APPENDIX A
1981 Secretarial Decision

SECRETARIAL DECISION

ALTERNATIVES FOR INCREASING RELEASES TO THE TRINITY

_________ 1. 120,500 acre-feet annual releases in all years (no action alternative)

_________ 2. 215,000 acre-feet annual releases in all years

_________ 3a. 287,000 acre-feet annual releases in all years

_________ 3b. 287,000 acre-feet annual releases in normal water years with reduction to 120,500 acre-feet in dry and critically dry years

__________ 4a. 340,000 acre-feet annual release in all years

_________ 4b. 340,000 acre-feet release in normal water years with reduction to 120,500 acre-feet in dry and critically dry years

_________ 4c. 340,000 acre-feet annual release in normal years; 220,000 acre-feet dry years; 140,000 acre-feet critically dry years

_________ Modified 4c. * WPRS will allocate CVP yield so that releases can be maintained at 340,000 acre-feet annually in normal years. FWS will prepare a detailed study plan to assess the results of habitat and watershed restoration. Prior to completion of the plan, releases will be 287,000 acre-feet. Releases will be incrementally increased to 340,000 acre-feet as habitat and watershed restoration measures are implemented. In dry years, releases will be 220,000 acre-feet; 140,000 acre-feet in critically dry years.

* (It is understood that no water allocated to the fishery under this agreement may be permanently allocated for any other purpose until the report provided for in paragraph (3) of the 12/30/80 Memorandum of Agreement has been acted on by the Secretary.

_________ 4d. 340,000 acre-feet annual release in all years until "interim water" is exhausted; thereafter, same releases as Alternative 4c.

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TRINITY RIVER FISHERY MITIGATION

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III. ALTERNATIVES FOR INCREASING RELEASES TO THE TRINITY

1. 120,500 acre-feet annual releases in all years (no action alternative)

2. 215,000 acre-feet annual releases in all years

3a. 287,000 acre-feet annual releases in all years

3b. 287,000 acre-feet annual releases in normal water years with reduction to 120,500 acre-feet in dry and critically dry years

4a. 340,000 acre-feet annual release in all years

4b. 340,000 acre-feet release in normal water years with reduction to 120,500 acre-feet in dry and critically dry years

4c. 340,000 acre-feet annual release in normal years; 220,000 acre - feet dry years; 140,000 acre-feet critically dry years (identified in the EIS as the proposed action).

Modified 4c. Alternative 4c as modified by agreement between FWS and WPRS

4d. 340,000 acre-feet annual release in all years until "interim water" is exhausted; thereafter, same releases as Alternative 4c

ATTACHMENTS

Agreement Between FWS and WPRS for Implementing and Evaluating Increased Stream Flows for the Trinity Division, Central Valley Project, California

Final Environmental Impact Statement on the Management of River Flows to Mitigate the Loss of the Anadromous Fishery of the Trinity River, California (FES #80-52)

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TRINITY RIVER FISHERY MITIGATION

I. INTRODUCTION

This SID concerns the operation of the Trinity River Division of the Central Valley Project in California. Since completion of the Division, over 80% of the mean runoff of the Trinity watershed above Lewiston Dam has been diverted to the Sacramento watershed for agricultural, hydroelectric, and other uses. This diversion has been accompanied by a severe decline in anadromous fish runs in the Trinity and Klamath Rivers. At issue are the quantity of water to be diverted and the quantity to be allowed to flow through its natural course for preservation and enhancement of anadromous fish runs on the Trinity and Klamath Rivers. Lead Assistant Secretary for this SID is the Assistant Secretary — Indian Affairs because of the federal trust responsibility to protect the fishing rights of the Hupa and Yurok tribes of the Hoopa Valley Indian Reservation.

This SID is a revision of a draft SID on the same subject distributed for review on January 8, 1980. Review of the earlier SID resulted in a decision by the Secretary, recorded in a memorandum dated April 18, 1980 (See Appendix 10 in the EIS), to increase releases from Lewiston Dam into the Trinity River during the current year (through April 30, 1981) and to prepare an environmental impact statement (EIS) prior to a decision by the Secretary on a permanent commitment of water for Trinity River Flows. The Fish and Wildlife Service (FWS) was directed to be the lead agency for the EIS, with the Bureau of Indian Affairs (BIA) and the Water and Power Resources Services (WPRS) directed to act as cooperating agencies. The draft EIS was released to the public on August 29, the comment period closed on October 17, the final EIS was filed with the Environmental Protection Agency on December 5, and a notice of availability was published in the Federal Register on December 12. The final EIS is attached to this SID. This SID constitutes the record of decision for the EIS. Because most of the information contained in the previous draft SD has been incorporated into the EIS, the discussion in the present SID has been substantially condensed.

The final EIS discusses eight alternatives, including the "no action" alternative. One of these, Alternative 4c, is identified as the proposed action. Following distribution of this SD in draft form on December 19, 1980, FWS and WPRS entered into an agreement, through which both agencies express a preference for a modified version of Alternative 4c. A copy of the agreement is attached to this SID. The primary purpose of the agreement is to aid in the implementation of Alternative 4c, in the event that the Secretary selects that alternative. The agreement contemplates a twelve year study period during which, in order to complement increased stream flows, an overall fish and wildlife management plan would be implemented by the member agencies of the Trinity River Basin Fish and Wildlife Task Force. All of the alternatives, except no action, assume that such a plan to improve habitat would be implemented. However, only the modified 4c specifies that the decision made based on this SID will be reviewed at a future date, i.e., 12 years after implementation.

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II. BACKGROUND

A. HUPA AND YUROK FISHING RIGHTS

For hundreds of years the Hupa, Karuk, and Yurok Indian tribes have resided along the Trinity and Klamath Rivers and their tributaries and have utilized the fishery in the practice of their religion, in barter, and as a principal food source. The achievement of wealth and status and the pursuit of enterprise were vital aspects of the traditional cultures of these tribes, and these aspects of culture were largely based upon the abundance of salmon. To protect fundamental tribal rights, including utilization of the fishery, Federal reservations were created during the 1855-1891 period pursuant to Congressional authority. (See Sections C7.O and D5.3 of the EIS.)

Secretarial responsibilities regarding tribal fishing rights and tribal entitlement to water to provide a viable fishery have been extensively outlined in a memorandum dated March 14, 1979, from the Associate Solicitor, Division of Indian Affairs to the Assistant Secretary - Indian Affairs. This memorandum states, in part:

> "It has been clearly established in the courts that an important 'Indian purpose' for the creation of both the initial reservation and the subsequent extension was to reserve to the tribes occupying the reservation the right to take fish from the Klamath and Trinity Rivers. Mattz v. Arnett, 412 U.S. 481 (1973); Arnett v. 5 Gill Nets, 48 Cal. App.3d 459 (1975); Donahue v. Justice Court, 15 Cal. App.3d 557 (1971).
>
> "It is also well established that when federal reservations are created pursuant to Congressional authority, the Federal Government reserves the use of such water as may be necessary for the purposes for which the reservation was created. Winters v. United States, 207 U.S. 564 (1908); Arizona v. California, .373 U.S. 546 (1963); Cappaert v. United States, 426 U.S. 128 (1976); United States v. New Mexico, 98 5. Ct. 3012 (1978).
>
> "Both the tribal rights to fish and to the water needed to make the fishing right meaningful are tribal assets, which the Secretary has an obligation as trustee to manage for the benefit of the tribes. A trustee has a duty to exercise such care and skill as a person of ordinary prudence would exercise in dealing with his or her own property. Restatement (Second) of Trusts (1959) (hereinafter Trusts) Sec. 174. This obligation includes both the duty to preserve the trust assets and to make them productive. Trusts Sec. 181. The most fundamental duty of the trustee, however, is loyalty to the beneficiary. The trustee must administer trust assets solely in the interests of the beneficiary. Trusts Sec. 170.
>
> "These basic principles of trust law have been applied in recent years in the context of federal Indian law by the United States Supreme Court, United States v. Mason, 412 U.S. 392 (1973), by the federal trial court that has the Hoopa Valley Indian Reservation within its district, Manchester Band of Pomo Indians v. United States, 363 F. Supp. 1238 (N.D. Cal. 1973), by the Court of

> Claims in a case involving Indians living on that reservation, Coast Indian Community v. United States, 550 F.2d 639 (Ct. Cl. 1977), and by the federal district court for the District of Columbia with respect to Interior Department operating criteria for a dam that diverts water away from the Indian reservation where it is needed to preserve fish stocks for Indian use, Pyramid Lake Paiute Tribe of Indians v. Morton, 354 F. Supp. 252 (D. D.C. 1973)."

To summarize, the Hupa and Yurok Indians have rights to fish from the Trinity and Klamath Rivers and to adequate water to make their fishing rights meaningful. These rights are tribal assets which the Secretary, as trustee, has an obligation to manage for the benefit of the tribes. The Secretary may not abrogate these rights even if the benefit to a portion of the public from such an abrogation would be greater than the loss to the Indians.

Since 1977 the Department has been regulating Indian fishing on the Hoopa Valley Reservation in order to conserve the fish resources. In 1976, the United States Supreme Court declined to review the decision of a California appellate court in Arnett v. 5 Gill Nets that the State of California could not regulate Indian fishing on the Hoopa Valley Indian Reservation. Because the Yurok Tribe, which shares the reservation with the Hoopa Valley Tribe, has no organized tribal government, tribal regulation of the fishery was not possible. Since neither state nor tribal regulation was possible, the Interior Department used its regulatory authority to assure the preservation of the fishery on which the Indians of that reservation depend. In 1978, efforts to enforce these regulations met with bitter and sometimes violent resistance.

Prosecutions in the Court of Indian Offenses were vigorously defended by lawyers for the Indian fishers. Attorneys challenged the validity of the regulations, citing language in the preamble stating that a major problem affecting the fishery results from the substantial diversions of water from the Trinity River and that "regulation of the Indian fishery will provide only a small degree of protection for this resource." Defense attorneys argued that the Department has a trust obligation to halt other threats to the fishery rather than placing the entire conservation burden on the Indians. The Department decided that immediate action had to be taken with respect to such threats because of their potential to totally destroy the resource in a short time. The Indians were told that regulation of their fishing was needed to give the Department the time it needed to deal with the other problems.

The regulations currently in effect, which were promulgated in March 1979, permit the taking of fish for subsistence and ceremonial purposes, but, because of the decline in the state of the resource, do not permit the taking of fish for commercial purposes. If restoration of the fish habitat results in such increases in fish populations that the ban on commercial fishing can be lifted, then important economic and cultural benefits could be realized by the Hupa and Yurok Tribes (see Section D.5.3 of the EIS). To illustrate the potential economic benefit, the EIS predicts that the proposed action would allow Indians to catch an additional 10,260 salmon per year. Approximately 5,700 to 8,700 would be required to restore the tribes to the level of fish of North Fork Trinity River origin that were historically harvested for subsistence needs. Approximately 1,560 to 4,560 would then be available for commercial purposes. The economic benefits would depend on how the fish were marketed.

Any substantial economic benefits would help to improve the quality of life on the reservation, where unemployment is between 37 and 45 percent and the per capita income is less than half the national average (see Section C.7.4 of the EIS). Perhaps more important than economic benefits would be cultural benefits to the tribes if the fishery is restored. Regardless of whether the ban on commercial fishing is lifted, the fishery could provide for more of the subsistence needs of tribal members. For tribal members faced with the choice of leaving the reservation to gain employment or remaining on the reservation where employment opportunities are few but family and cultural ties are strong, the restoration of the fishery would likely result in more tribal members choosing to stay on the reservation, in effect, practicing “nature banking” as described in the EIS (EIS, p. C7 - 8). If the natural resource base of the reservation substantially contributes to the subsistence needs of tribal members, and if providing for subsistence needs is done in ways which are part of the tribes’ cultural traditions, such as harvesting salmon, then the cultures of the tribes will be more resilient in reacting to outside forces of cultural change.

B. TRINITY RIVER DIVISION

As early as 1931 the water development potential of the upper Trinity River was recognized. Plans for diversions to the Central Valley were formulated as part of the California State Water Plan. With the strong urging of the State of California, the U.S. Bureau of Reclamation (now WPRS) released preliminary plans for development of the river as part of the Central Valley Project (CVP), and in 1955 the Trinity River Division of the CVP was Congressionally authorized (Trinity River Act, P.L. 84 - 386).

The Secretary has authority under the Trinity River Act to mitigate losses of fish resources and habitat and provide for certain downstream water uses. The mandate that the operation of the Division be integrated with other CVP features to achieve the fullest, most beneficial, and most economic use of the developed water is qualified by Section 2, which states:

> “Provided, that the Secretary is authorized and directed to adopt appropriate measures to insure the preservation and propagation of fish and wildlife, including, but not limited to the maintenance of the flow of the Trinity River below the diversion point at not less than one hundred and fifty cubic feet per second for the months of July through November . . .”

Recent opinions of DOI’s Regional Solicitor in Sacramento and earlier reports of the Commissioner of Reclamation acknowledge the mandatory requirement of this proviso. The Secretary has acknowledged this responsibility in the April 18, 1980, memorandum noted earlier.

Construction of the Trinity River Division began in 1956, with water first impounded in 1960. Constructed features include: (1) Trinity Dam (Clair Engle Lake) on the Trinity River - with a capacity of 2.5 million acre-feet; (2) Lewiston Dam (and Reservoir), a flow regulating lake seven miles below Trinity Dam; (3) Trinity River Fish Hatchery immediately downstream from Lewiston Dam; (4) Whiskeytown Dam (and Lake) on Clear Creek, a tributary of the Sacramento River; and (5) two transmountain tunnels and four hydroelectric plants (two each in the Trinity and Sacramento Basins) - with a combined generating capacity of 397,000 kilowatts. (In the EIS, see Plate 2 of Appendix 1 and Section C.2.O.)

Diversions to the Sacramento River Basin commenced in 1963 and full operation began in 1964. Total annual releases downstream from Lewiston Dam were to be a minimum of 120,500 acre-feet, or approximately 10 percent of average annual unimpaired flows. The releases represent approximately 2 percent of the CVP's 8.1 million acre-feet of firm yield.

C. DECLINE OF THE FISHERY

Prior to construction of the Trinity River Division, the Trinity River was recognized as one of California's most famous and accessible fishing streams. Since 1963 when the Trinity River Division was placed into operation, salmon and steelhead runs in the Trinity River system have undergone severe declines: approximately 80 percent in the case of chinook salmon (from 50,000+ spawners to 11,100), and approximately 60 percent for steelhead trout (from 24,000+ to 10,000). This downward trend has occurred despite the provision from the time of project inception of flows to protect prime spawning and rearing habitat in 40 miles of the Trinity River below Lewiston Dam, the primary diversion structure, and the operation of a hatchery to replace 109 miles of upstream spawning and rearing habitat rendered inaccessible by the dam.

Both the quantity and the quality of fish habitat have been significantly diminished since pre-project periods. Temperature and turbidity levels have at times been higher than under pre-project conditions. Sand has filled poo1s and covered "riffles" important for the production of fish. Portions of the riverbed have become compacted and unusable for spawning and provide only limited fish food production. Reduced flows have also allowed the encroachment of riparian vegetation along the channel where it had not previously existed. A current estimate places spawning habitat losses at 80 to 90 percent even though a dozen spawning riffles have been rebuilt by the Trinity River Task Force. Given declines in salmon and steelhead numbers that have occurred since, overall fish habitat has likely declined by a larger proportion. The existing environment (post-project) can be described based on conditions measured by a 1978 flow study, documented in Hoffman, J. (USFWS), Trinity River Instream Flow Study: Final Report to the Task Force (1980). This study measured amounts of "weighted usable habitat" for adult, spawning and juvenile rearing purposes in selected representative study areas. The existing environment represents significant reduction in wetted area, spawning habitat, adult holding habitat, juvenile rearing habitat, increased (adverse) water temperatures at certain times, and decreased attraction and downstream transport flows relative to pre-project conditions.

Abusive logging practices, improper road construction, and floodplain development within the Trinity watershed have also contributed significantly to habitat degradation. Clearcutting has promoted increased sediment loading; removal of streamside vegetation has increased water temperatures; log jams at the mouths of tributary streams have blocked access for fish spawning and rearing. Logging within the basin has necessitated the construction of hundreds of miles of unpaved logging roads and skid trails. The resulting increased yield of sediment in the mainstem Trinity and its tributaries has reduced the biological productivity and fish carrying capacity of the stream.

Sustained high harvest pressure is also believed to have contributed to the decline of the fish runs on the Trinity. The bulk of the chinook salmon harvest occurs in the ocean fishery with commercial trollers accounting for an estimated 68 percent of the harvest and ocean sport fishers taking 20 percent of the fish. The remaining 12 percent are harvested in the river fishery, with Indians taking 10 percent and sport fishers the remaining 2 percent. The steelhead trout fishery is strictly a river fishery which is divided between sport (90 percent) and Indian harvesters (10 percent). The catch-spawning escapement ratio for fall run chinook is on the order of three to one, which means that, on the average, 25 percent of the adults return to spawn. For steelhead trout, it is estimated that perhaps 50 percent of the returning adults are taken.

In developing a stream management plan in this area it should be assumed that good management practices will be utilized regarding the ocean fishery. Data reflect that salmon harvest related to this system has been stable over the last decade, yet salmon populations continue to decline. This and other data has led to the hypothesis that the present declines in chinook salmon are, in the largest part, due to habitat loss and deterioration rather than the long term harvest rates. Therefore, further reduction of ocean harvest rates is not considered an alternative to increasing instream flows. It should also be noted that issues related to the allocation of the harvest between the ocean and Indian fisheries are currently in litigation. The outcome of this litigation will affect the allocation of benefits resulting from any increased flows.

Expanded hatchery operations have been advocated by some as an alternative to increased flow releases. Hatchery expansion could theoretically increase the size of salmonid runs, however, increased flow releases would also be required to provide adequate river conditions for fish passage to and from the Trinity River. Past experience indicates anadromous fish hatcheries and similar facilities in California have generally been unsuccessful in meeting their objectives. The one exception is the Nimbus Hatchery on the lower American River which has had the advantage of near optimal streamflows for rearing and migration since its construction. As sections BI.0 and C4.113 of the EIS notes, the success of the Trinity River Fish Hatchery cannot be positively demonstrated. Other reasons for preferring natural runs over hatchery bred fish are: the frequently devastating losses of young fish in hatcheries due to diseases; the greater genetic diversity maintained in wild stocks, the fact that hatcheries would be species specific (anadromous species) and would not contribute to the general needs of other fish and wildlife species which rely on the Trinity; and hatchery expansion would be inconsistent with Fish and Wildlife Service and California Department of Fish and Game policies which emphasize preservation of natural runs.

To summarize the condition of the fishery, the body of knowledge that has emanated thus far from the Trinity River Task Force has made clear beyond doubt that the decline in salmon and steelhead stocks is due fundamentally to three causative factors, and that the decline will continue toward virtual extirpation of the stocks unless significant corrective measures are applied. The fundamental causes of the fishery decline are excessive streambed sedimentation, inadequately regulated harvest, and insufficient streamflow. Restoration of salmon and steelhead populations to pre-project levels will require alleviation of each of these resource-limited factors. The course of action proposed in the EIS addresses what is believed to be the most critical of the limiting factors, i.e., insufficient streamflow. Restoration of streamflow is a necessary first step in rejuvenation of the fishery (For a thorough discussion of fishery issues, see Sections C.4 and D.5 of the EIS.)

D. TRINITY RIVER BASIN FISH AND WILDLIFE TASK FORCE

A state-federal work group and task force comprised of USBR, USFWS, and the California Department of Fish and Game (CDFG) was formed in 1971 to study more broadly the fish and wildlife problems of the basin. In 1972 funds were provided through the USBR to the CDFG and the USFWS to prepare a plan for identification and mitigation of fish and wildlife problems. Initial physical restoration of spawning areas near Lewiston was carried out in 1972 and 1973 under the auspices of the task force.

Trinity River conditions continued to worsen and in 1974 the public's growing concern regarding the decline of the endangered fishery activated the interest of Congressman Harold T. (Bizz) Johnson, in whose district the project is located. The membership of the Trinity River Basin Fish and Wildlife Task Force (Task Force) was subsequently expanded to develop and implement immediate and long-range restorative actions. Members of this multi-agency committee now included the USBR (i.e. WPRS), CDFG, USFWS, BIA, the California Department of Water Resources (DWR), Trinity County, Humboldt County, Hoopa Valley Business Council, the United States Forest Service (USFS), the United States Bureau of Land Management (BLM), and the United States Soil Conservation Service (SCS). The Task Force was expanded again in 1978 to include the California State Water Resources Control Board (SWRCB) and the National Marine Fisheries Service (NMFS) for a total of 13 entities.

The WPRS is the Task Force's lead agency and receives federal funds to carry out the Trinity River Basin Comprehensive Action Program with the assistance of other members of the Task Force. In Fiscal Year 1975, Congress authorized appropriations of $300,000 as the first part of a $7.6 million program scheduled for eight years. A five-year Interim Action Program was then begun in an effort to stem the further immediate decline of the fish and wildlife resources, while completing formulation of a comprehensive long-term cooperative management program.

Numerous Task Force studies and activities have been conducted, including watershed revegetation to control erosion, mechanical restoration of mainstem riffle and poo1 habitat, tributary stream improvement, hatchery operation assessments, sediment transport and removal studies, and fish population, migration and harvest assessments. In 1978, consultants were contracted to formulate specific management options for inclusion in the fish and wildlife program, to address questions of an institutional nature bearing on the program, and to prepare an overall management plan proposal for the Trinity River Basin. Substantial additional funding and personnel commitments at national, state, and local levels may be required to implement the management plan once it is completed and approved by the Task Force.

Without increased streamflows to improve fishery habitat and fish production, the actions outlined above (regarding land use and fish harvesting) will produce only limited improvements. Since the initiation of project operations in 1964, both CDFG and later the Task Force have made numerous attempts to secure an increase in flow releases down the Trinity River. In response, the minimum annual release of 120,500 acre-feet from Lewiston Reservoir was approximately doubled in 1974 and 1975 as part of a three-year experiment. The experimental release period, interrupted by a severe drought in 1976 and 1977, extended into early 1979. (These releases were extended on a voluntary basis by USBR into early 1980.) In a letter to CDFG dated March 3, 1977, the Regional Director, WPRS stated:

> "It appears that the Secretary (of the DOI) already has authority to provide added fish flows above the 'minimum' provided in the authorizing legislation. The level of flows required should be documented as a part of the Trinity River Basin Fish and Wildlife Action Program. At the same time such documentation of flow needs is satisfactorily completed, the Secretary can make the decision to provide the higher level of flows. I would support such a change in operation to provide those higher flows."

The Task Force, in an effort to provide the prerequisite documentation and complete the formulation of a basin management plan, initiated studies by private consultants (FK and VTN), CDFG, DWR, and USFWS. The USFWS study is the basis for a current flow regime of 286,700 acre - feet implemented in May 1980 and to be in effect through April, 1981 (as established by the Secretary). The FWS study plus the results of the other studies, as completed to date, are the basis of the alternatives considered in the EIS and presented to the Secretary in this SID.

The October 1980 report by Frederiksen, Kamine and Associates (FK) is the most recent of the studies completed for the task force. In its report FK has indicated that the anadromous fisheries of the Trinity River Basin could be restored with the implementation of a 14 - action program which includes increased downstream releases and watershed and habitat restoration efforts. FK recommends two levels of downstream releases, 260,000 acre-feet annually in normal and wet years, and 179,800 acre-feet in dry years. The recommendations which are currently under consideration are not identical to those recommended in the EIS and this SID, however, the 14 - action program including the FK recommendation for increased flows will be valuable to the task force in formulating its management program as well as FWS and WPRS in its assessment of the effectiveness of the flow releases and watershed and habitat restoration studies as detailed in the agreement executed between the two agencies.

E. IMPACTS ON THE CENTRAL VALLEY PROJECT

The Trinity River Division is an integral part of the CVP, and was the first major water development project in northwestern California constructed and operated to export water. Runoff water from the Trinity Basin is stored, regulated, and diverted through a system of dams, reservoirs, tunnels, and powerplants to the Sacramento River for use in water deficient areas of the Central Valley Basin. Currently, about one million acre-feet of water are exported annually from the Trinity Basin. This represents approximately 14 percent of the CVP's "firm yield" water supply of 8.1 million acre-feet. The diverted water supplies total irrigation needs equivalent to about 333,000 acres and approximately 100,000 additional acres through the use of return flows. The affected acreage is in the Sacramento, San Joaquin, and Santa Clara Valleys.

