11913	4224	740	510
966	557	568	379	349		1316	8317	11625	11936	4260	741	554
967	568	569	381	349		1317	8389	11770	11993	4282	741	558
968	574	572	381	349		1351	8428	11813	12064	4318	742	568
969	586	574	381	349		1359	8633	11834	12342	4322	746	589
970	597	583	382	349		1367	8731	11967	12358	4336	749	574
971	606	584	383	352		1374	8958	11994	12381	4242	751	591
972	609	585	385	353		1375	9309	12006	12383	4360	754	603
973	609	588	385	353		1398	9589	12016	12412	4375	765	606
974	613	599	386	353		1427	9632	12024	12778	4426	767	614
975	631	600	387	358		1440	9978	12045	12944	4493	768	622
976	637	618	387	359		1442	9978	12082	12961	4527	771	664
977	652	626	388	360		1445	10055	12151	13022	4554	773	675
978	656	628	390	360		1448	10477	12168	13290	4666	788	688
979	660	629	390	360		1450	10504	12177	13392	4672	788	706
980	668	631	390	361		1458	10547	12182	13506	4674	796	753
981	695	654	390	361		1501	10918	12251	13573	4722	797	796
982	708	656	391	363		1503	10922	12259	13919	4749	801	823
983	715	662	393	365		1513	11032	12269	13934	4767	804	827
984	718	667	394	365		1533	11176	12330	14194	4779	806	847
985	742	670	395	365		1535	11649	12349	14274	4802	806	896
986	758	702	395	367		1580	11660	12380	14898	5046	807	918
987	761	721	396	369		1606	11685	12394	14998	5063	810	924
988	770	721	397	371		1679	11789	12416	15685	5094	812	955
989	776	731	398	371		1694	11972	12441	15897	5104	821	992
990	804	732	398	378		1694	14680	12465	18293	5207	832	1654
991	808		400	378		1740		12472		5215	849	
992	830		401	379		1768		12476		5254	852	
993	836		405	382		1801		12484		5291	873	
994	837		406	385		1825		12526		5354	878	
995	847		407	388		1831		12531		5509	882	
996	866		409	389		1837		12549		5559	886	
997	878		409	399		1844		12608		5629	899	
998	879		411	392		1847		12620		5693	900	
999	881		412	393		1852		12679		5709	921	
1000	888		413	395		1855		12767		5713	920	
1001	890		416	397		1888		12805		5794	936	
1002	906		417	402		1913		12820		5794	940	
1003	909		418	402		2033		12826		5846	943	
1004	914		425	402		2039		12905		5901	944	
1005	923		426	405		2067		12967		6145	958	
1006	926		426	407		2159		13014		6216	964	
1007	930		426	409		2254		13067		6270	971	
1008	932		428	411		2284		13097		6473	985	
1009	950		428	417		2270		13328		6514	1020	
1010	957		428	418		2372		13338		6598	1070	
1011	960		429	422		2456		13396		6719	1093	
1012	966		431	422		2468		13513		6898	1135	
1013	969		432	430		2541		13524		6932	1159	
1014	970		443	434		2613		13719		6963	1171	
1015	982		448	441		2749		13940		7670	1171	
1016	1031		453	450		2827		13960		7795	1181	
1017	1039		467	450		2946		13990		8194	1209	
1018	1061		471	456		3007		14127		8881	1232	
1019	1097		488	456		3533		14151		10046	1328	
1020	1128		508	460		4066		14355		10352	1371	
1021	1140		523	461		4118		14612		10857	1550	
1022	1317		590	471		4655		15481		11861	1742	
1023	1506		591	491		4735		15069		12565	1931	

Appendix 5. List of flow exceedance values based on monthly averages computed from estimated daily virgin flows (Hydrosphere 1995) for the Yampa River which include all 10 cfs values. These values are provided for comparison only, and do not represent flow recommendation by the Fish and Wildlife Service.

MONTH	80%[1] Exceedance DRY	50% Exceedance AVERAGE	20% Exceedance WET
OCT	91	184	294
NOV	184	234	305
DEC	162	209	312
JAN	197	221	306
FEB	226	267	381
MAR	440	496	694
APR	Existing flows minus the depletion baseline (Table 3)		
MAY			
JUN			
JULY			
AUG	152	349	483
SEP	78	141	219

[1]Exceedances in cfs