In addition to agricultural benefits, the Trinity Division also supplies a major source of hydroelectric generating capacity. The Trinity Division includes four powerplants which are operated in conjunction with the water demands for irrigation. Power generated is directly related to the demands for project water. Since the greatest diversions are made during the summer months when irrigation needs are greatest, these months also represent the period when maximum amounts of hydroelectric energy are generated. The energy provides "peaking power" to Central Valley users, which include primarily irrigation districts, municipalities, military installations, and other Federal agencies. The average annual generation of the Trinity Division is about 1.1 billion kwh. This compares with an average annual generation of 5.5 billion kwh for the CVP.

A decision to increase flow releases to the Trinity River for fishery conservation purposes reduces the supply of water available for irrigation and power production. The impact of a decrease in agricultural water supply under the various alternatives can be represented in terms of acres which could not be irrigated and corresponding agronomic losses. The range of impacts for the alternatives considered is summarized in the next section of this SID and is thoroughly discussed in Section D.3 of the EIS.

Increased flow releases to the Trinity River would also have a negative impact on CVP power benefits. Every acre foot of water which is diverted from the Trinity River Basin generates 1,100 kwh as the water passes through three powerplants. Approximately that amount of energy would be lost for each additional acre-foot of water released down the Trinity. (The actual loss is somewhat less because the Lewiston Powerplant, with a present 350 kw installed capacity, would generate a small amount of electrical energy as waters were released down the Trinity.)

Additionally, downstream releases during dry or critically dry years would reduce the dependable capacity of the Trinity powerplants. (Dependable capacity is that portion of the powerplant's installed capacity in kilowatts that can be relied upon to meet preference customer loads under adverse hydrologic conditions.) The loss in decreased generation can be expressed in terms of the cost of foreign oil required to replace the lost energy ($33 per barrel, based on April 1980 prices, or the cost of replacing generation through the use of coal, geothermal steam, or banked power transferred to Pacific Gas and Electric Company at times when CVP generation exceeds CVP demand). Because California's utility system is heavily based on oil-fired generation, power lost to Trinity releases would likely be replaced by combustion of oil, at least in the near term. The loss in decreased dependable capacity can be expressed in terms of the costs required to construct a new powerplant to replace the lost dependable capacity. These impacts are summarized in the next section of the SID and are thoroughly discussed in Section D.4 of the EIS.

III. ALTERNATIVES FOR INCREASING RELEASES TO THE TRINITY

As noted earlier in this SID, and as analyzed in the EIS, restoration of streamflow is a necessary first step in rejuvenation of the fishery. A number of other actions should also be taken, such as those recommended in the FK report (Proposed Trinity River Basin Fish and Wildlife Management Program). However, other actions will produce limited benefits without increased releases for streamflows. The draft SID which was circulated on January 8, 1980, led to a decision to prepare an environmental impact statement (EIS) prior to a decision by the Secretary on a permanent commitment of water to be released into the Trinity River to mitigate damage to the fishery. As a result of the scoping process, the options presented in the January 8 draft SID were modified somewhat. The alternatives analyzed in the EIS are as follows:

Alt. 1	120,500 acre-feet annual releases in all years (no action alternative)
Alt. 2	215,000 acre-feet annual releases in all years
Alt. 3a	287,000 acre-feet annual releases in all years
Alt. 3b	287,000 acre-feet annual releases in normal water years with reduction to 120,500 acre-feet in dry and critically dry years.
Alt. 4a	340,000 acre-feet annual release in all years
Alt. 4b	340,000 acre-feet release in normal water years with reduction to 120,500 acre-feet in dry and critically dry years
Alt. 4c	340,000 acre-feet annual release in normal years; 220,000 acre-feet dry years; 140,000 acre-feet critically dry years (identified in the EIS as the proposed action)
Alt. 4d	340,000 acre-feet annual release in all years until "interim water" is exhausted; thereafter, same releases as Alternative 4c

Section B of the EIS explains how these alternatives were developed as well as why other possible alternatives were discarded after initial consideration. Section B also contains a summary of the environmental impacts of each alternative (see pp. B-6 to B-13). These environmental consequences are thoroughly analyzed in Section D of the EIS. A brief summary is presented in this SID.

The FWS-WPRS agreement discussed earlier in this SID is in effect a modification of Alternative 4c, as follows:

Modified Alt. 4c. WPRS will allocate CVP yield so that releases can be maintained at 340,000 acre-feet annually in normal years. FWS will prepare a detailed study plan to assess the results of habitat and watershed restoration. Prior to completion of the plan, releases will be 287,000 acre-feet. Releases will be incrementally increased to 340,000 acre-feet as habitat and watershed restoration measures are implemented. In dry years, releases will be 220,000 acre-feet; 140,000 acre-feet in critically dry years.

The principal differences between the modified 4c and the original 4c is that in the modified version: (1) releases of more than 287,000 acre-feet in normal years would be conditioned on habitat and watershed improvements; and (2) the success of restoration efforts, including increased releases for streamflows, would be reviewed following a 12 year study period. All of the other alternatives, except no action, would involve an ongoing evaluation effort, but only the modified 4c specifies a time frame for the evaluation.

Increasing flow releases to the Trinity River would generally result in favorable environmental, social, and economic impacts in the Trinity River Basin. The primary effect of the proposed course of action, when coupled with an intensive streambed, watershed, and harvest management program, would be restoration of the anadromous fishery to levels approaching pre-project conditions.

A relative value index for habitat is useful for purposes of explaining the different impacts of the various alternatives on fish habitat. This approach must be exercised with caution, however, because of assumptions which must be made concerning the relationship among streamflows, habitat, and fish production. One of the assumptions used in developing this relative habitat index is that there is a direct linear relationship between flow and fish habitat and between fish production and fish habitat within the range of releases from 120,500 acre-feet to 340,000 acre-feet (see Section D5.211 in the EIS). Fishery habitat values, spawning run sizes, and partial increased economic values were estimated for each of the alternatives. These figures are shown in the table below.

Table 1
Chinook Salmon and Steelhead Trout Spawning
Escapement under Alternative Trinity Flow Releases

Alt.	Average Annual Release (ac-ft)	Relative Habitat Index Value	Chinook Salmon Spawning Escapement	Steelhead Spawning Escapement
1	120,500	.20	11,000	10,000
2	215,000	.54	32,100	17,600
3a	287,000	.81	42,600	21,300
3b	245,000	.65	36,400	19,100
4a*	340,000	1.00	50,000	24,000
4b	285,000	.80	42,200	21,200
4c	308,000	.88	45,300	22,800
4d	308,000	.88	45,300	22,800

*Spawning escapement predicted to be restored to estimated minimum pre-project levels based on Hoffman (USFWS), Trinity River Instream Flow Study (1980).

Salmon provides one-third of the economic value of the California commercial fishery and the North Coast constitutes the heart of this industry. Chinook salmon also help maintain an important sport fishery off the northern California coast. In addition, chinook salmon and steelhead trout represent the major contributors to the Trinity River sport fishery and are the heart of the Indian fishery. Restoration of this resource would benefit each of these major user groups.

The partial economic values for chinook salmon and steelhead trout fisheries attributable to the alternatives are displayed in the table below.

Table 2
Annual Net Increase in Economic Value of Trinity River
Chinook Salmon and Steelhead Trout Fishery
(millions of dollars) under Various Alternatives

Alternatives	Chinook Salmon	Steelhead	Total	Compensation b/
1 [a]	-0-	-0-	-0-	-0-
2	1.6	1.2	2.8	8.4
3a	2.3	1.8	4.1	12.3
3b	1.8	1.4	3.2	9.6
4a	2.9	2.2	5.1	15.3
4b	2.3	1.8	4.1	12.3
4c	2.5	2.0	4.5	13.5
4d	2.5	2.0	4.5	13.5

a/ The existing salmon fishery is valued at 0.8 million dollars and the steelhead fishery at 1.6 million dollars.

b/ The "willingness to pay" approach is useful in expressing the value of added commodities or uses. However, a different approach - "willingness to sell" - is needed to estimate the loss when a user is being asked to give up a commodity or use. For this SID, compensatory values are assumed to be three times the value that users are willing to pay.

Increasing flow releases to the Trinity River would also result in improved water quality in the mainstem downstream of Lewiston Dam and increased use of the Trinity River by recreationists engaging in fishing (other than for salmon and steelhead), swimming, canoeing, and whitewater rafting. Increased opportunity for whitewater rafting would afford a major recreational attraction. The best whitewater conditions occur in the early spring when heavy runoff enters the mainstem from tributaries; the release of higher flows from Lewiston Reservoir would extend the rafting season into the summer.

Increased fish numbers and fishing, better water quality, and increased recreation opportunities, would greatly benefit the tourism and recreational - support industries, a main source of income in both Trinity and Humboldt Counties.

Restoration of the anadromous fish runs, in addition to the economic benefits shown, would significantly benefit the Hupa and Yurok peoples who depend upon salmon and steelhead for their ceremonial and subsistence needs, as well as for commercial purposes.

The data presented in Table 1 indicate for each alternative, the probability that the fishery will recover to near project levels. The data in Table 2 indicate the economic benefits projected for each alternative. Tables 3 and 4 below, present data on the impacts on CVP water and power users. It might be noted that, as a result of the analysis conducted in preparing the EIS, the figures on agricultural impacts have changed substantially since the distribution of the previous SID on January 8, 1980.

Table 3 summarizes the analysis of projected agricultural economic losses, due to land which could not be irrigated, assuming that water conservation or alternative sources of water are not utilized to bring the land into production. Until the year 2000, there would be no specific Impacts on CVP water users during normal and dry water years under any of the alternatives, i.e., up to 340,000 acre-feet. During critically dry water years, all the alternatives would require placing deficiencies on water users; however, all water users or groups of users would share the deficiency. The deficiencies can be imposed under existing contracts. However, the situation will change when the ultimate requirements of project water users are to be met, beginning in the years 2000 - 2020. At that time, the deficiency criteria in water service contracts will need to be revised to reflect the impact on project yield if these releases continue at this level. (This assumes no construction of new facilities and a meeting of D -1485 requirements.)

The net values associated with land not developed under each of the eight alternatives range from 0 to 4.1 million dollars annually, assuming that lands of average value per acre are not developed for agricultural production, or, alternatively, from 0 to 1.0 million dollars annually, assuming that lands generating the lowest income (irrigated pasture) are not developed. The ranges of value are displayed below. (Note: figures incorporate agricultural costs resulting from non-development of agricultural return flows of 17.5 percent.)

Table 3
Agronomic Losses in the Year 2020 Associated with Implementation of Alternative Flow. Releases

		Net Agronomic Value	
Alt.	Forgone (acres)	Average Value (millions of $'s)	Lowest Value (millions of $'s)
1	- 0 -	- 0 -	-0-
2	45,000	2.0	0.5
3a	79,000	3.4	0.9
3b	22,000	0.9	0.2
4a	95,600	4.1	1.0
4b	28,300	1.2	0.3
4c	42,300	1.8	0.5
4d	42,300	1.8	0.5

It should be noted when considering the loss figures indicated above that no residual value is assigned to lands not put into production. There is no way of predicting the uses that such lands would be put to and therefore no way of quantifying their residual value. However, some residual value would exist that would reduce the net losses described above.

Table 4 presents, data on the costs of replacing power losses, to both average annual generation and project dependable capacity.

Table 4
Power Losses Associated with Implementation of Alternative Flow Releases (millions of dollars)

Alt.	Oil	Coal	Geothermal	Banked Power
1	- 0 -	- 0 -	- 0 -	- 0 -
2	7.0	5.1	3.6	3.1
3	12.2	9.1	6.4	5.6
3b	7.7	5.4	3.4	2.8
4a	16.2	12.1	8.6	7.4
4b	10.2	7.1	4.5	3.6
4c	11.3	7.9	5.0	4.1
4d	11.3	7.9	5.0	4.1

Some additional consequences (positive and negative) of the proposed action on the Central Valley Basin are not amenable to quantification. On the negative side is a reduction in the volume of Trinity River water entering the Sacramento River and thus potentially available for: (1) cooling Sacramento River water which tends in the late summer to fall to exceed the upper limit of the optimum range for salmon spawning, egg incubation and rearing; and (2) reducing the Sacramento River flow releases from Shasta Lake required for diluting high concentrations of copper and zinc in flows emanating from Spring Creek, a Sacramento tributary (it is anticipated that entry of these pollutants into Spring Creek from mining operations will ultimately need to be controlled through Implementation of the Clean Water Act). On the positive side, the reduction in the amount of colder Trinity River water flowing down the Sacramento River in spring could be a benefit since Sacramento River water temperatures tend to be below optimal for salmon at that time. Some additional minor benefit would accrue to reduced pumping in the Sacramento - San Joaquin Delta, where pumping operations of the CVP and the State Water Project have had massive adverse impacts on both fish and wildlife.

It is to be noted that for the purpose of judging the economic merit of the proposed course of action, application of the traditional benefit/cost analysis to the resource problem addressed in this EIS is not appropriate. Providing greater flows to the Trinity River below Lewiston Dam would be a loss - compensation measure, which is a feature of the Trinity River Division, not subject to a separate benefit/cost analysis. Moreover, as observed at the outset, there are responsibilities arising from congressional enactments, which are augmented by the federal trust responsibility to the Hupa and Yurok tribes, that compel restoration of the river's salmon and steelhead resources to pre-project levels.

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APPENDIX B

Agreement Between USFWS and WPRS

Agreement Between the
U.S. Fish and Wildlife Service
and the
Water and Power Resources Service
for
Implementing and Evaluating Increased Stream flows
for the Trinity Division,
Central Valley Project, California

This agreement is intended to affirm the commitment of the Fish and Wildlife Service (FWS) and the Water and Power Resources Service (WPRS) to work cooperatively to halt further fishery declines and to begin effective restoration in the Trinity River. It is consistent with the congressional intent in authorizing the Trinity River Division, Central Valley Project (CVP), California.

This agreement together with the Environmental Impact Statement (EIS) on the management of Trinity River flows is available for consideration by the Secretary in reaching a decision on Trinity River flows. This agreement is developed in recognition and support of the Trinity River Basin Fish and Wildlife Task Force (Task Force) and its goals and objectives of restoration of salmon and steelhead resources in the Trinity River Basin. It reflects a recognition that although it would be desirable to sustain environmental values through high releases to the Trinity River in all years, there are compelling needs and uses outside of the basin for water and power which require a reasonable compromise between water export and instream releases - especially in water-short years. It is suspected that the flows to be released in dry and critically dry years may be insufficient to support desirable levels of salmon and steelhead habitat. However, the flows to be allocated for dry and critically dry years will help to allow habitat below Lewiston Dam to be maintained at levels at least comparable to those which would have existed during dry and critically dry years in the absence of the project. FWS will carefully assess the flows provided under this agreement to determine their effectiveness in maintaining favorable Instream habitat conditions, and will also determine what management options are available for compensating for temporary reductions in fishery habitat during dry and critically dry years.

Therefore, it is mutually agreed as follows:

(1) WPRS will allocate CVP yield so the releases below Lewiston Dam for fishery preservation and propagation can be maintained at 340,000 acre-feet annually in all but dry z and critically dry water years when the release shall be 220,000 and 140,000 acre-feet, respectively. Dry and critically dry years will be based on Shasta Lake inflow.

Critically dry years shall mean any year in which either of the following conditions exists:

(a) The forecasted natural inflow to Shasta Lake for the current year is equal to or less than three million two hundred thousand (3,200,000)

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acre-feet as such forecast is made by WPRS on or before February 15 and reviewed as frequently thereafter as conditions and information warrant or

(b) The total accumulated actual deficiencies below four million (4,000,000) acre-feet in the prior water year or series of successive prior water years each of which has inflows of less than four million (4,000,000) acre-feet, together with the forecasted deficiency for the current water year, exceed eight hundred thousand (800,000) acre-feet.

Dry years shall mean any year that the forecasted natural inflow to Shasta Lake is less than four million (4,000,000) acre-feet and neither of the above conditions exists.

These definitions are consistent with the definitions used in the CVP power contract with Pacific Gas and Electric Company and many of the CVP water service contracts. Applying these definitions to the past 69 years of record would result in 12 percent of the years being defined dry and 9 percent being defined as critically dry years.

(2) During the first 12 years of these revised flow releases, the schedule of flows within any year shall be provided to WPRS by FWS in consultation with the California Department of Fish and Game (Fish and Game). FWS will evaluate the releases to determine how well they affect the propagation of fish consistent with fishery restoration objectives.

(3) At the end of 12 years following adoption and implementation of this agreement, FWS, after consultation with WPRS and Fish and Game, will submit a report to the Secretary, summarizing the effectiveness of restoration of flows and other measures including intensive stream and watershed management programs in rebuilding Trinity River salmon and steelhead stocks. The report will specifically address the adequacy of habitat at 140,000, 220,000, and 287,000 acre-feet annual release levels for all water year types and the need to maintain, increase or decrease the full 340,000 acre-feet CVP yield allocation. Recommendations concerning what measures should be continued, eliminated, or implemented to maintain compensation for fishery impacts attributable to the Trinity River Division will also be included. The report may also address the possible rescheduling of the allocated CVP yield by water year type and other measures necessary to better maintain favorable instream habitat conditions.

(4) The completion of a Fish and Wildlife Management Plan by the Task Force and its implementation is integral to successful restoration of the anadromous resources of the Trinity River Basin. FWS and WPRS will continue to work with the Task Force in completing the plan and assuring its successful implementation.

(5) FWS in consultation with WPRS and the Task Force will prepare, during the first year after adoption and implementation of this agreement, a detailed study plan to assess the results of the habitat and watershed restoration efforts as required in (3) above. Until the study plan is completed and approved by the Director, FWS, and the FWS is in a position to implement the study, fishery releases to the Trinity shall not exceed 287,000 acre-feet in any normal year. As instream and watershed management measures are put in place, flows will be incrementally increased up to a maximum of 340,000 acre-feet, both to sustain those measures and to facilitate the evaluation.

Director, Fish and Wildlife Service

DEC 29 1980

Date

Commissioner - Water and Power Resources Service

12/30/80

Date

Approved:

Secretary of the Interior

1-14-81

Date

UNITED STATES GOVERNMENT

memorandum

DATE: JAN 16, 1981

REPLY TO ATTN OF: Commissioner of Indian Affairs

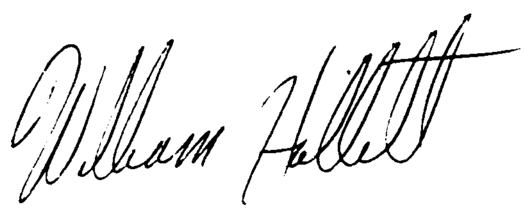
SUBJECT: Amendment to the Agreement Between the Fish and Wildlife Service and the Water and Power Resources Service Regarding Trinity River Streamflows.

TO: Commissioner, Water and Power Resources Service
Director, Fish and Wildlife Service

On January 14, 1981, the Secretary acted on the Secretarial Issue Document on Trinity River Fishery Mitigation, selecting alternative 4c, which had been recommended by all the Assistant Secretaries involved in this issue. On that date, the Secretary also approved the agreement between FWS and WPRS.

In order to provide for the ongoing involvement of the Bureau of Indian affairs and the Hoopa Valley Business Council in the implementation of this decision, I am requesting your approval of the attached amendment to the agreement. This amendment provides that FWS, in developing the annual schedule of flow releases and in preparing the report to the Secretary, will include both the BIA and the Hoopa Valley Business Council in the consultation which the agreement specifies is to include WPRS and the California Department of Fish and Game.

Your approval of this amendment would be appreciated.



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Amendment to the Agreement
Between the
U.S. Fish and Wildlife Service
and the
Water and Power Resources Services
for
Implementing and Evaluating Increased Stream Flows
for the Trinity Division
Central Valley Project, California

This is an amendment to the agreement signed by the Director, Fish and Wildlife Service on December 29, 1980, and the Commissioner - Water and Power Resources Service on December 30, 1980, and approved by the Secretary of the Interior on January 14, 1981. Pursuant to this amendment, the consultation required by paragraphs (2) and (3) of the Agreement shall be expanded to include the Bureau of Indian Affairs.

Lynn A. Greenwalt	R. Keith Higginson
Director, Fish and Wildlife Service	Commissioner - Water and Power Resources Service
01-19-81	1/19/81
Date	Date

APPENDIX C

1991 Secretarial Decision

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

MAY 8, 1991

Memorandum

To: Secretary

From: Assistant Secretary - Fish and Wildlife and Parks
Assistant Secretary - Indian Affairs
Assistant Secretary - Water and Sciences

Subject: Trinity River Flows

By copy of your July 13, 1990, letter to the Hoopa Valley Tribe, you directed the Assistant Secretary for Fish and Wildlife and Parks to conduct a review of Trinity River flows that are currently governed by the 1981 Secretarial Issue Document. During the past 9 months, the Assistant Secretaries for Water and Sciences, Indian Affairs, and Fish and Wildlife and Parks have worked diligently to reach a consensus concerning flow requirements for the Trinity River. This memorandum and the attached Position Statement contain our recommendation on this issue.

We recommend that, during the period of 1992 through 1996, flow releases into the Trinity River be at least 340,000 acre-feet (AF) for each dry or, wetter water year and 340,000 AF in each critically dry year if at all possible. We further recommend that between 240,000 AF and 340,000 AF be released into the Trinity River in 1991 depending on the ramping formula contained in the attached position statement. The 1991 flow releases will be accomplished under Central Valley Project hardship provisions. A prompt decision is critical since reduced flows will go into effect in early May, 1991.

The attached Position Statement provides a detailed summary of the major legal, biological, and administrative factors that support our decision. Briefly, fishery needs, the Department's trust responsibility to the Hoopa Valley and Yurok Tribes, the biological integrity of the U.S. Fish and Wildlife Service's 12 year Trinity River Flow Evaluation, the needs of the Restoration Project, and the comprehensive administrative record concerning Trinity River flow requirements support our recommendation to increase flow releases into the Trinity River.

Constance B. Harriman
Assistant Secretary
for Fish and Wildlife
and Parks

Eddie F. Brown
Assistant Secretary
for Indian Affairs

Assistant Secretary
for Water and Sciences

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TRINITY RIVER FLOWS

The Bureau of Reclamation is directed to release into the Trinity River in 1991 between 240,000 AF and 340,000 AF depending on the inflow to Shasta Reservoir and using the ramping formula contained in the attached position statement. The Bureau of Reclamation is also directed to release into the Trinity River, during water years 1992 through 1996, at least 340,000 AF for each dry or wetter water year and 340,000 AF in each critically dry year if at all possible. The Assistant Secretaries for Fish and Wildlife and Parks, Indian Affairs, and Water and Sciences are directed to formalize the 1992 through 1996 flow release agreement by December 1, 1991.

Secretary of the Interior

Attachment

Date: May 8, 1991

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REVIEW OF TRINITY RIVER FLOWS

POSITION STATEMENT
of the
Assistant Secretary for Fish and Wildlife and Parks
the
Assistant Secretary for Indian Affairs
and the
Assistant Secretary for Water and Sciences

ISSUE: The adequacy of fishery flow releases from Departmental reservoirs into the Trinity River, California

BACKGROUND:

- The Trinity River Division of the Central Valley Irrigation Project was completed by the Bureau of Reclamation (Bureau) in 1963, leading to an 80% decline in salmon and steelhead production from the Trinity River. This project reduced average stream flows from 1,200,000 acre-feet (AF) per year to 120,000 AF per year.

- The Hoopa Valley and Yurok Tribes rely on the harvest of anadromous salmonids produced in the Trinity River for subsistence, ceremonial, religious, and commercial purposes.

- The Service estimates that the economic impact of the Trinity River Division and other sources on the non-Tribal commercial and sport fisheries that rely on Trinity River salmon and steelhead has been in excess of 20 million dollars per year.

- In 1981 the Secretary of the Interior signed a Secretarial Issue Document (SID) directing the Bureau to implement the following schedule for flow releases into the Trinity River: 340, 000 AF during normal or wet water years (Shasta Reservoir inflow of at least 4,000,000 AF): 220,000 AF during dry water years (Shasta Reservoir inflow of between 3,200,000 AF and 4,000,000 AF); and 140, 000 AF during critically dry water years (Shasta Reservoir inflow of less than 3,200,000 AF).

- The SID also directs the Fish and Wildlife Service (Service) to evaluate these flows during a 12- year period (the evaluation began in 1985) to determine their efficacy in restoring the Trinity River fishery and to make long-term flow recommendations. Available hydrologic information indicated that 2 of the 12 years during the evaluation would be sub-normal water years. During the first 6 years of the flow evaluation (1986-1990), 5 years were designated as dry.

- An Environmental Impact Statement regarding the management of flows in the Trinity River was prepared in 1981. Information available in 1981 indicated that flow releases of 340,000 AF per year, combined with extensive streambed and watershed rehabilitation, would provide for full restoration of fish populations.

- In 1984, Congress passed the Trinity River Restoration Act directing the Department to fully restore the Trinity River fishery using such measures as erosion control, channel modification, harvest control, and hatchery modernization to augment flow modification. The Bureau and the Service began jointly implementing the Restoration Program in 1986.

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- The Hoopa Tribe filed an administrative appeal in 1988 seeking Secretarial intervention to resolve the Trinity River flow issue.
- The Hoopa Valley Tribe asserts that a minimum of 340,000 AF per year is required to attain fishery restoration and to meet the Secretary's trust responsibility.
- In July, 1990, Secretary Lujan asked A/S FWP to review Trinity River flows and the need for supplemental documentation if flows are altered.

STATUS

- SID-prescribed flow releases have been inadequate to sustain, much less restore fish production in the Trinity River. After peaking in 1986 due in large part to drastically curtailing harvest, fish populations have steadily declined to levels approximating pre-1981 levels.
- The Service has released preliminary results indicating that 340,000 AF provides 56% of optimum habitat , not 100% as had previously been postulated (240,000 AF provides 34% and 14,000 AF provides 15%). Even with full implementation of the Restoration Program, 340,000 AF would provide only 80% of needed habitat.
- In addition to adversely impacting fish habitat, SID-prescribed flows during this prolonged drought have resulted in poor migration survival of fish, have curtailed the anticipated flow related restoration of stream morphology, and have precluded the orderly progress of the flow evaluation and the Restoration Program.
- The Service has determined that SID-prescribed flows for sub-normal water years will not allow for the restoration and evaluation of the Trinity river fishery resources.
- The Bureau of Indian Affairs takes the position that the Secretary is authorized and required to manage the Trinity River fishery with the trust obligations of the United States, as reflected in their April 3, 1991, memorandum to the Commissioner of the Bureau.
- 1991 has been designated as a critically dry water year in Northern California. The April forecast of annual inflow to Shasta Lake is at 2,900,000 AF at the 90% exceedence level.
- The allocation of Trinity River salmon for commercial, sport, and tribal purposes has reached crisis proportion for 1991: minimum escapement levels may not be reached; tribal commercial fishing will not be allowed and subsistence fishing will be at emergency subsistence levels; in-river sport fishing may be prohibited; and ocean fishing will be at the lowest rate in recent history.
- The Sierra Club petitioned the National Marine Fisheries Service (NMFS) to force the Bureau to consult with NMFS regarding the operation of the CVP as it pertains to the threatened Sacramento winter chinook. The ongoing consultation is expected to culminate in the issuance of a Biological Opinion by December 1991.

- Water diverted from the Trinity River to the Sacramento River can only minimally influence the management of the threatened Sacramento River winter chinook due to the relative small quantity of water diverted, the physical constraints on diversion rate, and because it is significantly warmed during the diversion from Trinity Lake through Lewiston, Whiskeytown and Keswick Lakes. The Bureau's April 17, 1991, preliminary CVP operations analysis showed that decreasing Trinity River diversion to the Sacramento River by 100,000 AF would only increase Sacramento river temperatures by 0.1 degrees Fahrenheit (from 64.0 to 64.1 degrees in August). The target temperature for protecting winter chinook is 56 degrees.

- The Bureau has also been asked to consult with the Service regarding CVP operations in relation to endangered bald eagles at Trinity Lake. The Service's draft biological opinion states that 1991 CVP operations are not likely to jeopardize the continued existence of the bald eagle. In the opinion, the Service has not placed any criteria on flow releases or reservoir pool elevations for 1991.

- The Bureau has identified four scenarios for providing additional water to the Trinity River. Two of the flow releases scenarios for increasing 240,000 AF to 340,000 AF in 1991 would not impact winter chinook.

- The original Environmental Impact Statement (EIS) on managing Trinity River flows and the January 1991 tiered Environmental Assessment appear to provide the needed documentation under the National Environmental Policy Act for Secretary to make an informed decision. All of the alternatives being considered in the review fall within the original scope of the 1981 EIS. The Secretary also has the authority to revise Trinity River flows pending completion of additional environmental documentation if it is needed.

- Congress has submitted legislative report language (House Repot102-21, Part 1) related to the Emergency Drought Relief Act (H. R. 355) recommending that 340,000 AF be released into the Trinity River in 1991 and future years as a measure of fulfilling the Government's trust responsibilities to the Hoopa Valley Tribe.

POSITION OF MAJOR CONSTITUENTS

- The Trinity River Task Force, comprised of 14 agencies/groups including the Service, Bureau, Bureau of Indian Affairs, and the Hoopa Valley Tribe, unanimously recommended that the Secretary release 340,000 AF into the Trinity River in 1991 if at all possible.

- Congressmen Riggs (CA) has written to the Secretary recommending that 340,000 AF be released into the Trinity River during 1991.

- The Hoopa Valley Tribe has filed an administrative appeal for the release of 340,000 AF or more during 1991 and during the balance of the flow evaluation period.

- The Klamath River Restoration Task Force recommends that 340,000 AF be released into the Trinity River during the remainder of the flow evaluation period.

- The Klamath Fishery Management Council, Trinity County (county of origin for Trinity River water), Humboldt County, and various commercial and sport fishing groups all support 340,000 AF.

- Numerous Irrigation Districts and CVP power users have stated that SID-prescribed flows for the Trinity River should not be exceeded without adequate NEPA review.

DEPARTMENTAL REVIEW:

- A Departmental review team comprised of representatives from the Service, Bureau, and Bureau of Indian Affairs has been working extensively since October, 1990 to develop a consensus recommendation for Trinity River flows. The team recommends that:

  - for water year 1991 the following criteria be used to determine flow releases: 1) if the most up-to-date forecast (not to extend beyond the June 1 forecast) for projected inflow to Shasta Reservoir equals or exceeds 3,200,000 AF, releases into Trinity River should not be less than 340,000 AF; 3) if the most up-to-date forecast (not to extend beyond the June 1 forecast) for projected inflow to Shasta Reservoir is between 2,900,000 AF and 3,200,000 AF, flow releases into Trinity River should be based on the ramping formula:

    $$TR = (SI \div 3) - 726{,}667$$

    Where: TR = Trinity River Release in AF
    SI = Shasta Reservoir Inflow in AF

    and, 3) if the forecast for inflow to Shasta Reservoir is less than or equal to 2,900,000 AF, releases into Trinity River should not be less than 240,000 AF.

  - for water years 1992-1996: at least 340,000 AF should be released into the Trinity River in dry or wetter years (i.e. when inflow to Shasta Reservoir is equal to or greater than 3,200,000 AF)., and at least 340,000 AF should be released into the Trinity River in critically dry years if at all possible. "If at all possible" means if the water is physically available and can be released into the Trinity River consistent with existing Federal Statutes and Regulations.

- If the Secretary does not take an action on this matter, the existing SID prescribes that 140,000 AF will be released into the Trinity River in 1991. This flow would lead to further declines in Trinity River fish production and would further hamper restoration and evaluation efforts.

- If flow changes are to be made for 1991, the decision is needed by early May 1991. The most critical component of the annual flow regime is the May flows needed to protect migrating juvenile fish.

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APPENDIX D

Chinook Salmon Run Size Review

CH2MHILL

MEMORANDUM

TO: **Mark Hampton, USFWS, Weaverville, CA.**

FROM: **Tim Hammaker, CH2MHill, Redding CA.**

DATE: **March 26, 1995**

SUBJECT: **Chinook Salmon Run Size Review**

PROJECT: **SWW33785.36.TH**

The attached tables provide a summary of the historic chinook salmon data reviewed in regards to Trinity River run sizes. Table D-1 summarizes the various pre-Trinity Division Project run-size estimates. There was no attempt to account for historic angler harvest and Indian harvest as these numbers are not generally available. In order to standardize for pre and post-dam run information spawning escapement estimates were chosen for comparison. These estimates include adults and grilse as the original authors generally did not separate these components. The literature revels that spawning estimates/run size estimates were conducted by several authors for the years: 1944, 1945, 1955, and 1956. These estimates are seen in bold on attached Table D-1. Moffett and Smith (1950) also provided an anecdotal reference to an estimate of 15,000 chinook salmon which passed above Lewiston for the year 1946. This estimate was also included in Table D-1 for a summary of spawning escapements above Lewiston. Fredriksen, Kamine and Associates (1980) expanded Moffett and Smith's (1950) estimated 1944 and 1945 estimated escapements to derive escapements for Trinity River downstream of Lewiston for those years. The original estimated spawning escapements have been reported, revised, and otherwise modified over the years as shown in the additional references shown in Table D-1. For the summary of pre-project estimated spawning escapements the original estimate or what appears to be a reasonable expansion of the original estimates were used to provide a "pre-dam" mean spawning escapement.

From Table D-1 it is estimated that the "pre-dam" spawning escapement, based on the four "good" estimates, ranged from 19,000 to 67,115 with a mean of 38,154 natural spawning chinook salmon above the North Fork. Of this total, the estimated spawning escapement above Lewiston ranged from 9,000 to 36,913 with a mean of 18,432 chinook salmon. The estimate for chinook salmon below Lewiston ranged from 10,000 to 30,134 natural spawners with a mean of 18,834. The authors of the historic spawning estimates generally agreed that approximately 50% of the chinook run spawned above Lewiston.

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Table D-2 provides a summary of the "post-dam" spawning escapements for chinook salmon. The 1963 estimate by LaFaunce (1965) is probably one of the better estimates for the Trinity for the years immediately following the construction of the dams. However the estimate for 1963 would have included salmon from the 1960 and 1961 brood years which would have been affected by the construction of the dams. While the 1963 estimate is included in the summary for the "post-dam" spawning estimates, this number may slightly inflate the estimate for chinook salmon below the dams for years subsequent to construction. Other spawning estimates used in the "post-dam" summary include 1968, 1969, 1971, 1973 made by various authors prior to CDFG's Klamath Basin fall chinook salmon spawner escapement estimates which began in 1978. The CDFG estimates were also included in the Summary Table D-2 to provide an average estimated total spawning escapement (including grilse) for the river for the post-dam interval. Those values used to summarize the spawning escapement in Table D-2 are shown in bold.

The "post-dam" spawning escapement summary indicates that the Trinity River downstream of Lewiston had an estimated range of 5,249 to 113,007 with a mean of 27,650 chinook salmon for the years 1963 through 1994. However, based on estimates of Trinity River Hatchery (TRH) origin coded wire tagged chinook salmon carcasses recovered from inriver, for the years 1992 and 1994, and 1987, a very significant hatchery component of inriver spawners can be demonstrated. For the years of 1992, 1993, and 1994 CDFG's preliminary estimates of the proportion of TRH origin spawners were 32.8%, 14.3%, and 54.2% of the basin run size respectively. Coupled with an estimate of TRH origin spawners of 59% of inriver spawners for 1987 (M. Hampton, USFWS, pers. comm.) indications are that a significant number of inriver spawners are of hatchery origin.

Using the mean proportion of these TRH origin estimated spawners (32.8%, 54.2% and 59% = mean of 48.6%) an adjustment was made for the post-dam spawning escapement estimate (including grilse). CDFG's estimate of proportion of TRH origin spawners for 1993 (14.3%) was not used for the "adjustment" as this number reflected a severe IHN outbreak in the hatchery which resulted in a release of only 650,000 fall chinook smolts for that year class. This adjustment is shown on Table D-2 as the final row in that table. The "adjusted" natural inriver spawning escapement ranges from 2,551 to 54,921 with a mean of 13,465 chinook salmon for the period from 1963 to the present. Comparing that mean estimate of approximately 13,000 native spawners to the estimated mean pre-dam estimated spawning escapement below Lewiston of approximately 19,000 spawners (Table D-1) it appears that the "post-dam" average has averaged approximately 68% of historic numbers. While these averages may be simplistic it does indicate that generally speaking spawning escapement in the Trinity River below Lewiston has not been as great as that for the same reach prior to construction of the dams when accounting for the TR Hatchery component of inriver spawning.

Additional Tables are enclosed which summarize the CDFG's "Mega Table" for the years 1978 through 1994. Figure D-3 (graph) shows the "un-adjusted" in basin run and the "adjusted" run estimate using the TRH origin adjustment factor described above. Please note that this chart shows an adjusted in basin run-size which takes the Trinity inriver spawning escapement added to the angler harvest and then adjusts this term by the 48.8% estimated TRH proportion of the inriver run. Other Charts are self-explanatory and are from the "Mega Table". At the present time I have not completed review of the coho salmon and steelhead historic run sizes.

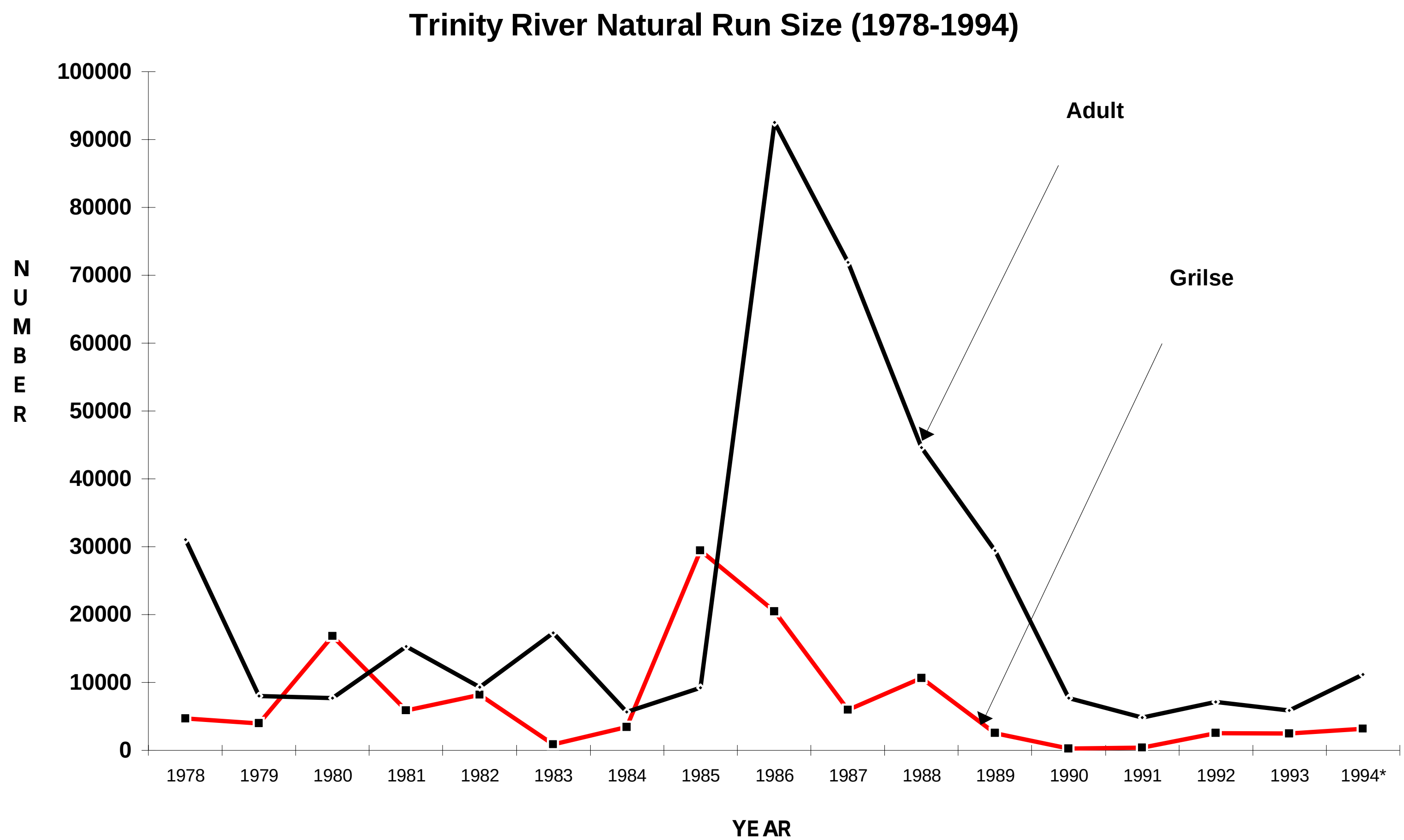

Figure D-1. Trinity River Natural Run Size (1978-1994)

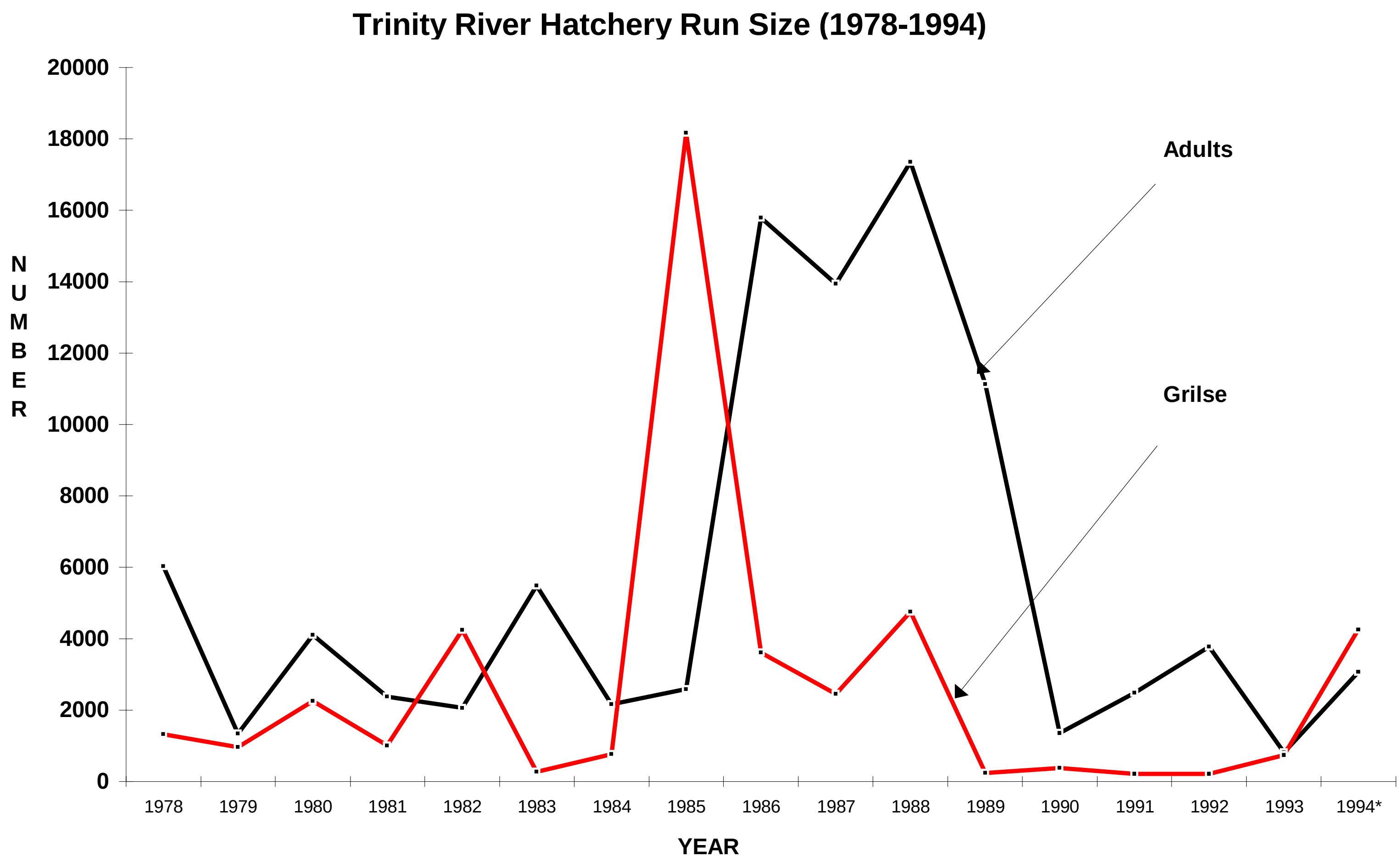

Figure D-2. Trinity River Hatchery Run Size (1978-1994)

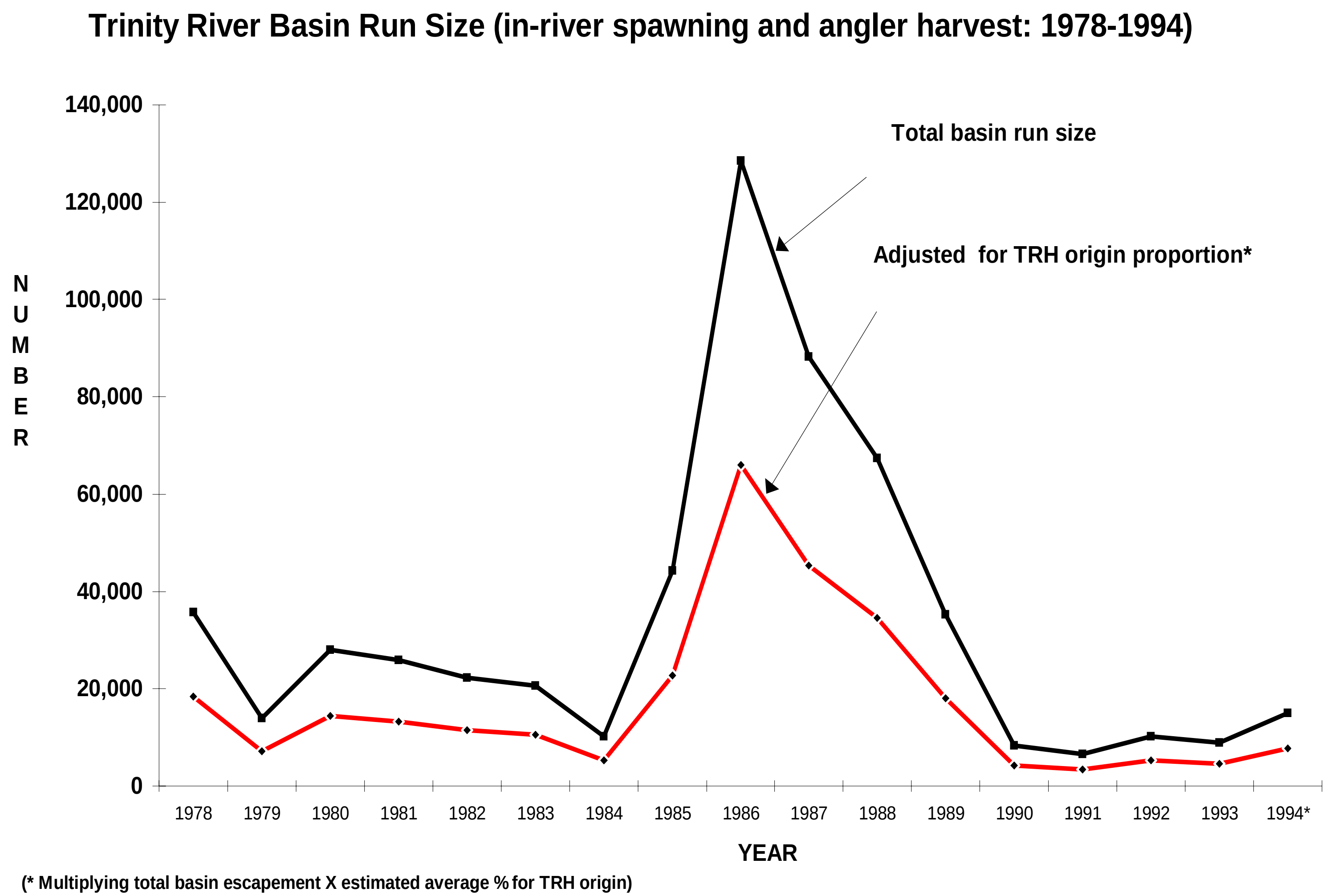

Figure D-3. Trinity River Basin Run Size (in-river spawning and angler harvest: 1978-1994)

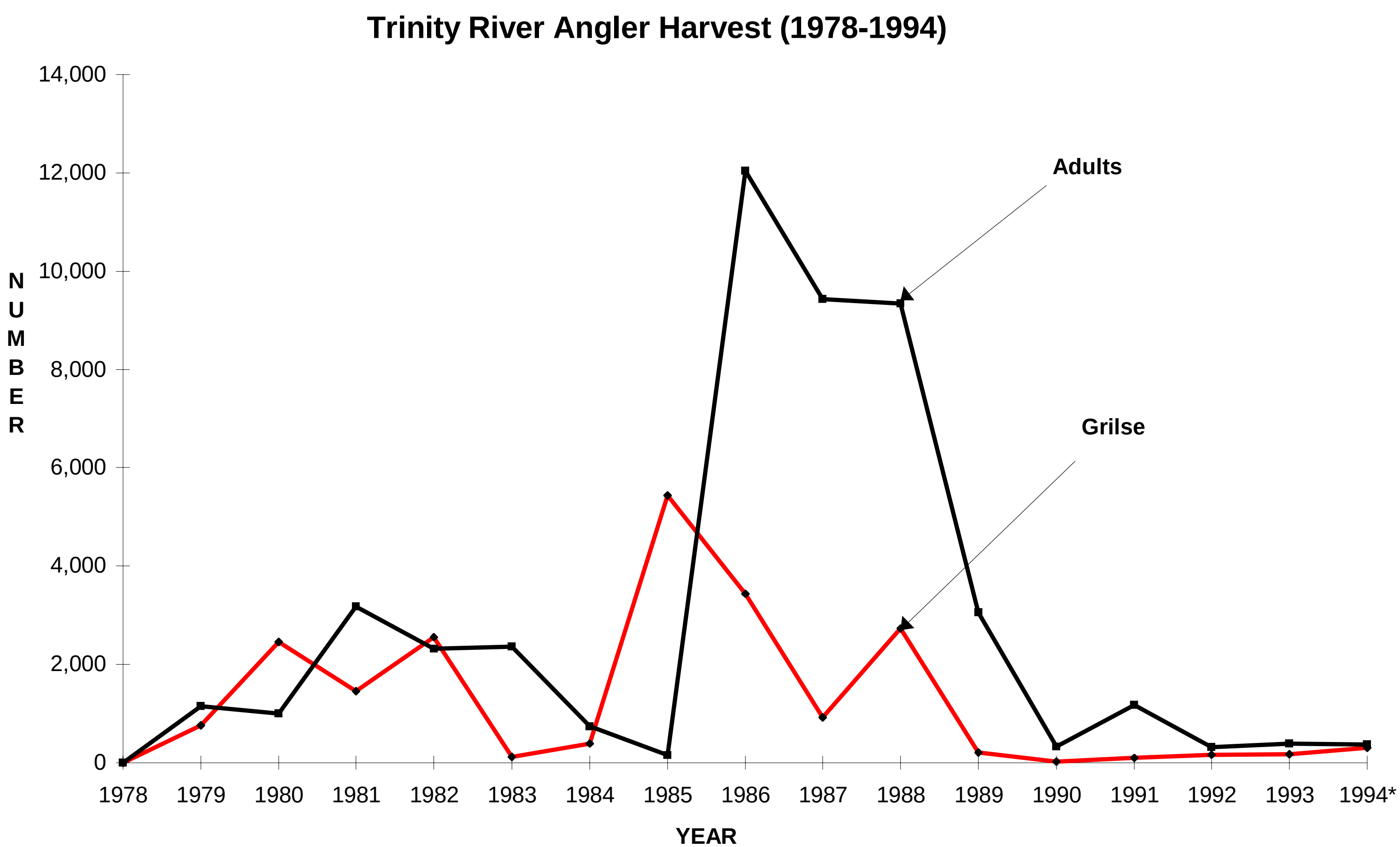

Figure D-4. Trinity River Angler Harvest (1978 - 1994)

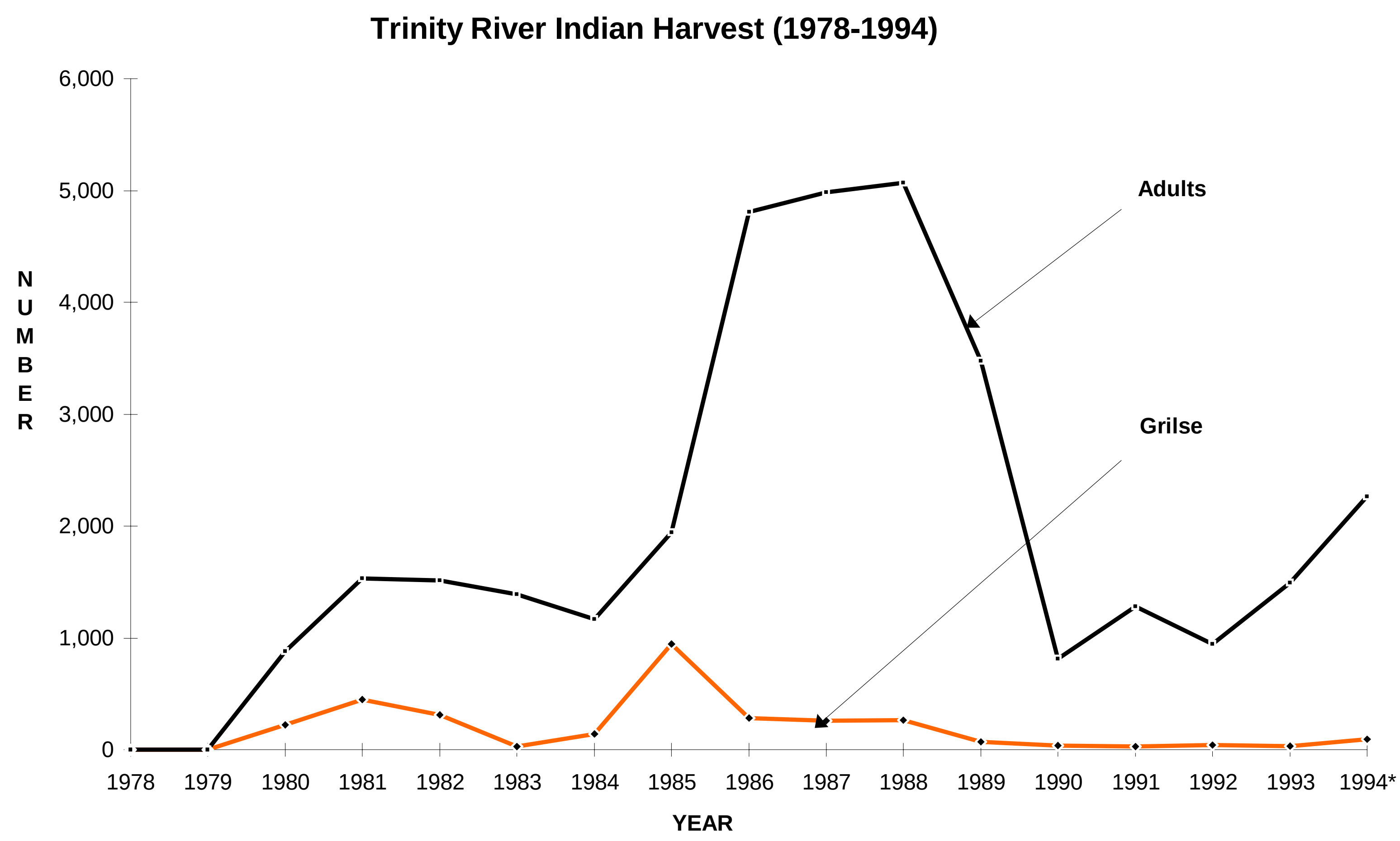

Figure D-5. Trinity River Indian Harvest (1978-1994)

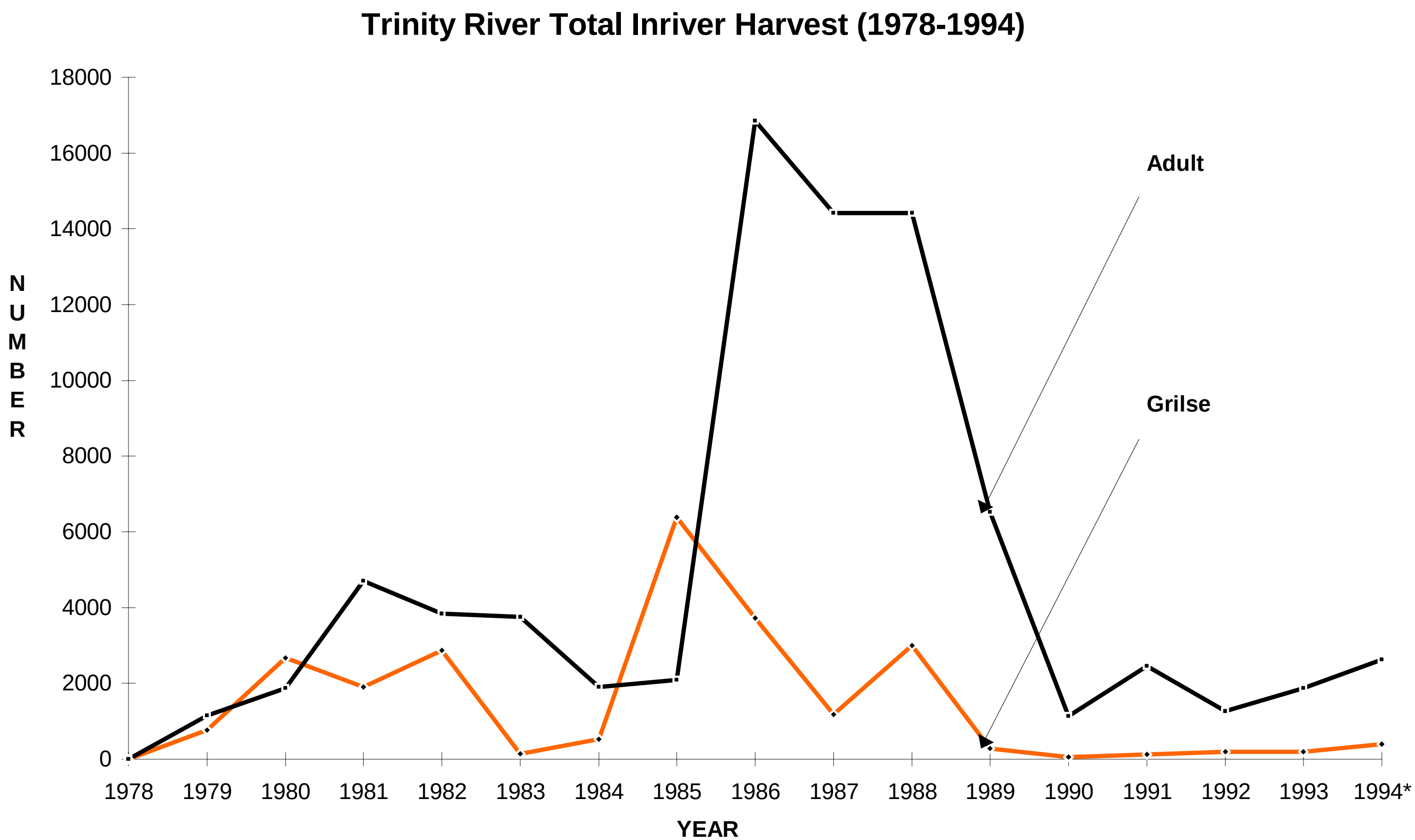

Figure D-6. Trinity River Total Inriver Harvest (1978 - 1994)

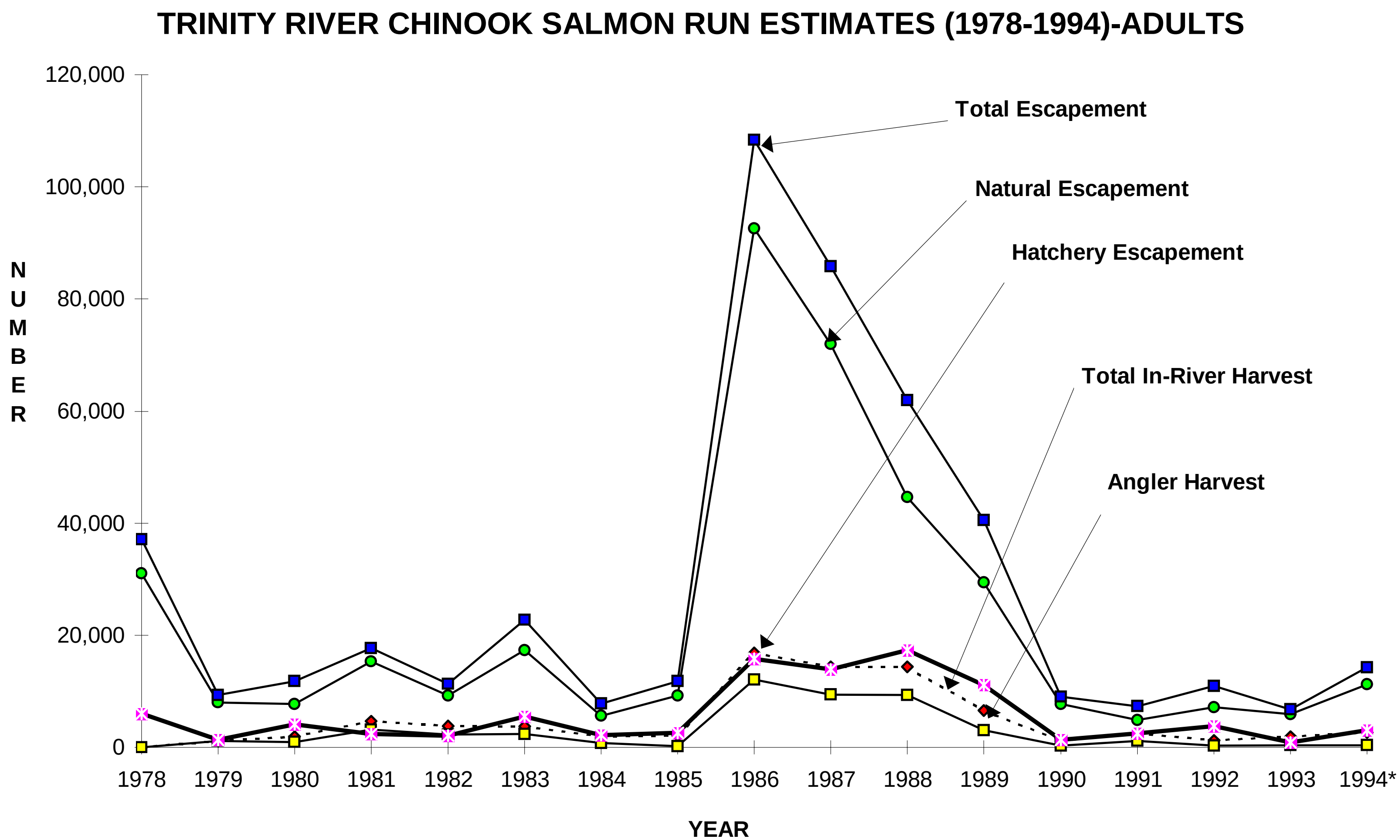

Figure D-7. Trinity River Chinook Salmon Run Estimates (1978- 1994)- Adults

Table D-1. Trinity River Chinook Run Size Estimates (historical) from the Literature

PRE-DAM YEAR(S)	RUN SIZE ESTIMATE	COMMENTS AND SOURCES
1944	27,000	Mean of the estimated range of 18,000 to 36,000, (includs grilse) (Moffet and Smith, 1950; as cited by Leidy and Leidy, 1984)
1944	21,000	Estimated spawning escapement including grilse above Brown's Creek (Moffett and Smith, 1950).
1944	25,600	Total estimated spawning escapement for Upper Trinity above North fork including grilse (Moffet and Smith, 1950)
1944	12,000	Estimated spawning escapement, including grilse, above Lewiston (Moffett and Smith, 1950)
1944	13,500	Estimated spawning escapement, including grilse, below Lewiston (Moffett and Smith, 1950 as cited by Fedriksen Kamine and Assoc., 1980)
1944	12,000	Extrapolated from estimated spawning escapement above Lewiston (including grilse)(USFWS/CDFG ,1956)
1944	25,500	Total spawning escapement for upper Trinity River above North Fork (including grilse) using Gibbs' (1956) distribution and Moffett and Smith's (1950) estimate. (Fredriksen, Kamine & Assoc. 1980)
1944	12,000	Total spawning escapement including grilse above Lewiston.(Moffett and Smith, 1950 as cited by Fredriksen, Kamine & Assoc. 1980)
1944	13,500	Total spawning escapement including grilse below Lewiston using Gibbs' (1956) distribution. (Fredriksen, Kamine & Assoc. 1980)
1945	27,000	Mean of the estimated range of 18,000 to 36,000 (includes grilse) (Moffet and Smith, 1950; as cited by Leidy and Leidy, 1984)
1945	19,000	Total spawning escapement for upper Trinity River above North Fork (including grilse) using Gibbs' (1956) distribution and Moffett and Smith's (1950) estimate. (Fredriksen, Kamine & Assoc. 1980)
1945	9,000	Extrapolated from estimated spawning escapement above Lewiston (includes grilse) (Moffet and Smith, 1950 as cited by USFWS/CDFG ,1956)
1945	9,000	Estimated spawning escapement, including grilse, above Lewiston (Moffett and Smith, 1950)
1945	9,000	Total spawning escapement including grilse above Lewiston.(Moffett and Smith, 1950 as cited by Fredriksen, Kamine & Assoc. 1980)
1945	10,000	Total spawning escapement including grilse below Lewiston using Gibbs' (1956) distribution and Moffett and Smith's (1950) estimate. (Fredriksen, Kamine & Assoc. 1980)
1946	15,000	Estimated above Lewiston (assumed including grilse) (Moffet and Smith, 1950)
Historic	59,000	Estimated from commercial harvest and angler harvest data from landings and average adult weights as calculated by Moffett and Smith, (1950).
1944, 1945	10,000	Estimate of the portion of spawning escapement (including grilse) above the present dam location (Moffet and Smith, 1950 as cited by Wales , 1950).
Historic	84,000	Estimated Klamath system total escapement counts of 168,000; of which 1/2 were Trinity fish, (Coots, 1967 as cited by Leidy and Leidy, 1984)
Historic	66,000	Historic chinook spawning escapements within the Trinity River drainage (Holmberg, 1972 as cited by Leidy and Leidy, 1984).
1955	27,445-50,126	Total estimated spawning escapement including grilse (Gibbs, 1956).
1955	38,786	Mean of the estimated total spawning escapement range of >27,445<50,126 for upper Trinity River river above North Fork (Gibbs, 1956).
1955	35,000	Total escapement including grilse for upper Trinity River (estimated from Gibbs, (1956) by USFWS/CDFG (1956).
1955	40,900	Total mainstem spawning escapement including grilse as estimated by Fredriksen, Kamine & Assoc.(1980) from Gibbs' (1956) data.
1955	25,000	Total spawning escapement including grilse above Lewiston (Fredriksen, Kamine & Assoc., 1980 estimated from Gibbs' (1956) data.
1955	15,600	Total spawning escapement including grilse below Lewiston (Fredriksen, Kamine & Assoc., 1980 estimated from Gibbs' (1956) data.
1955	300	Total spawning escapement including grilse for tributaries below Lewiston (Fredriksen, Kamine & Assoc., 1980 estimated from Gibbs' (1956) data.
1955	24,000	Total Fall run spawning escapement including grilse above Lewiston (USFWS/CDFG ,1956 estimated from Gibbs' (1956) data.

Table D-1. Continued.

PRE-DAM YEAR(S)	RUN SIZE ESTIMATE	COMMENTS AND SOURCES
1955	3,000	Total Spring run spawning escapement including grilse above Lewiston (USFWS/CDFG ,1956 estimated from Gibbs'(1956) data.
1955	8,000	Total Summer run spawning escapement including grilse above Lewiston (USFWS/CDFG ,1956 estimated from Gibbs'(1956) data.
1955	19,245	Total spawning escapement estimate including grilse for the reach above the present dams= 47% X 40,946 (Rogers 1972) modification of Gibbs' (1955) estimate and distribution.
1955	21,701	Total spawning escapement including grilse estimate for the reach below the present dams= 53% X 40,946 (Rogers 1972) modification of Gibbs' (1955) estimate and distributions.
1955	18,500	Mean of the estimated range of total spawning escapement including grilse (13,000-24,000) above Lewiston by (Gibbs , 1956 as cited by USFWS/CDFG , 1956).
1956	55,000	Total estimated spawning escapement including grilse (CDFG , undated as cited by USFWS, 1960) as cited by Leidy and Leidy, 1984.
1956	67,115	Mean estimated total spawning escapement including grilse (95% C.L.= 58,000 to 77,000 (Weber, 1965).
1956	67,200	Total mainstem run including grilse (Weber, 1965 as cited by Fredriksen, Kamine & Assoc. 1980).
1956	36,913	Estimated total spwaning escapement including grilse above Lewiston (using redd counts for distribution: 55.1%) (Weber ,1965).
1956	30,134	Estimated total spawning escapement including grilse below Lewiston using redd counts for distribution: 44.9%) (Weber ,1965).
1956	39,000	Total spawning escapement including grilse above Lewiston as estimated by Weber, 1965 (Fredriksen, Kamine & Assoc. 1980).
1956	28,200	Total spawning escapement including grilse below Lewiston as estimated by Weber, 1965 (as cited by Fredriksen, Kamine & Assoc. 1980).
1956	42,013	Total spawning escapement including grilse above Lewiston (62.6%) as estimated by Weber (1965) and using carcass counts for estimating distribution: 62.6%).
1956	25,110	Total spawning escapement including grilse below Lewiston (37.4%) as estimated by Weber (1965) and using carcass counts for estimating distribution: 37.4%).
1958	3,013	Adults trapped at Lewiston, (from Bedell. 1979 as cited by Fredriksen, Kamine & Assoc. 1980.
1958-1959	3,891	Total trapped including grilse at Lewiston trapping station (Murray, 1960)
1959	4,549	Adults trapped at Lewiston, (from Bedell. 1979 as cited by Fredriksen, Kamine & Assoc. 1980.
1959-1960	7,250	Total trapped including grilse at Lewiston trapping station (Murray, 1960)
1960	2,112	Adults trapped at Lewiston, (from Bedell. 1979 as cited by Fredriksen, Kamine & Assoc. 1980.
1960-1961	2,780	Adults trapped at Lewiston trapping station (Murray, 1960)
1960-1961	6,910	Including grilse at trapping station at Lewiston (Murray, 1962)(note: grilse would be of an age class subsequent to the initiation of trapping activities.
1961	846	Total escapement from mainstem above Lewiston (Fredriksen, Kamine & Assoc. 1980)
1962	1,504	Total escapement from mainstem above Lewiston (Fredriksen, Kamine & Assoc. 1980)
Mean (Total)	**38,154**	**Using total spawning escapements for 1944, 1945, 1955, 1956 for below Lewiston**
Range	**19,000-67,115**	
Mean (above)	**18,432**	**Using total spawning escapements for 1944, 1945, 1946,1955, 1956 for above Lewiston**
Range	**9,000-36,913**	
Mean (below)	**18,834**	**Using total spawning escapements for 1944, 1945, 1955, 1956 for below Lewiston**
Range	**10,000-30,134**	

Table D-2. Post-Dam In River Chinook Salmon Spawning Escapement Only.

POST-DAM YEAR(S)	RUN SIZE ESTIMATE	COMMENTS AND SOURCES
1963	82,342	Estimated spawning escapement after completion of the present dams (Both hatchery and natural) (LaFaunce, 1965).
1963	75,607	Estimated spawning escapement (natural) (LaFaunce, 1965)
1963	72,500	Mainstem below Lewiston (LaFaunce, 1963 as cited by (Fredriksen, Kamine & Assoc. 1980)
1963	3,500	Tributaries below Lewiston (LaFaunce, 1963 as cited by Fredriksen, Kamine & Assoc. 1980)
1968	30,350	Total estimated spawning escapement (both natural and hatchery) (Rogers, 1970)
1968	25,578	Estimated spawning escapement (natural)(Rogers, 1970)
1968	25,500	Mainstem below Lewiston (Rogers, 1968 as cited by Fredriksen, Kamine & Assoc. 1980).
1968	100	Tributaries (Rodgers, 1968 as cited by Fredriksen and Kamine, 1980).
1969	48,479	Total estimated spawning escapement with 95% C.L.= 27,572 to 70,950 (Smith, 1975)
1969	45,900	Mainstem below Lewiston (Smith, 1969 (methods and estimate not agreed upon as cited by Fredriksen, Kamine & Assoc. 1980).
1969	45,893	Estimated spawning escapement (natural)(Smith, 1975)
1970	19,396	Total estimated spawning escapement (both natural and hatchery) (Rogers, 1973)
1970	14,952	Estimated spawning escapement (natural)(Rogers, 1973)
1970	14,900	Mainstem below Lewiston including small males (Rogers, 1970 as cited by Fredriksen, Kamine & Assoc. 1980).
1971	166,510	Total estimated spawning escapement using an estimation method (both natural and hatchery) (Rogers, 1982); This method probably resulted in an estimate which is greater than actual spawning numbers.
1971	161,352	Estimated spawning escapement (natural) (Rogers, 1982)
1971	42,800	Mainstem (Rogers as reported by Hubbell, (1973) as cited by Fredriksen and Kamine, 1980).
1968-1972	30,500	Estimated average spawning escapment below Lewiston Dam (Burton, et al 1977; as cited by Leidy and Leidy, 1984) Including Hatchery?
1972	20,600	Mainstem (Miller as cited by VTN as cited by Fredriksen and Kamine, 1980) (not throught to be a valid estimate, op. sit)
1973	6,200	Mainstem (Burton as cited by Fredriksen and Kamine, 1980).
1974	4,000	Mainstem (Miller as cited by VTN as cited by Fredriksen and Kamine, 1980) (not throught to be a valid estimate, op. sit)
1976	4,000	Mainstem (Miller as cited by VTN as cited by Fredriksen and Kamine, 1980) (not throught to be a valid estimate, op. sit)
1977	4,500	Mainstem (Miller as cited by VTN as cited by Fredriksen and Kamine, 1980) (not throught to be a valid estimate, op. sit)
1978	7,000	Mainstem (Miller as cited by VTN as cited by Fredriksen and Kamine, 1980) (not throught to be a valid estimate, op. sit)
1978	35,764	Total spawning escapement including grilse forTrinity River Basin (CDFG, 1994 "Klamath River Basin Fall Chinook Salmon Spawner Escapement above Willow Creek"
1979	11,964	Total spawning escapement including grilse forTrinity River Basin (CDFG, 1994 "Klamath River Basin Fall Chinook Salmon Spawner Escapement above Willow Creek"
1980	24,537	Total spawning escapement including grilse forTrinity River Basin (CDFG, 1994 "Klamath River Basin Fall Chinook Salmon Spawner Escapement above Willow Creek"
1981	21,246	Total spawning escapement including grilse forTrinity River Basin (CDFG, 1994 "Klamath River Basin Fall Chinook Salmon Spawner Escapement above Willow Creek"
1978-1981	38,900	Estimated average total chinook spawning escapment for the Trinity River (USFWS, 1983; as cited by Leidy and Leidy, 1984)? Including Hatchery?

Table D-2. Continued.

POST-DAM YEAR(S)	RUN SIZE ESTIMATE	COMMENTS AND SOURCES
1978-1981	30,200	Estimated average fall run spawning escapment for the Trinity River (USFWS, 1983; as cited by Leidy and Leidy, 1984)? Including Hatchery?
1978-1981	8,700	Estimated average spring run spawning escapment for the Trinity River (USFWS, 1983; as cited by Leidy and Leidy, 1984)? Including Hatchery?
1982	17,423	Total spawning escapement including grilse forTrinity River Basin (CDFG, 1994 "Klamath River Basin Fall Chinook Salmon Spawner Escapement above Willow Creek"
1983	18,137	Total spawning escapement including grilse forTrinity River Basin (CDFG, 1994 "Klamath River Basin Fall Chinook Salmon Spawner Escapement above Willow Creek"
1984	9,070	Total spawning escapement including grilse forTrinity River Basin (CDFG, 1994 "Klamath River Basin Fall Chinook Salmon Spawner Escapement above Willow Creek"
1985	38,671	Total spawning escapement including grilse forTrinity River Basin (CDFG, 1994 "Klamath River Basin Fall Chinook Salmon Spawner Escapement above Willow Creek"
1986	113,007	Total spawning escapement including grilse forTrinity River Basin (CDFG, 1994 "Klamath River Basin Fall Chinook Salmon Spawner Escapement above Willow Creek"
1987	77,869	Total spawning escapement including grilse forTrinity River Basin (CDFG, 1994 "Klamath River Basin Fall Chinook Salmon Spawner Escapement above Willow Creek"
1987	26,857	Mean of the range (24,706 to 29,008) of the estimated fall run spawning escapement using the Schaeffer Method (Stempl, 1988)? Including Hatchery?
1987	15,788	Mean of the range (13,637-17,939) of the estimated spawning escapement using the Schaeffer Method (Stempl, 1988)
1987	42,645	Estimated spawning escapment total for both spring and fall runs using Schaeffer Methods for spawner population estimation (Stempl, 1988).
1988	55,242	Total spawning escapement including grilse forTrinity River Basin (CDFG, 1994 "Klamath River Basin Fall Chinook Salmon Spawner Escapement above Willow Creek"
1989	31,988	Total spawning escapement including grilse forTrinity River Basin (CDFG, 1994 "Klamath River Basin Fall Chinook Salmon Spawner Escapement above Willow Creek"
1990	7,923	Total spawning escapement including grilse forTrinity River Basin (CDFG, 1994 "Klamath River Basin Fall Chinook Salmon Spawner Escapement above Willow Creek"
1991	5,249	Total spawning escapement including grilse forTrinity River Basin (CDFG, 1994 "Klamath River Basin Fall Chinook Salmon Spawner Escapement above Willow Creek"
1992	9,702	Total spawning escapement including grilse forTrinity River Basin (CDFG, 1994 "Klamath River Basin Fall Chinook Salmon Spawner Escapement above Willow Creek"
1993	8,370	Total spawning escapement including grilse forTrinity River Basin (CDFG, 1994 "Klamath River Basin Fall Chinook Salmon Spawner Escapement above Willow Creek"
1994	14,359	Total spawning escapement including grilse forTrinity River Basin (CDFG, 1994 "Klamath River Basin Fall Chinook Salmon Spawner Escapement above Willow Creek"
Post-dam in river spawning escapement		
Mean	**27,650**	**Using: 1963, 1968, 1969, 1970, 1971, 1973, and 1978 through 1994 estimated in-river spawning escapements**
Range	**5,249-113,007**	
Adjusted Post-dam spawning escapement		
Mean	**13,465**	**Using estimated spawning escapements from above and adjusted for ESTIMATED in-river spawning of Trinity River Hatchery origin fish;**
Range	**2,551-54,921**	**(mean for 1986, 1994, and 1992=48.6% of basin run size and range of 32.8-59%.)**

Table D-3. Estimates of Run Sizes of Coho Salmon and Steelhead before and after contruction of the TRD.

	COHO SALMON	
PRE-DAM YEAR(S)	**RUN SIZE ESTIMATE**	**COMMENTS AND SOURCES**
unknown	8,000	Holmberg, 1972 as cited by Leidy and Leidy, 1984
historic	5,000	Estimate spawning escapment for Trinity above Lewiston (USFWS/CDFG ,1956)
POST-DAM YEAR(S)	**RUN SIZE ESTIMATE**	**COMMENTS AND SOURCES**
1969	3,200	Total escapment estimate (Smith, 1975)
1969	1,996	Hatchery return (Smith, 1975)
1969	1,204	Natural spawning escapment (Smith, 1975)
1970	5,245	Total escapment estimate (Rogers, 1972)
1970	3,147	Hatchery return (Rogers, 1972)
1970	2,098	Natural spawning escapment (Rogers, 1972)
1971	509	Total escapment estimate (Rogers, 1982)
1971	47	Hatchery return (Rogers, 1982)
1971	462	Natural spawning escapment (Rogers, 1982)
1973-1980	3,277	Average hatchery returns 1973-1980 (Leidy and Leidy, 1984).
	STEELHEAD	
PRE-DAM YEAR(S)	**RUN SIZE ESTIMATE**	**COMMENTS AND SOURCES**
Historic	10,000	At least this number (USFWS/CDFG, (1956)
1958-1964	3,034	Average adult counts at Lewiston (Hubbell (1973) as cited by CDFG (1977).
		(all estimates refer to estimates for river below the present dams)
POST-DAM YEAR(S)	**RUN SIZE ESTIMATE**	**COMMENTS AND SOURCES**
1960	2,071	Trinity River Hatchery records (Rogers, 1972)
1961	3,526	Trinity River Hatchery records (Rogers, 1972)
1962	3,243	Trinity River Hatchery records (Rogers, 1972)
1963	1,687	Trinity River Hatchery records (Rogers, 1972)
1964	894	Trinity River Hatchery records (Rogers, 1972)

Table D-3. Continued.

POST-DAM YEAR(S)	RUN SIZE ESTIMATE	COMMENTS AND SOURCES
1964	8,044	Natural escapement: mean of the range of 7,499 to 8,684 as determined by visual survey methods used for estimating spawning
		escapement (LaFaunce, 1965)
1965	6,941	Trinity River Hatchery records (Rogers, 1972)
1966	992	Trinity River Hatchery records (Rogers, 1972)
1967	135	Trinity River Hatchery records (Rogers, 1972)
1968	232	Trinity River Hatchery records (Rogers, 1972)
1969	554	Trinity River Hatchery records (Rogers, 1972)
1969	*	* no estimate of natural escapement was made due to the lack of significant recoveries at the Trinity River Hatchery but estimated
		to be greater than the Coho escapement for that year (3200) (Smith, 1975)
1970	241	Trinity River Hatchery records (Rogers, 1972)
1971	67	Trinity River Hatchery records (Rogers, 1972)
1971	*	* no estimate of natural escapement in the mainstem was made due to the lack of significant recoveries at the Trinity River Hatchery
		(Rogers, 1982)
1971	413	Natural spawning escapement estimate for mainstemTrinity River tributaries, of which 18 were previously surveyed by LaFaunce in 1964
		(Rogers, 1972).
1972	242	Trinity River Hatchery records (Rogers, 1973)
1972	1,011	Natural spawning escapement estimate for mainstemTrinity River tributaries, of which 18 were previously surveyed by LaFaunce in 1964
		(Rogers, 1973).
1963-1973	249	Average Trinity River Hatchery escapement (CDFG, 1977)
1980-1981	24,000	Average spawning escapement (USFWS ,1983)

Table D-4. Trinity River fall run chinook run size estimates.

	TRINITY RIVER			ANGLER HARVEST			TOTAL IN-BASIN HARVEST		
YEAR	GRILSE	ADULT	TOTAL	ADULT	GRILSE	TOTAL	ADULT	GRILSE	TOTAL
1978	4,712	31,052	35,764	0	0	0	31,052	4,712	35,764
1979	3,936	8,028	11,964	1,157	765	1,922	9,185	4,701	13,886
1980	16,837	7,700	24,537	998	2,456	3,454	8,698	19,293	27,991
1981	5,906	15,340	21,246	3,174	1,456	4,630	18,514	7,362	25,876
1982	8,149	9,274	17,423	2,321	2,554	4,875	11,595	10,703	22,298
1983	853	17,284	18,137	2,360	116	2,476	19,644	969	20,613
1984	3,416	5,654	9,070	736	393	1,129	6,390	3,809	10,199
1985	29,454	9,217	38,671	154	5,442	5,596	9,371	34,896	44,267
1986	20,459	92,548	113,007	12,039	3,438	15,477	104,587	23,897	128,484
1987	5,949	71,920	77,869	9,433	923	10,356	81,353	6,872	88,225
1988	10,626	44,616	55,242	9,341	2,735	12,076	53,957	13,361	67,318
1989	2,543	29,445	31,988	3,054	209	3,263	32,499	2,752	35,251
1990	241	7,682	7,923	328	22	350	8,010	263	8,273
1991	382	4,867	5,249	1,177	94	1,271	6,044	476	6,520
1992	2,563	7,139	9,702	314	158	472	7,453	2,721	10,174
1993	2,465	5,905	8,370	391	172	563	6,296	2,637	8,933
1994*	3,150	11,209	14,359	366	308	674	11,575	3,458	15,033
MEAN	7,155	22,287	29,442	2,959	1,328	4,287	25,246	8,483	33,729

APPENDIX E

Trinity River Natural Salmon and Steelhead Escapement Evaluation

Introduction

Since 1978, the CDFG has operated fish monitoring weirs in the Trinity River (at Junction City for spring-run chinook and at Willow Creek for fall-run chinook, steelhead and coho) to mark salmon for harvest and spawning escapement estimation. The CDFG has also adipose fin-clipped/coded wire tagged chinook and coho salmon and fin-clipped steelhead released from Trinity River Fish Hatchery (TRFH). Data collected from recoveries of marked fish in the fisheries, spawning ground surveys and at the hatchery allow for the evaluation of rearing practices and contributions of hatchery-produced fish to the inriver spawning escapement and harvest. This analysis was conducted to assess the current status of the naturally produced spawning escapement of chinook and coho salmon and steelhead of the Trinity River relative to the escapement goals of the Trinity River Restoration Program. For the purposes of this evaluation, the term "inriver spawners" refers to fish that spawn in the Trinity River and excludes fish that return to the TRFH. "Naturally produced" refers to fish whose parents were inriver spawners; "hatchery-produced" refers to fish whose parents were spawned at TRFH.

Methods

Adipose fin-clip data collected at TRFH and at the two weirs were used to estimate the proportion of the inriver spawning escapement (jacks and adults) that were hatchery-produced and naturally produced. The CDFG assumes that the adipose fin clip rate for salmon observed at TRFH represents a population of 100% hatchery-produced fish (CDFG, 1995). Comparison of the adipose fin-clip ($AD\%_{weir}/AD\%_{hatchery}$) rates between fish recovered at the hatchery and at the two weir sites (Willow Creek and Junction City), yields an estimate of the proportion of hatchery-produced fish in the basin (Zuspan, CDFG, 1996, pers. comm.), and subsequently the proportion of naturally produced fish spawning inriver. When the ad-clip rate at the hatchery was less than the ad-clip rate observed at the weirs, it was assumed that all fish were of hatchery origin. Some naturally produced chinook salmon spawn in the hatchery, and since 1991, some adipose fin-clipped chinook salmon observed at the Willow Creek weir were naturally produced. While both of these factors compromise the accuracy of the proportioning, they are unlikely to have a large effect because these numbers are extremely small in any given year. Fin-clip data prior to 1982 was not used because 1982 was the first year that all age classes were represented by fin-clipped fish.

This analysis does not address the impacts of ocean and inriver fisheries on the fishery resources of the Trinity River because data specific to the harvest of Trinity River naturally produced salmonids is extremely limited.

Results

Chinook Salmon: The current fall-run chinook escapement goal of the Trinity River Fish and Wildlife Program is 62,000 naturally produced adult inriver spawners in the Trinity River Basin. Total inriver spawners (jacks and adults) above Willow Creek ranged from 5,249 in 1991 to 113,007 in 1986, and averaged 28,843 from 1978 to 1995 (Table E-1). Adult inriver spawners have ranged from 4,867 in 1991 to 92,548 in 1986, and averaged 25,359 during this period. Substantial numbers of these inriver spawners were hatchery-produced but were designated as "natural" spawners by CDFG because they spawned in the river. Based on ad-clip rates observed at the TRFH and the Willow Creek weir for the period 1982 to 1995, the proportion of naturally produced inriver spawners (jacks and adults) has ranged from 10% in 1985 to 94% in 1992, and averaged 44%. After the proportion of hatchery-produced fall-run chinook are removed from the number of inriver spawners (jacks and adults), numbers of naturally produced fall-run chinook ranged from 2,354 in 1991 to 41,371 in 1995, and averaged 11,044.

Table E.1. Trinity River fall-run chinook spawning escapement above Willow Creek weir and origin of spawners. TRFH = Trinity River Fish Hatchery, WCW = Willow Creek Weir, %H= % of TOTAL BASIN escapement that were hatchery-produced, %Nat= % of Inriver Spawners that were naturally produced. (CDFG, 1996b).

Year	Inriver Escapement (WCW to Lewiston Dam) Jacks	Inriver Escapement (WCW to Lewiston Dam) Adults	Returns to TRFH	BASIN TOTAL	Ad-clip Rate WCW	Ad-clip Rate TRFH	Basin %H	Hatchery Produced	Naturally Produced	Total Inriver Spawners	Inriver %Nat
	A	B	C	D=A+B+C	E	F	G=E/F	H=G*D	I=D-H	J=A+B	K=I/J
1978	4,712	31,052	7,359	43,123	-	-	-	-	-	35,764	-
1979	3,936	8,028	2,299	14,263	-	-	-	-	-	11,964	-
1980	16,837	7,700	6,255	30,792	-	-	-	-	-	24,537	-
1981	5,906	15,340	3,374	24,620	-	-	-	-	-	21,246	-
1982	8,149	9,274	6,293	23,716	0.161	0.218	73.8%	17,515	6,201	17,423	36%
1983	853	17,284	5,765	23,902	0.128	0.148	86.5%	20,672	3,230	18,137	18%
1984	3,416	5,654	2,932	12,002	0.081	0.129	62.8%	7,536	4,466	9,070	49%
1985	29,454	9,217	20,749	59,420	0.192	0.205	93.7%	55,651	3,768	38,671	10%
1986	20,459	92,548	19,404	132,411	0.216	0.268	80.6%	106,719	25,692	113,007	23%
1987	5,949	71,920	16,387	94,256	0.197	0.221	89.1%	84,020	10,236	77,869	13%
1988	10,626	44,616	22,104	77,346	0.111	0.134	82.8%	64,070	13,275	55,242	24%
1989	2,543	29,445	11,371	43,359	0.068	0.103	66.0%	28,625	14,734	31,988	46%
1990	241	7,682	1,719	9,642	0.060	0.128	46.9%	4,519	5,122	7,923	65%
1991	382	4,867	2,687	7,936	0.083	0.118	70.3%	5,582	2,354	5,249	45%
1992	2,563	7,139	3,990	13,692	0.039	0.118	33.1%	4,525	9,167	9,702	94%
1993	2,465	5,905	1,551	9,921	0.040	0.182	22.0%	2,180	7,741	8,370	92%
1994	2,505	10,906	7,706	21,117	0.084	0.128	65.6%	13,858	7,259	13,411	54%
1995	9,262	77,876	15,254	102,392	0.059	0.099	59.6%	61,021	41,371	87,138	47%
1978-1995											
Avg	7,237	25,359	8,733	41,328	-	-	-	-	-	32,597	-
Min	241	4,867	1,551	7,936	-	-	-	-	-	5,249	-
Max	29,454	92,548	22,104	132,411	-	-	-	-	-	113,007	-
1982-1995											
Avg	7,062	28,167	9,851	45,079	-	-	66.7%	35,231	11,044	35,231	44.0%
Min	241	4,867	1,551	7,936	-	-	22.0%	2,180	2,348	5,249	10.0%
Max	29,454	92,548	22,104	132,411	-	-	93.7%	106,719	41,371	113,007	94.0%

From 1978 to 1994, estimates of spring-run chinook inriver spawners (jacks and adults) above Junction City ranged from 1,360 in 1991 to 39,570 in 1988, and averaged 9,803 (Table E-2). From 1982 to 1994, the proportion of naturally produced inriver spawners (jacks and adults) has ranged from 0 to 100%, and averaged 32%. During this period, naturally produced spring-run chinook salmon ranged from 0 to 6,214 fish, averaging 1,551. Several tributaries to the Trinity River also support populations of spring-run chinook, mainly the South Fork Trinity River, New River, North Fork Trinity River, and Canyon Creek (Table E-3), all of which are below the Junction City Weir. Spawning escapement in the South Fork Trinity River has ranged from 33 to 599 fish. Spawning escapements of spring-run chinook in the Salmon River, a tributary to the Klamath River, have ranged from less than 133 to 1,433. The current escapement goal of the Trinity River Fish and Wildlife Program is 6,000 naturally produced spring-run chinook inriver spawners in the Trinity River Basin.

Coho Salmon: The Trinity River Restoration Program's spawning escapement goal for inriver adult coho salmon in the mainstem Trinity River is 1,400 fish. Since 1978, the estimated spawning escapement of coho salmon (jacks and adults) in the Trinity River above Willow Creek has ranged from 558 to 32,373, averaging 10,192 fish (Table E-4). Data for the proportion of hatchery-produced coho salmon was available from 1991 to 1995. During this period, the proportion of naturally produced fish to inriver escapement ranged from 0% to 14%, and averaged 3%. The annual number of naturally produced inriver spawners averaged 202 fish. Based on these data, the Trinity River coho population is predominately of hatchery origin.

Steelhead: The Restoration Program's goal for steelhead is 40,000 naturally produced spawners. Since 1980, the CDFG produced 12 estimates of steelhead inriver escapement upstream from Willow Creek and estimated the hatchery contribution to the natural escapement in six of these years (Table E-5). Numbers of inriver spawners in the Trinity River Basin above Willow Creek have ranged from 1,977 to 28,933 fish, and averaged 9,160. The percentage of naturally produced fish to the inriver spawners ranged from 59% to 88%, and averaged 70% for the six years for which data were available. During these years, numbers of naturally produced inriver spawners ranged from 1,176 to 14,462, and averaged 4,724. The data collected to generate these estimates only account for the fall-run and the early portion of the winter-run and only provides an assessment for a portion of the Trinity River steelhead population.

Currently there are no mitigation or Trinity River Fish and Wildlife Management restoration goals for summer-run steelhead. The largest populations of summer-run steelhead in the Trinity River Basin are now found in the North Fork Trinity and New River (Table E-6). Canyon Creek and the South Fork Trinity also support small runs of summer-run steelhead, although these populations have undoubtedly declined greatly over the years.

Conclusion

Current populations of naturally produced Trinity River anadromous salmonids are at low levels compared to the escapement goals of the Trinity River Fish and Wildlife Restoration Program. The large spawning escapements that have occurred were typically dominated by TRFH fish that spawned in the natural areas of the Trinity and are not indicative of healthy spawning and rearing conditions in the Trinity River. The high contribution of hatchery-produced fish can be attributed to the increased survival at early life stages that these fish experience while naturally produced fish are exposed to the spawning and rearing conditions that exist in the Trinity River that have been severely degraded by the operation of the TRD.

Table E.2. Trinity River spring chinook spawning escapement above Junction City weir and origin of spawners. TRFH = Trinity River Fish Hatchery, JCW = Junction City Weir, %H= % of TOTAL BASIN escapement that were hatchery-produced, %Nat= % of Inriver Spawners that were naturally produced. (Stemple 1988, Zuspan and Sinnen 1996)

Year	Ad-Clip Rate TRFH	Ad-Clip Rate JCW	BASIN %H	Total Inriver Spawners	Returns to TRFH	BASIN TOTAL	Hatchery Produced	Naturally Produced	Total Inriver Spawners	Inriver %Nat
	A	B	C=B/A	D	E	F=D+E	G=F*C	H=F-G	I	J=H/I
1978	-	-	-	14,413	3,833	18,246	-	-	14,413	-
1979	-	-	-	5 ,008	1,771	6,779	-	-	5 ,008	-
1980	-	-	-	2,926	900	3,826	-	-	2,926	-
1981	-	-	-	3,604	2,500	6,104	-	-	3,604	-
1982	0.753	0.489	64.9%	4,255	1,376	5,631	3,657	1,974	4,255	46%
1983	-	-	-	-	1,158	-	-	-	-	-
1984	0.319	0.028	8.8%	1,494	812	2,306	202	2,104	1,494	100%
1985	0.240	0.223	92.9%	5,696	3,153	8,849	8,222	627	5,696	11%
1986	0.097	0.174	100%	17,706	8,544	26,250	26,250	0	17,706	0%
1987	0.138	0.135	97.8%	31,660	9,853	41,513	40,611	902	31,660	3%
1988	0.130	0.115	88.5%	39,570	14,282	53,852	47,638	6,214	39,570	16%
1989	0.145	0.131	90.3%	18,676	5,000	23,676	21,390	2,286	18,676	12%
1990	0.149	0.125	83.9%	3,006	2,537	5,543	4,650	893	3,006	30%
1991	0.088	0.061	69.3%	1,360	685	2,045	1,418	627	1,360	46%
1992	0.118	0.069	58.5%	1,886	1,846	3,732	2,182	1,550	1,886	82%
1993	0.083	0.091	100%	2,148	2,661	4,809	4,809	0	2,148	0%
1994	0.220	0.170	77.3%	3,447	2,887	4,894	4,894	1,440	3,447	42%
Average (1978-1994)		-	-	9,803	4,215	14,284	-	-	9,803	-
Min	-	-	-	1,360	685	1,158	-	-	1,360	-
Max	-	-	-	39,570	14,282	53,852	-	-	39,570	-
Average (1984-1994)		-	77.7%	10,909	4,470	15,378	13,827	1,551	10,909	32%
Min	-	-	8.8%	1,360	685	2,045	202	0	1,360	0%
Max	-	-	100%	39,570	14,282	53,852	47,638	6,214	39,570	100%

Table E.3. Spring Chinook Spawning Escapement in Trinity River Tributaries and the Salmon River. NS=No Survey was conducted that year.

Stream	1988	1989	1990	1991	1992	1993	1994	1995
Trinity River Basin								
North Fork	28	NS	6	0	0	14	1	50
Canyon Creek	233	NS	13	3	0	7	5	0
New River	12	17	13	2	18	31	5	21
South Fork	59	33	82	186	259	560	378	599
Klamath River Basin								
Salmon River	1,039	287	148	190	330	1,300	1,249	1,215

Although other factors (oceanic conditions, ocean/inriver harvest) also affect spawning populations, natural production of Trinity River salmonid populations is limited during the freshwater phase of their life cycles. A more obvious indicator of the poor condition of the freshwater habitat of the Trinity River is the status of anadromous salmonids. NMFS listed coho salmon as a threatened under the Endangered Species Act; chinook salmon and steelhead are both candidate species.

Table E.4. Trinity River coho salmon spawning escapement above Willow Creek weir and origin of spawners. TRFH = Trinity River Fish Hatchery, WCW = Willow Creek Weir, %H= % of TOTAL BASIN escapement that were hatchery-produced, %Nat= % of Inriver Spawners that were naturally produced. (Zuspan and Sinnen 1996, 1994 and 1995 data were preliminary from personnel communication with W. Sinnen and subject to revision)

Year	Ad-Clip Rate TRFH	Ad-Clip Rate WCW	BASIN %H	Inriver Spawners	Returns to TRFH	BASIN TOTAL	Origin Hatchery	Origin Naturally	%Nat
	A	B	C=B/A	D	E	F=D+E	G=C*F	H=F-G	I=H/D
1978	-	-	-	5,477	3,655	9,132	-	-	-
1979	-	-	-	7,262	3,535	10,797	-	-	-
1980	-	-	-	2,771	3,323	6,094	-	-	-
1981	-	-	-	5,481	4,523	10,004	-	-	-
1982	-	-	-	6,255	4,798	11,053	-	-	-
1983	-	-	-	1,083	706	1,789	-	-	-
1984	-	-	-	9,159	8,861	18,020	-	-	-
1985	-	-	-	26,384	11,786	38,170	-	-	-
1986	-	-	-	19,281	7,991	27,272	-	-	-
1987	-	-	-	32,373	23,338	55,711	-	-	-
1988	-	-	-	24,127	12,816	36,943	-	-	-
1989	-	-	-	13,482	4,970	18,452	-	-	-
1990	-	-	-	2,215	1,635	3,850	-	-	-
1991	0.003	0.003	100%	6,327	2,688	9,015	9,015	0	0%
1992	0.100	0.091	91%	6,733	3,582	10,315	9,387	928	14%
1993	0.136	0.134	99%	3,440	2,117	5,557	5,475	82	2%
1994	0.061	0.070	100%	558	294	852	852	0	0%
1995	0.097	0.104	100%	11,050	4,767	15,817	15,817	0	0%
Avg (1978-1995)		-	-	10,192	6,454	18,058	-	-	-
Min	-	-	-	558	294	852	-	-	-
Max	-	-	-	32,373	23,338	55,711	-	-	-
Avg(1991-1995)		-	98%	5,622	2,690	8,311	8,109	202	3%
Min	-	-	91%	558	294	852	852	0	0%
Max	-	-	100%	11,050	4,767	15,817	15,817	928	14%

Table E.5. Trinity River fall steelhead natural spawning escapement above Willow Creek weir and origin of spawners (Zuspan and Sinnen 1996). TRFH = Trinity River Fish Hatchery, WCW = Willow Creek Weir, %H= % of TOTAL BASIN escapement that were hatchery-produced, %Nat= % of Inriver Spawners that were naturally produced.

Year	Inriver Spawners above WCW	Origin		%Origin	
		Hatchery Produced	Naturally Produced	%H	%Nat
1980	19,563	5,101	14,462	26%	74%
1981	-	-	-	-	-
1982	7,860	971	6,889	12%	88%
1983	6,661	-	-	-	-
1984	6,430	-	-	-	-
1985	-	-	-	-	-
1986	-	-	-	-	-
1987	-	-	-	-	-
1988	11,926	-	-	-	-
1989	28,933	-	-	-	-
1990	3,188	-	-	-	-
1991	8,631	-	-	-	-
1992	2,299	759	1,540	33%	67%
1993	1,977	801	1,176	41%	59%
1994	3,288	878	2,410	27%	73%
1995	3,291	1,424	1,867	43%	57%
1980-1995					
Avg	8,671	-	-	-	-
Min	1,977	-	-	-	-
Max	28,933	-	-	-	-
1980,1982,1992-1995					
Avg	6,380	1,656	4,724	30%	70%
Min	1,977	759	1,176	12%	57%
Max	19,563	5,101	14,462	43%	88%

Table E.6. Summer steelhead counts and estimates (in parentheses) in the Trinity River Basin provided by CDFG. NS=No Survey was conducted that year.

	Location in Trinity Basin				
Year	**South Fork**	**New River**	**North Fork**	**Canyon Creek**	**Upper Trinity**
1980	NS	320 (355)	456	6	31
1981	NS	236 (250)	219	3	2
1982	26	114 (300)	193 (210)	20	NS
1983	NS	NS	160	3	9
1984	8 (30)	335 (340)	179	20	5
1985	3 (20)	NS	57 (112)	10	9
1986	73 (100)	NS	NS	NS	6
1987	NS	(300)	36 (300)	0	9
1988	30	204 (350)	624	32	16
1989	37	600	347 (600)	NS	8
1990	66	343	554	15	13
1991	9 (43)	500-600	825-1037	3	NS
1992	29	272	369	6	NS
1993	42	368	604	24	NS
1994	22	404	990	45	NS
1995	30	775	828	17	NS

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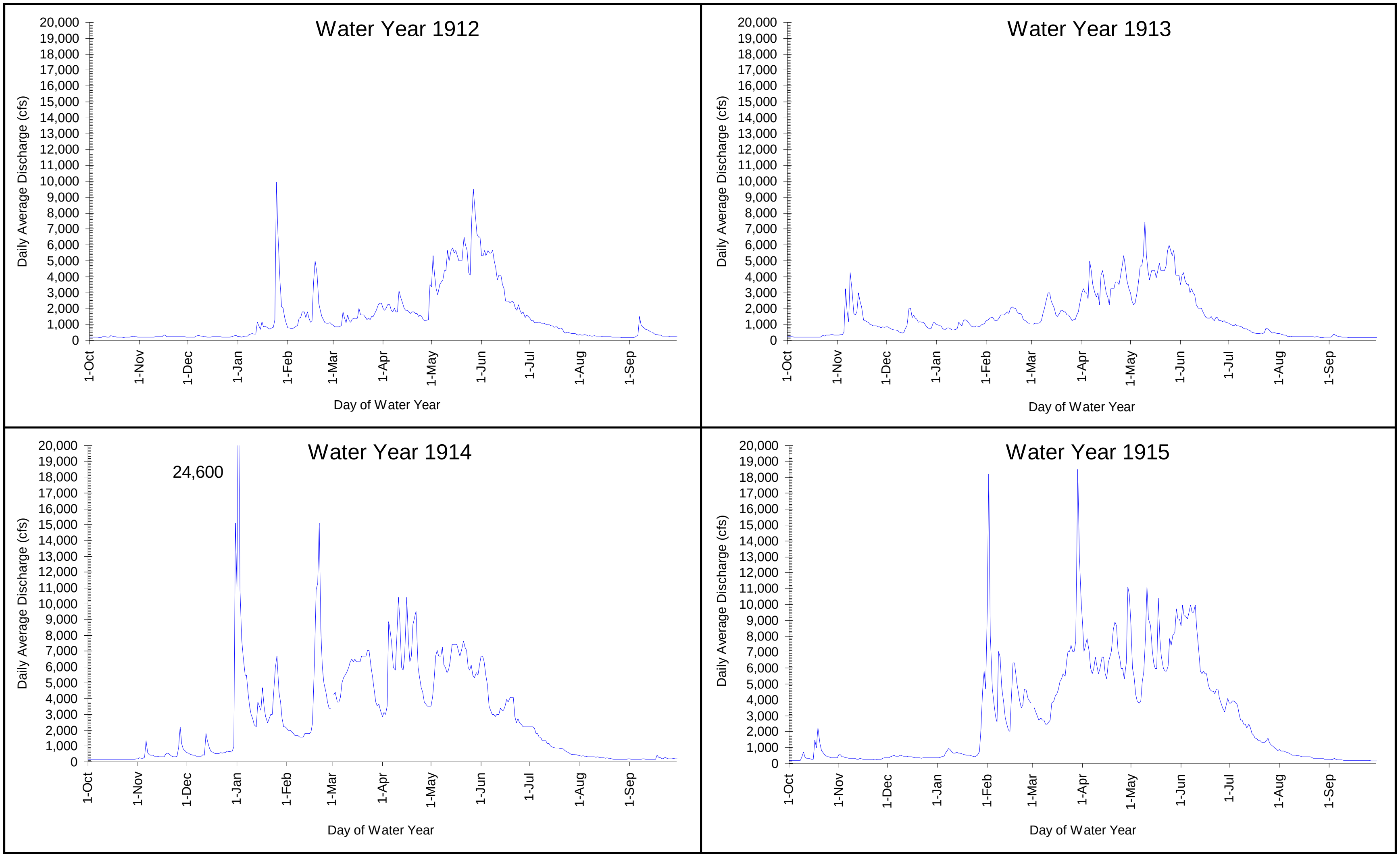
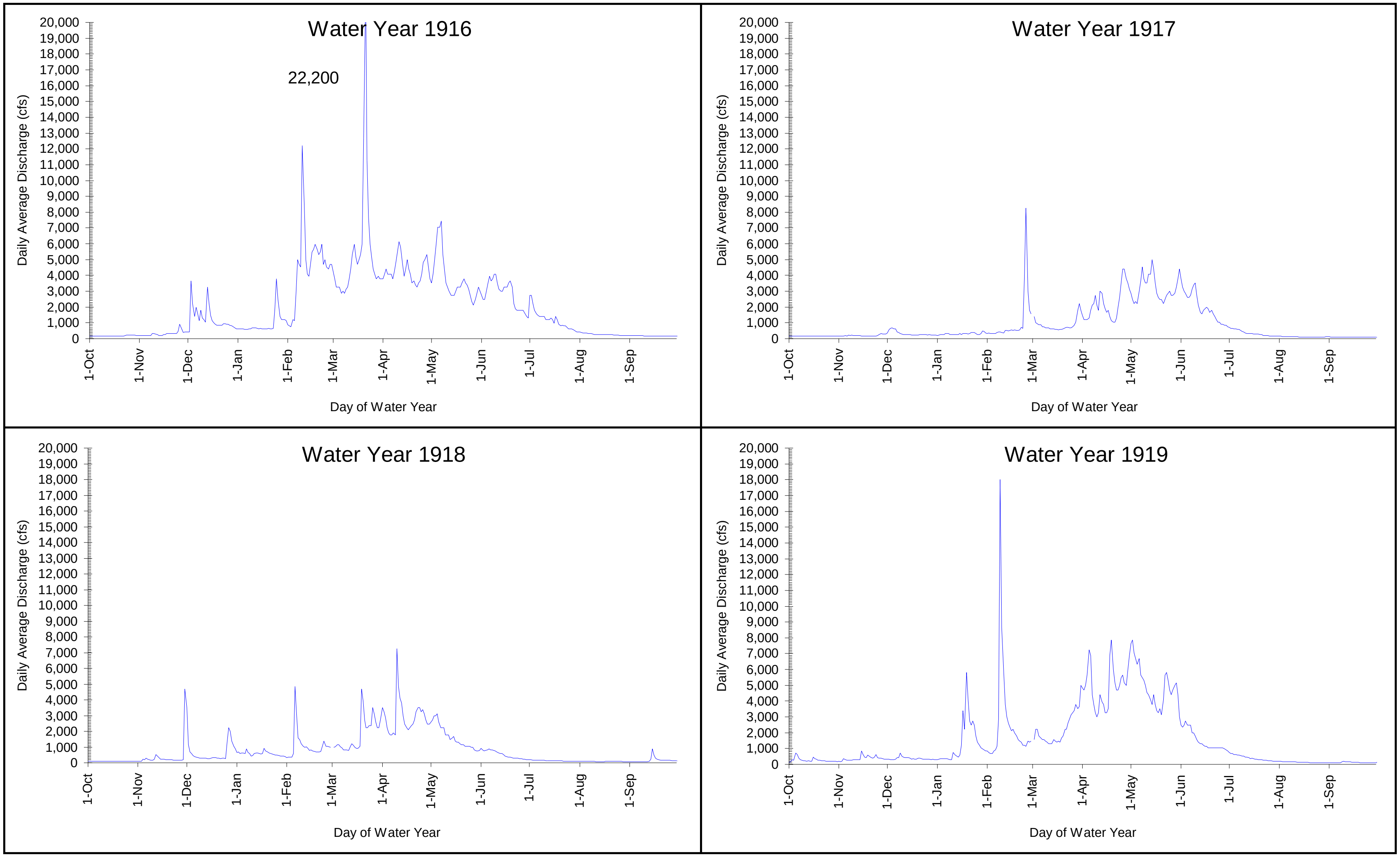
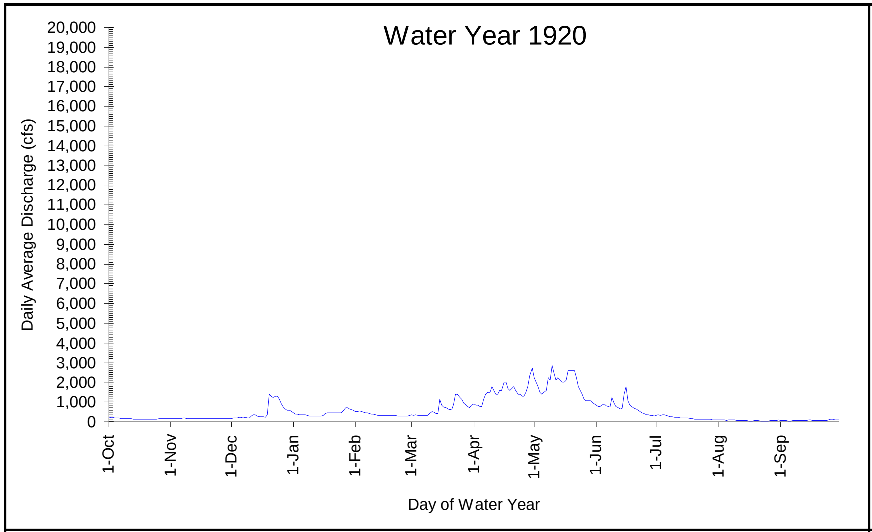
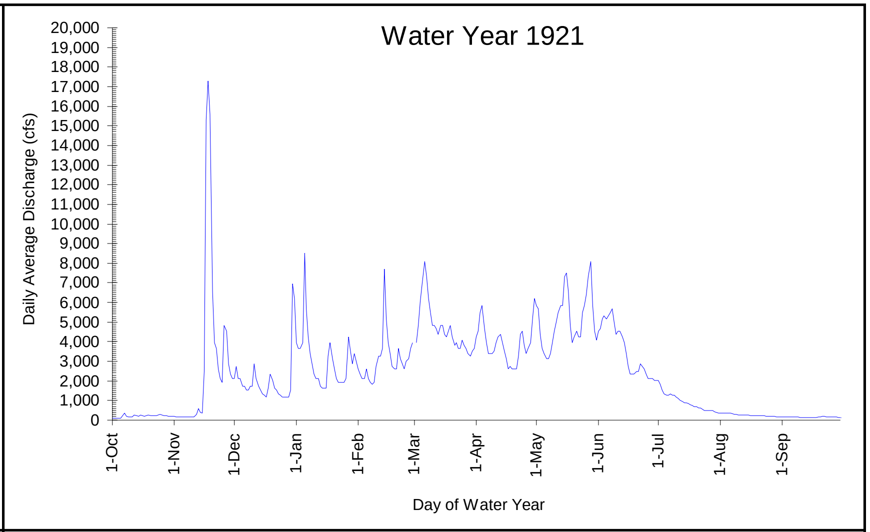
APPENDIX F

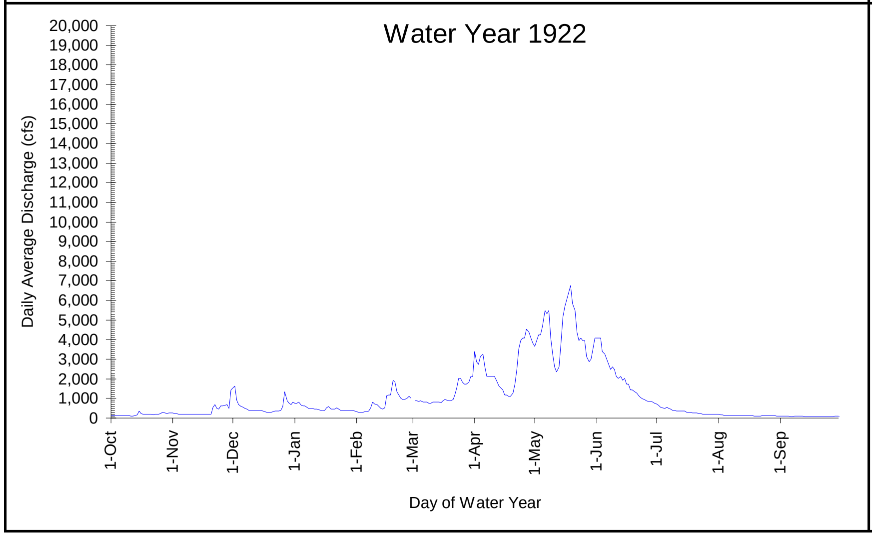
Hydrographs of the Trinity River at Lewiston - 1912 to 1997

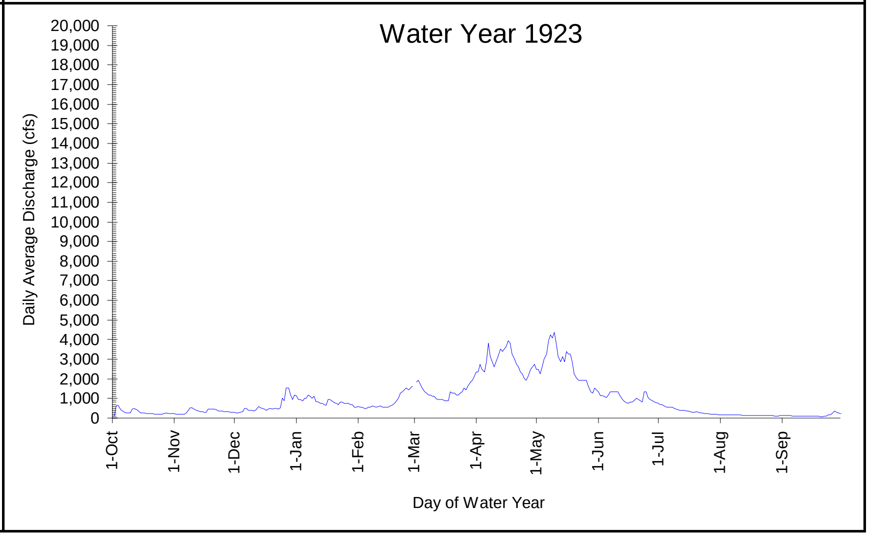

Water Year 1912
Water Year 1913
Water Year 1914
Water Year 1915
24,600
Daily Average Discharge (cfs)
Day of Water Year
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
17,000
18,000
19,000
20,000
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep

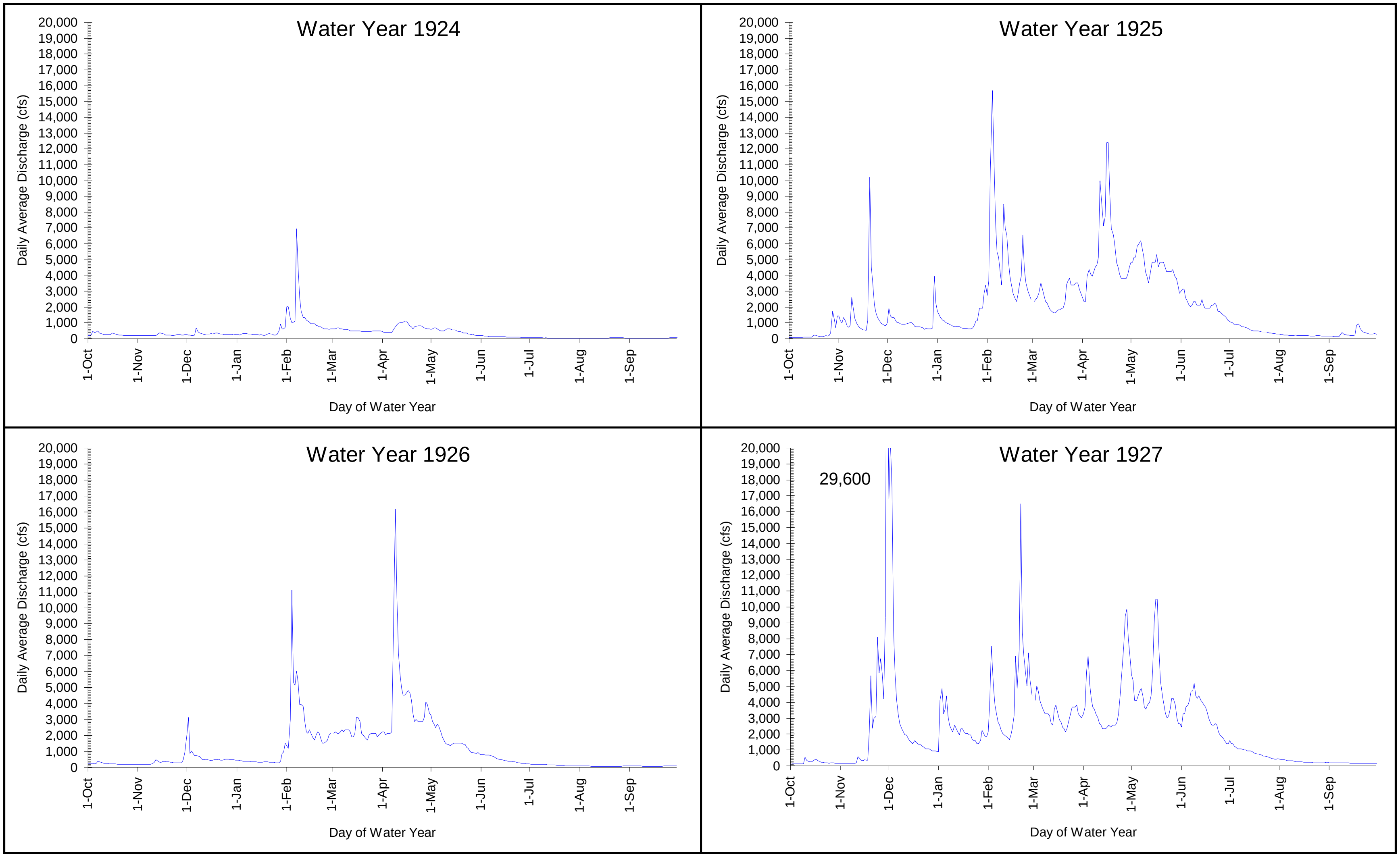

Water Year 1916
22,200
Daily Average Discharge (cfs)
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
Day of Water Year
Water Year 1917
Water Year 1918
Water Year 1919

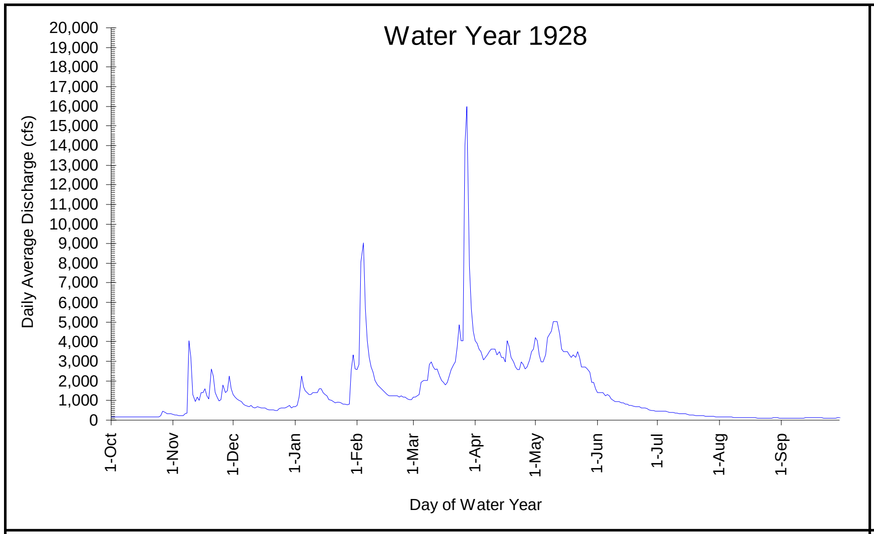

Water Year 1920
Daily Average Discharge (cfs)
Day of Water Year


Water Year 1921
Daily Average Discharge (cfs)
Day of Water Year


Water Year 1922
Daily Average Discharge (cfs)
Day of Water Year


Water Year 1923
Daily Average Discharge (cfs)
Day of Water Year


Water Year 1924
Water Year 1925
Water Year 1926
Water Year 1927
29,600
Daily Average Discharge (cfs)
Day of Water Year
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
17,000
18,000
19,000
20,000
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep



Water Year 1928
Daily Average Discharge (cfs)
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19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Oct
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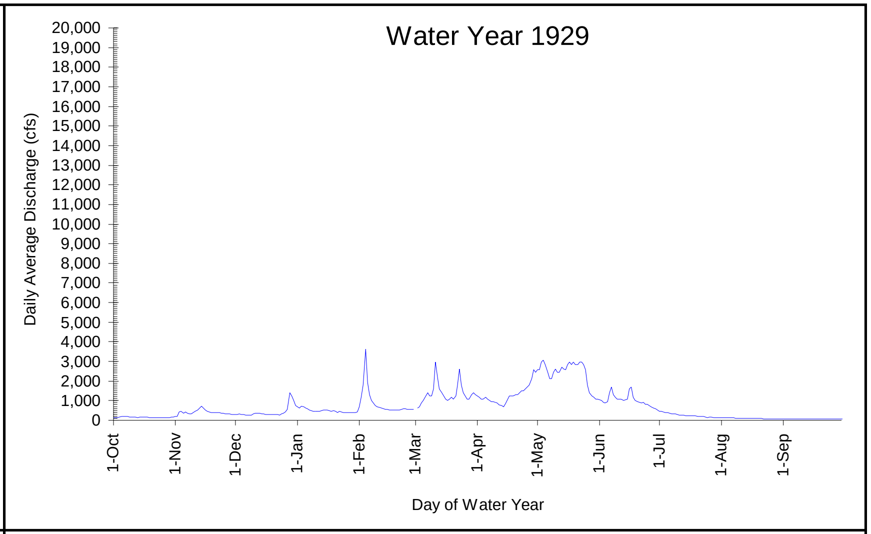
1-Jun
1-Jul
1-Aug
1-Sep
Day of Water Year



Water Year 1929
Daily Average Discharge (cfs)
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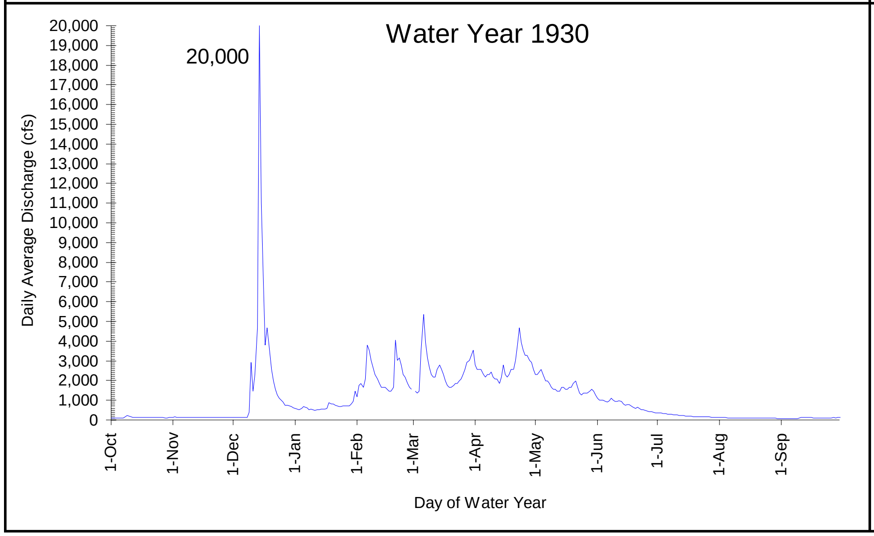
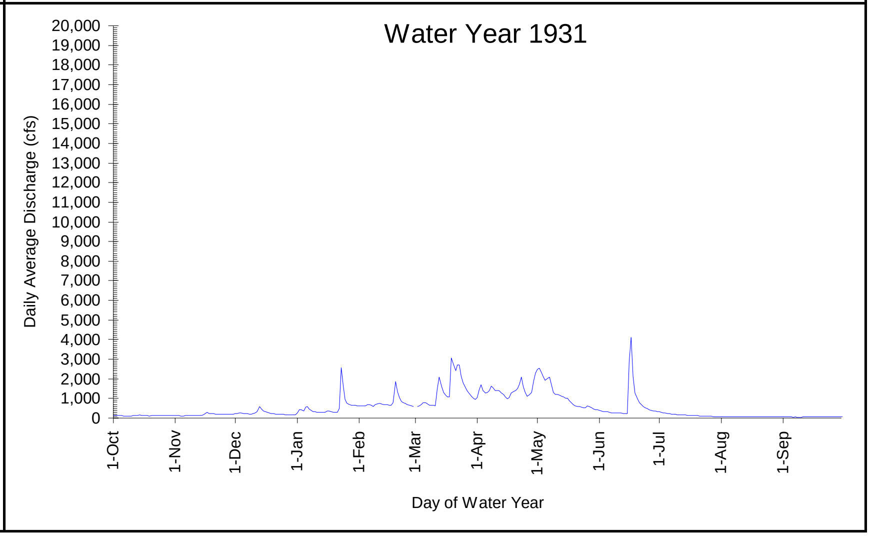
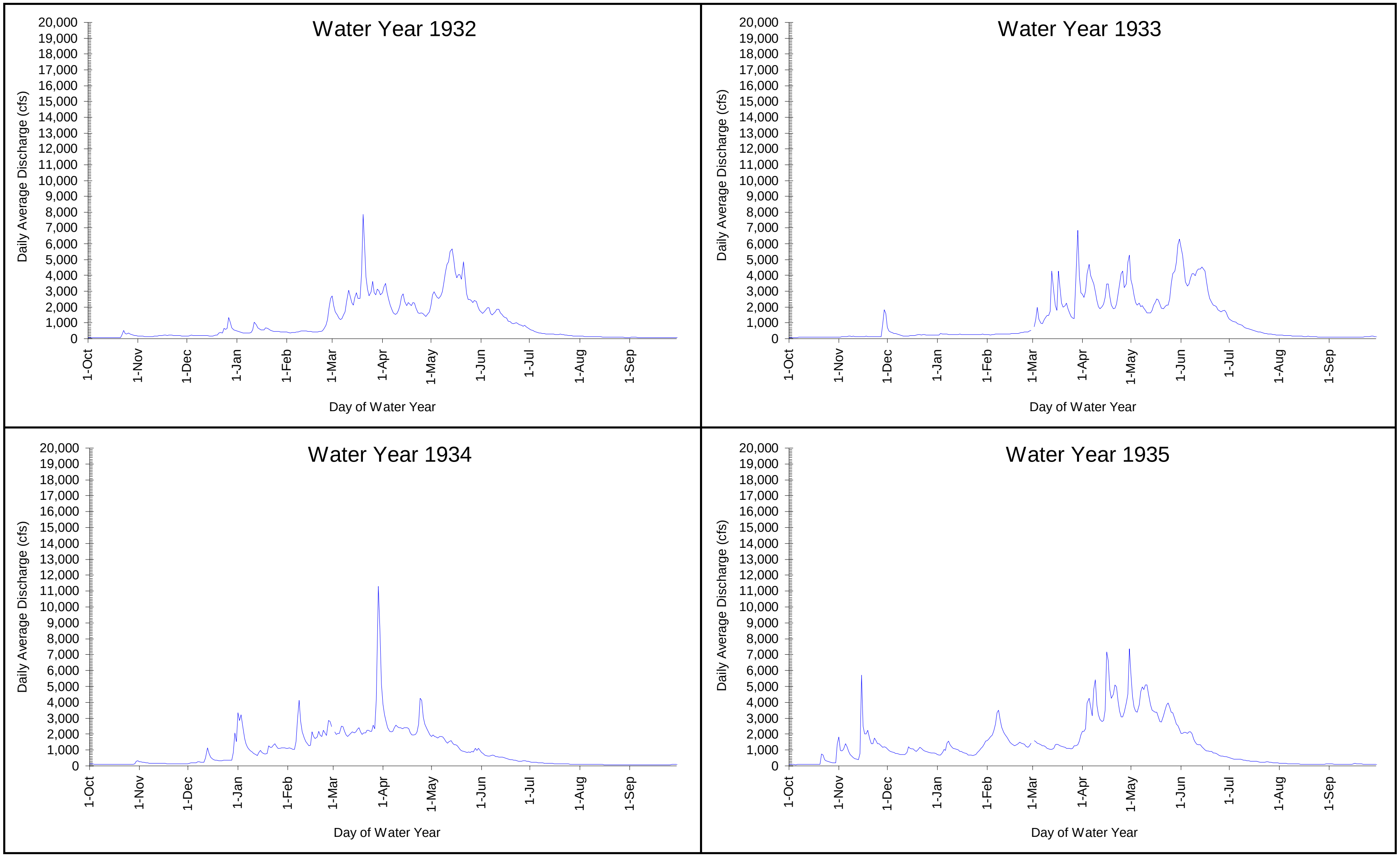
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
Day of Water Year

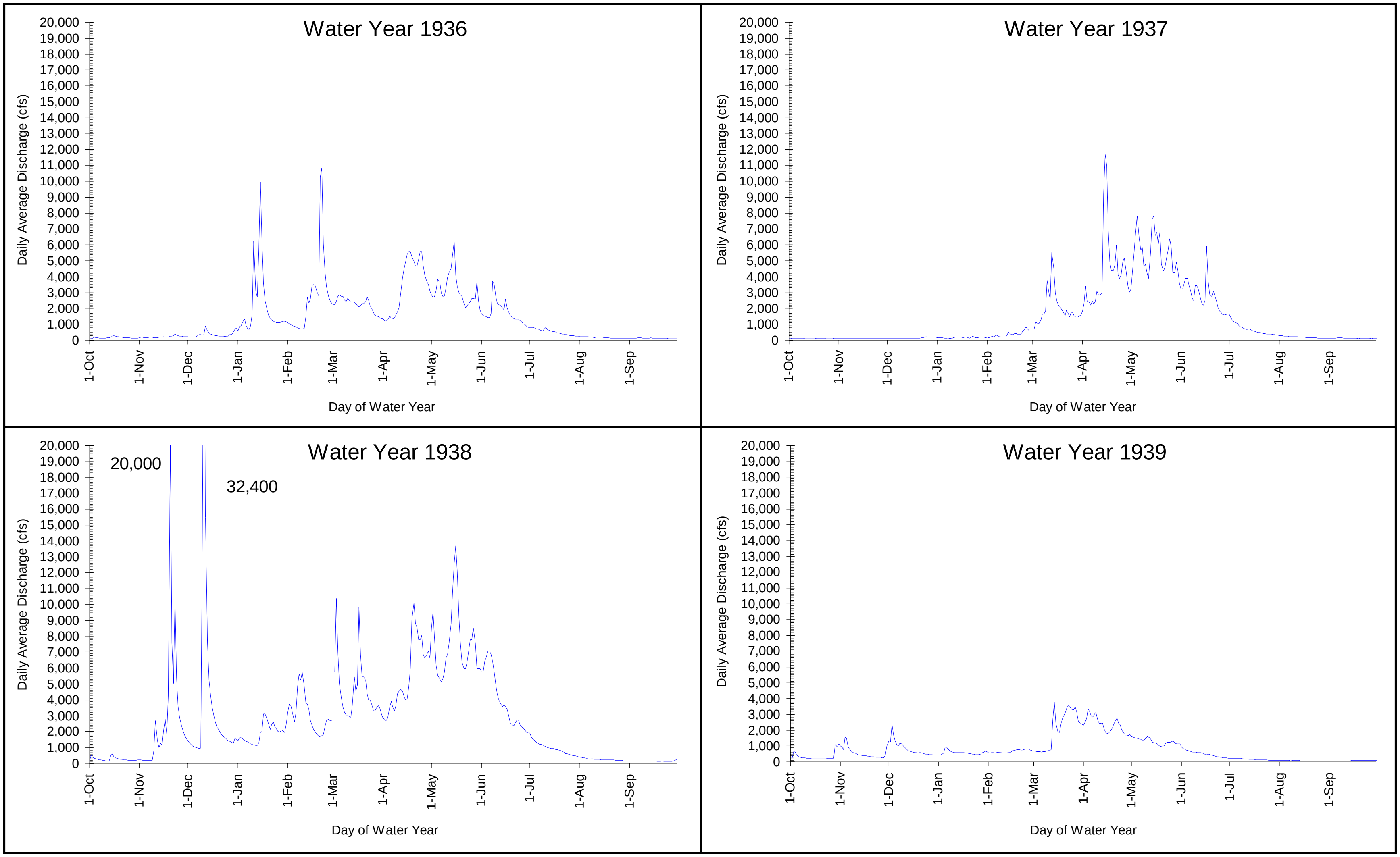


Water Year 1930
20,000
Daily Average Discharge (cfs)
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
Day of Water Year



Water Year 1931
Daily Average Discharge (cfs)
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
Day of Water Year


Water Year 1932
Water Year 1933
Water Year 1934
Water Year 1935
Daily Average Discharge (cfs)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
17,000
18,000
19,000
20,000
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
Day of Water Year


Water Year 1936
Water Year 1937
Water Year 1938
Water Year 1939
20,000
32,400
Daily Average Discharge (cfs)
Day of Water Year
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
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14,000
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16,000
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18,000
19,000
20,000
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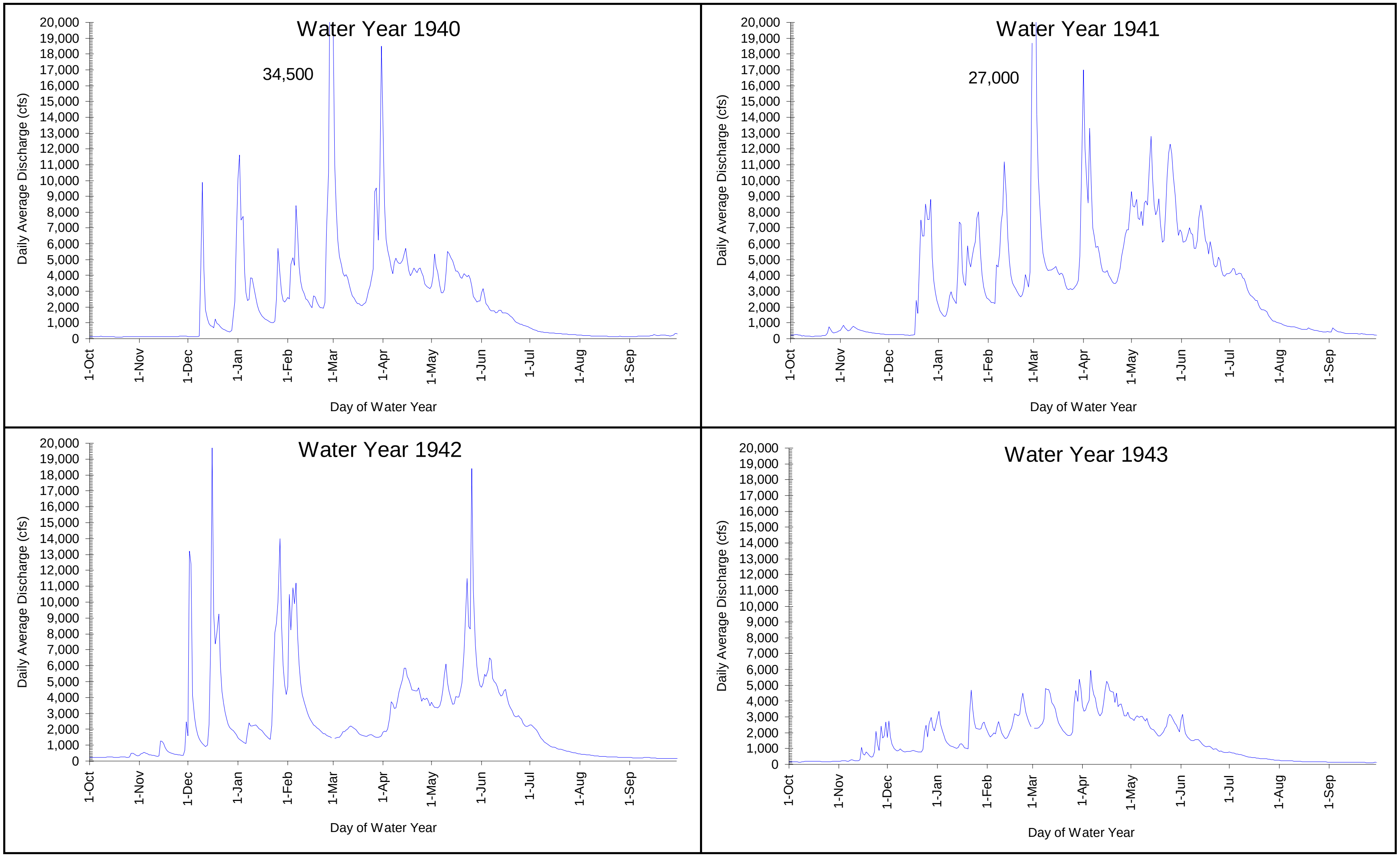
1-Jul
1-Aug
1-Sep


Water Year 1940
34,500
Water Year 1941
27,000
Water Year 1942
Water Year 1943
Daily Average Discharge (cfs)
Day of Water Year
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
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20,000
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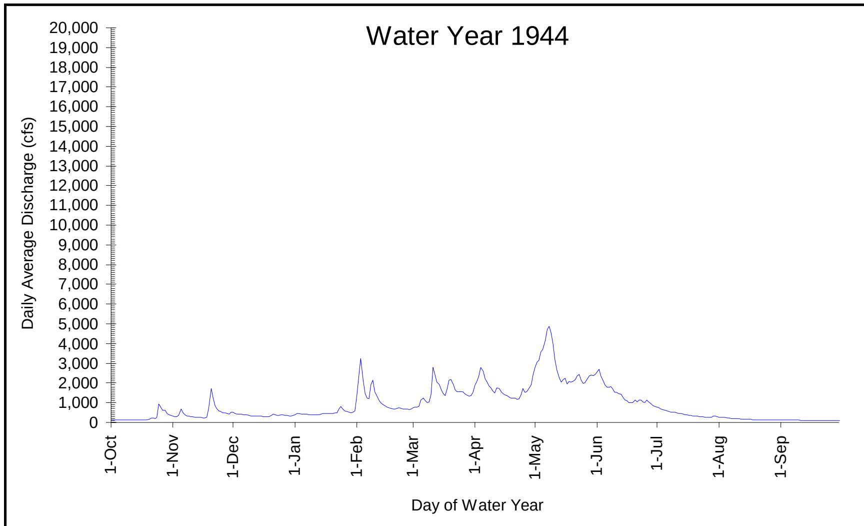
1-Jul
1-Aug
1-Sep


Water Year 1944
Daily Average Discharge (cfs)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
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10,000
11,000
12,000
13,000
14,000
15,000
16,000
17,000
18,000
19,000
20,000
1-Oct
1-Nov
1-Dec
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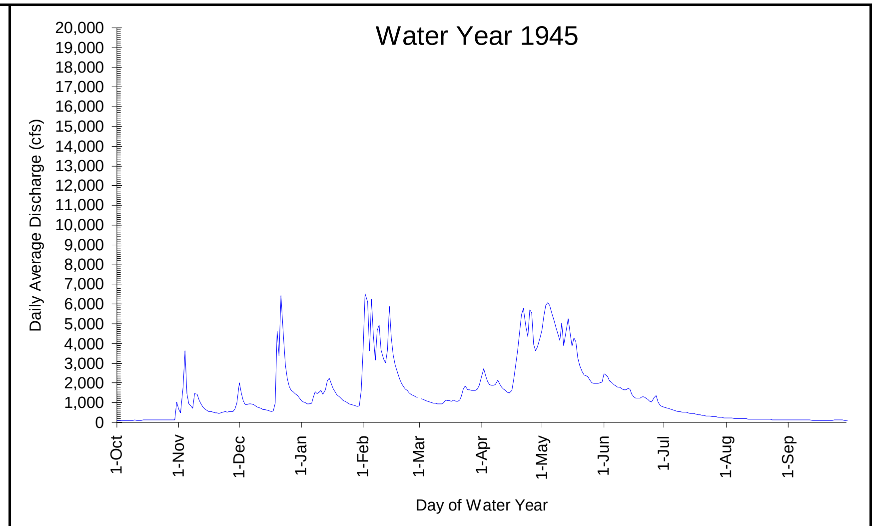
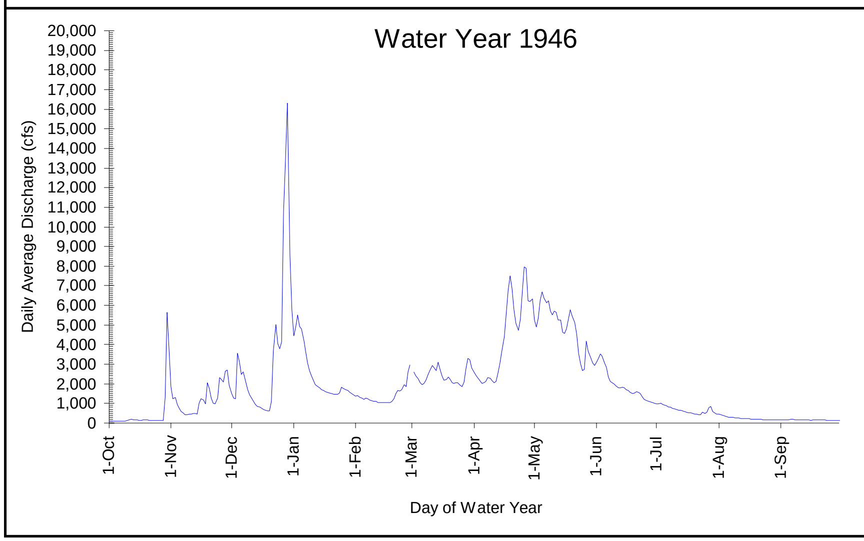
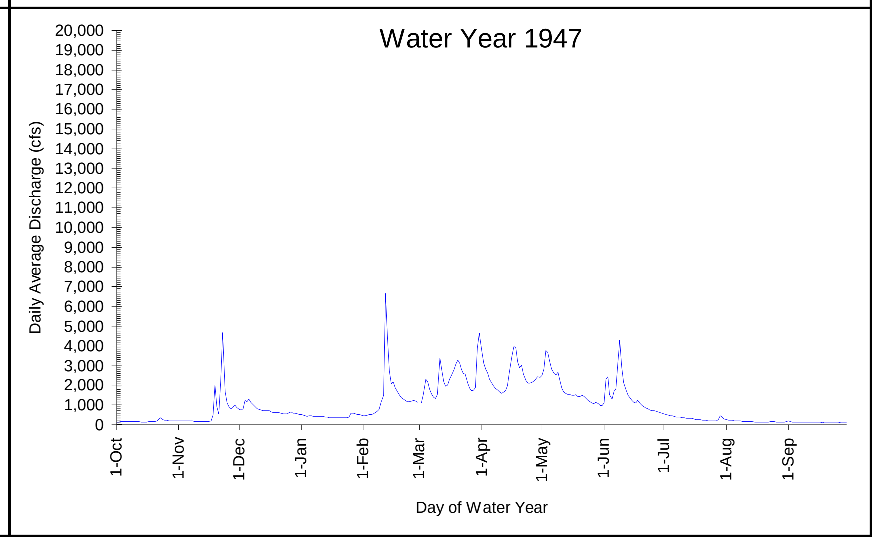
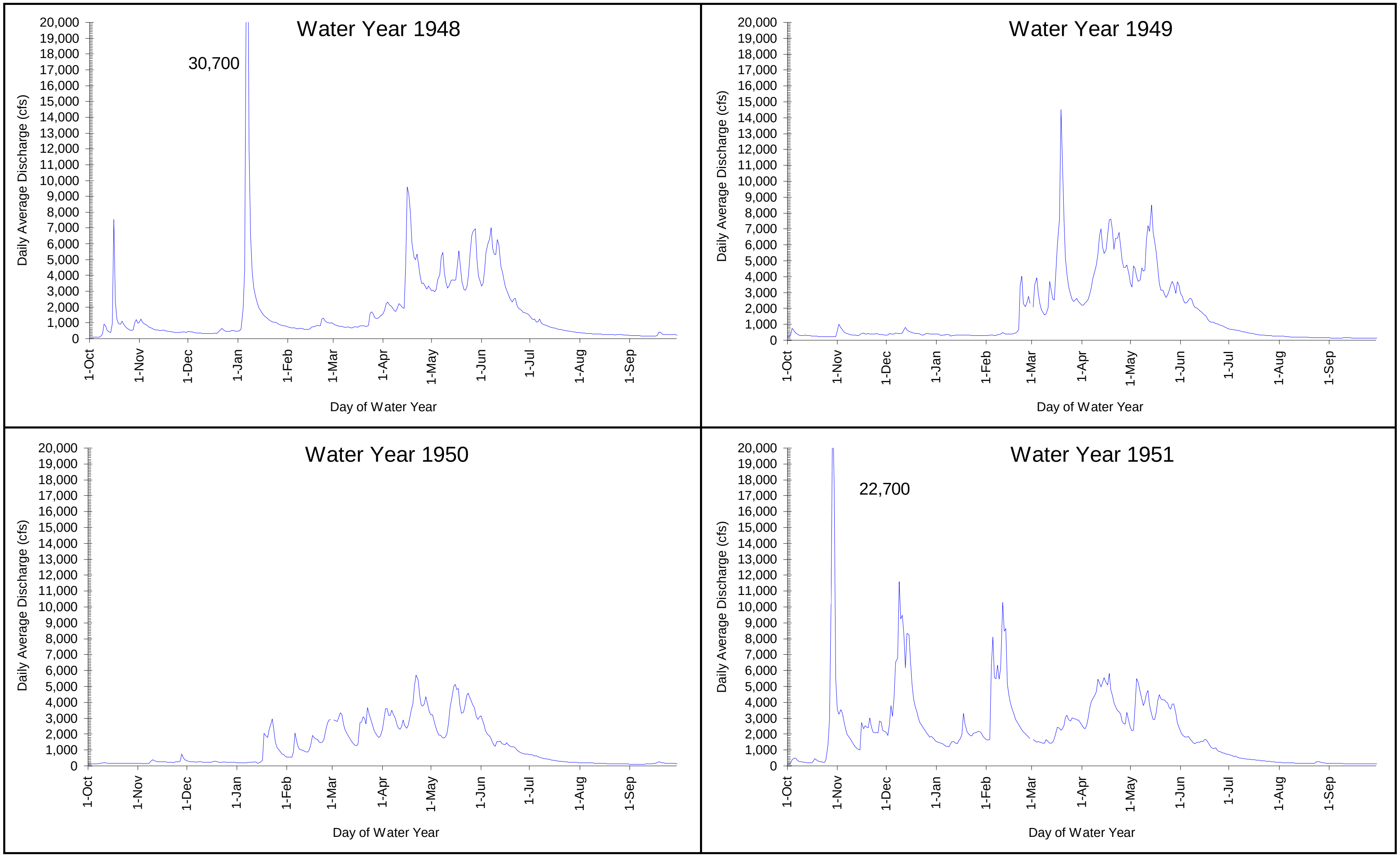
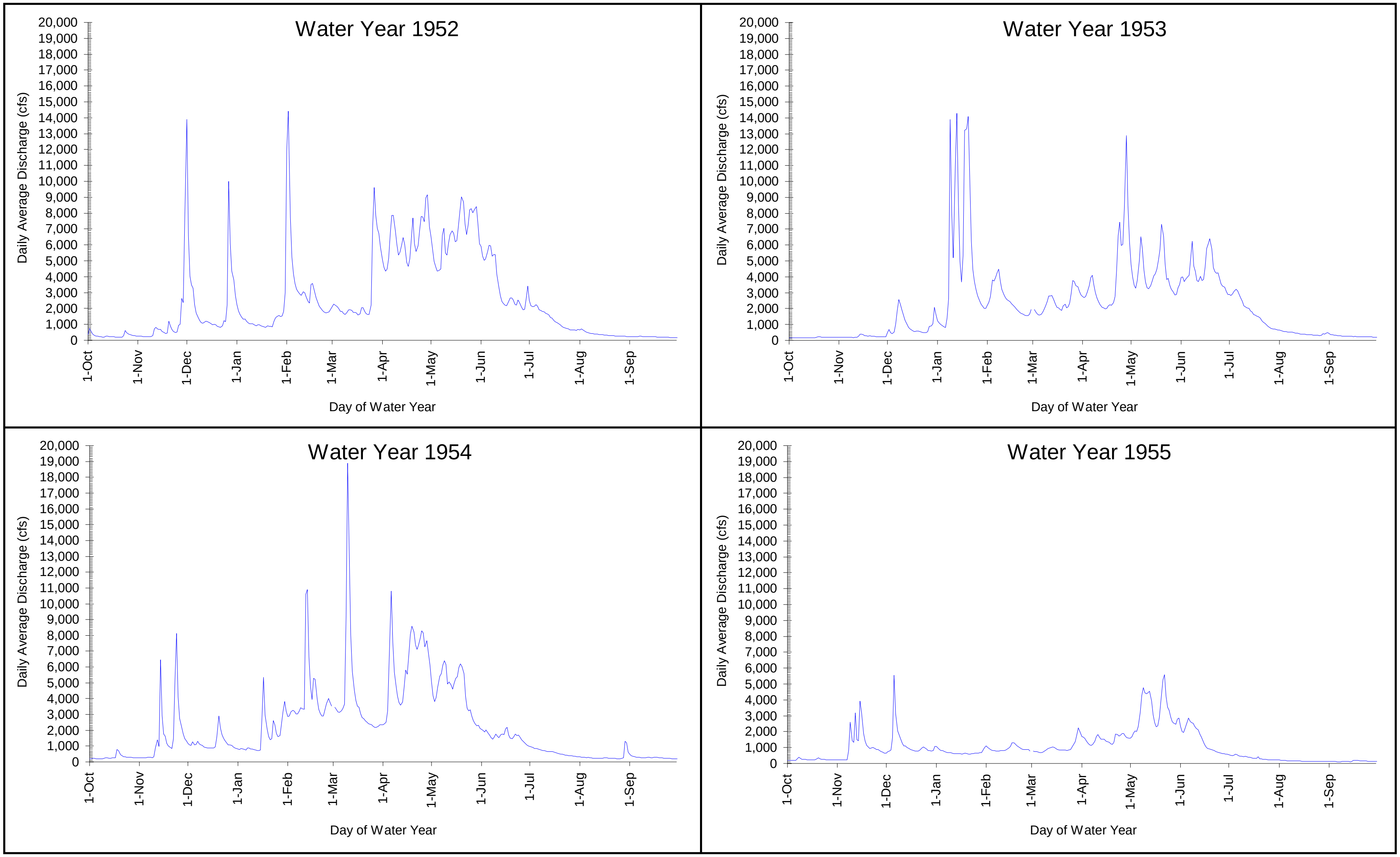
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
Day of Water Year


Water Year 1945
Daily Average Discharge (cfs)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
17,000
18,000
19,000
20,000
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
Day of Water Year


Water Year 1946
Daily Average Discharge (cfs)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
17,000
18,000
19,000
20,000
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
Day of Water Year


Water Year 1947
Daily Average Discharge (cfs)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
17,000
18,000
19,000
20,000
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
Day of Water Year


Water Year 1948
30,700
Water Year 1949
Water Year 1950
Water Year 1951
22,700
Daily Average Discharge (cfs)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
17,000
18,000
19,000
20,000
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
Day of Water Year


Water Year 1952
Water Year 1953
Water Year 1954
Water Year 1955
Daily Average Discharge (cfs)
Day of Water Year
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
17,000
18,000
19,000
20,000
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1-Jan
1-Feb
1-Mar
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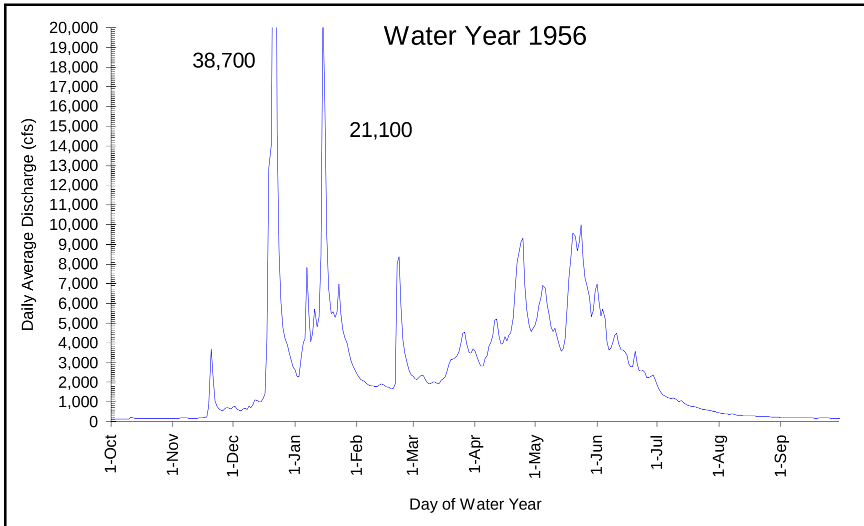
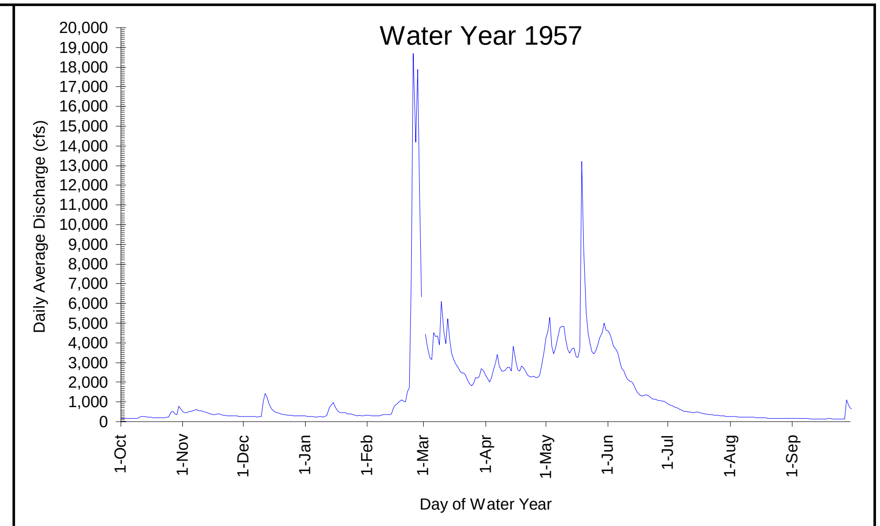
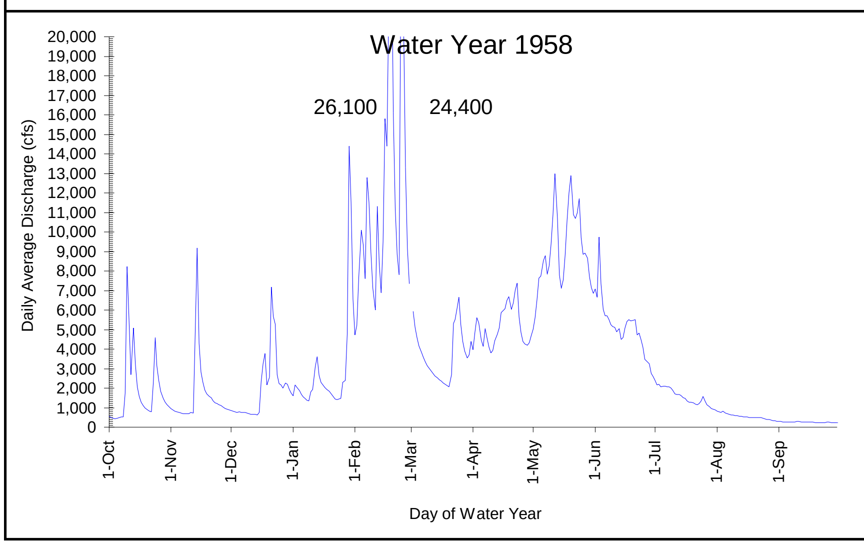
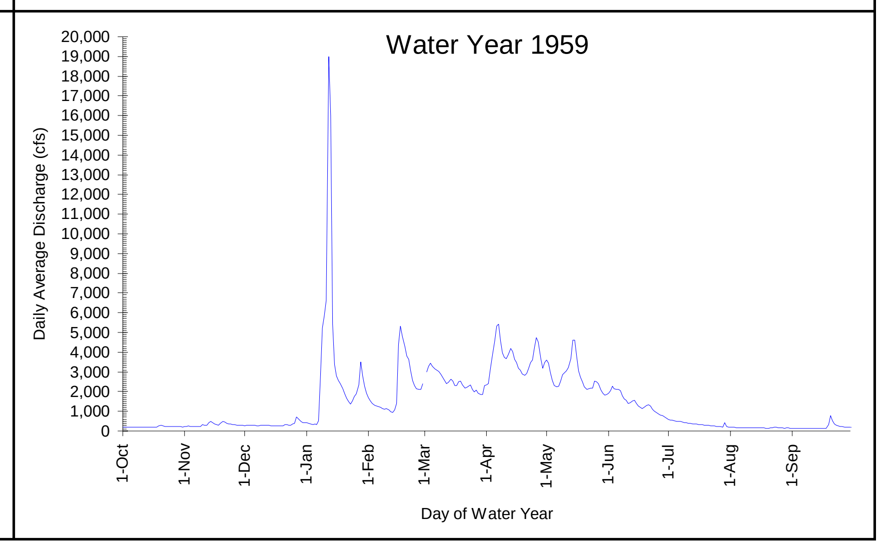
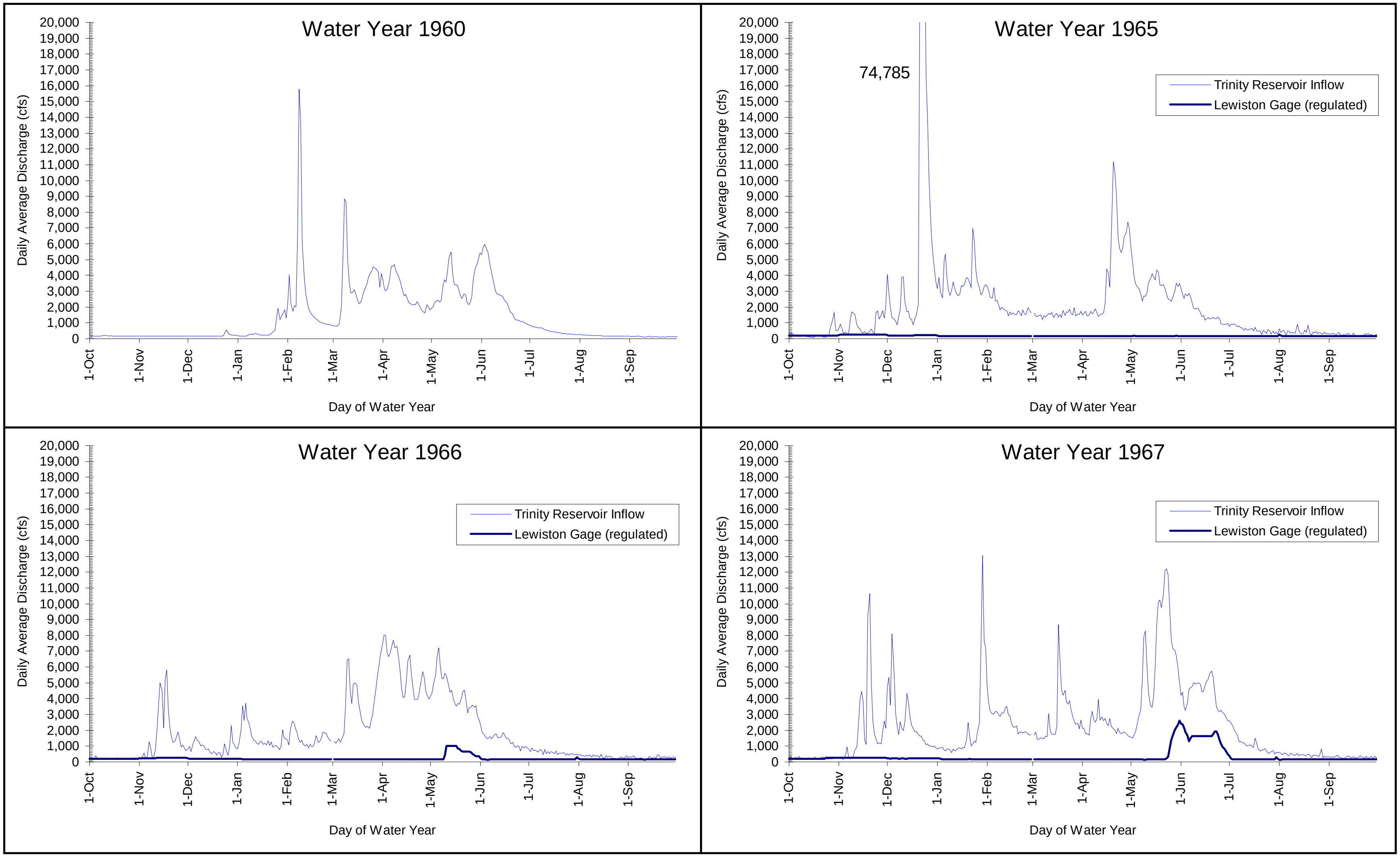
1-Jul
1-Aug
1-Sep

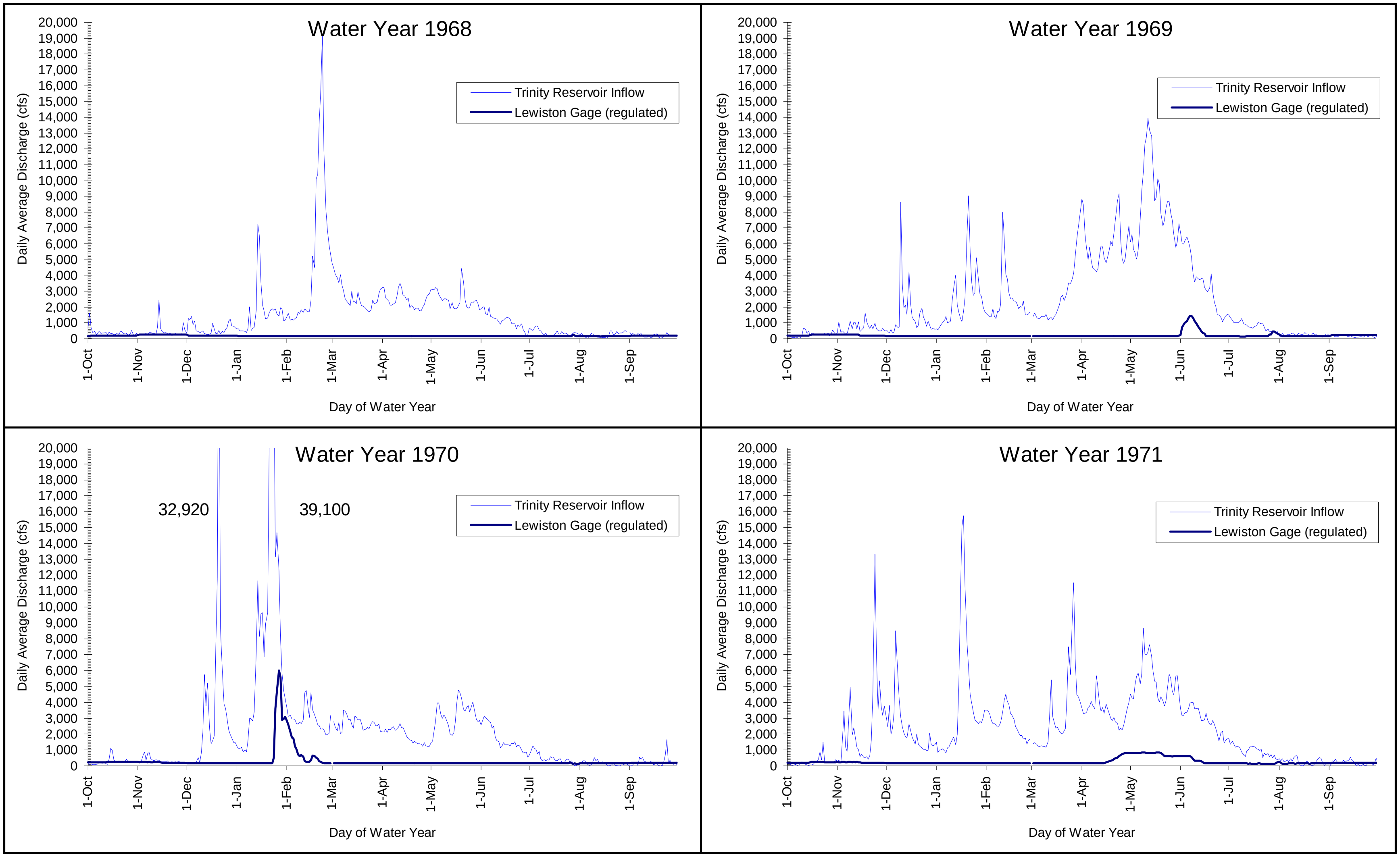

Water Year 1956
38,700
21,100
Daily Average Discharge (cfs)
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
Day of Water Year

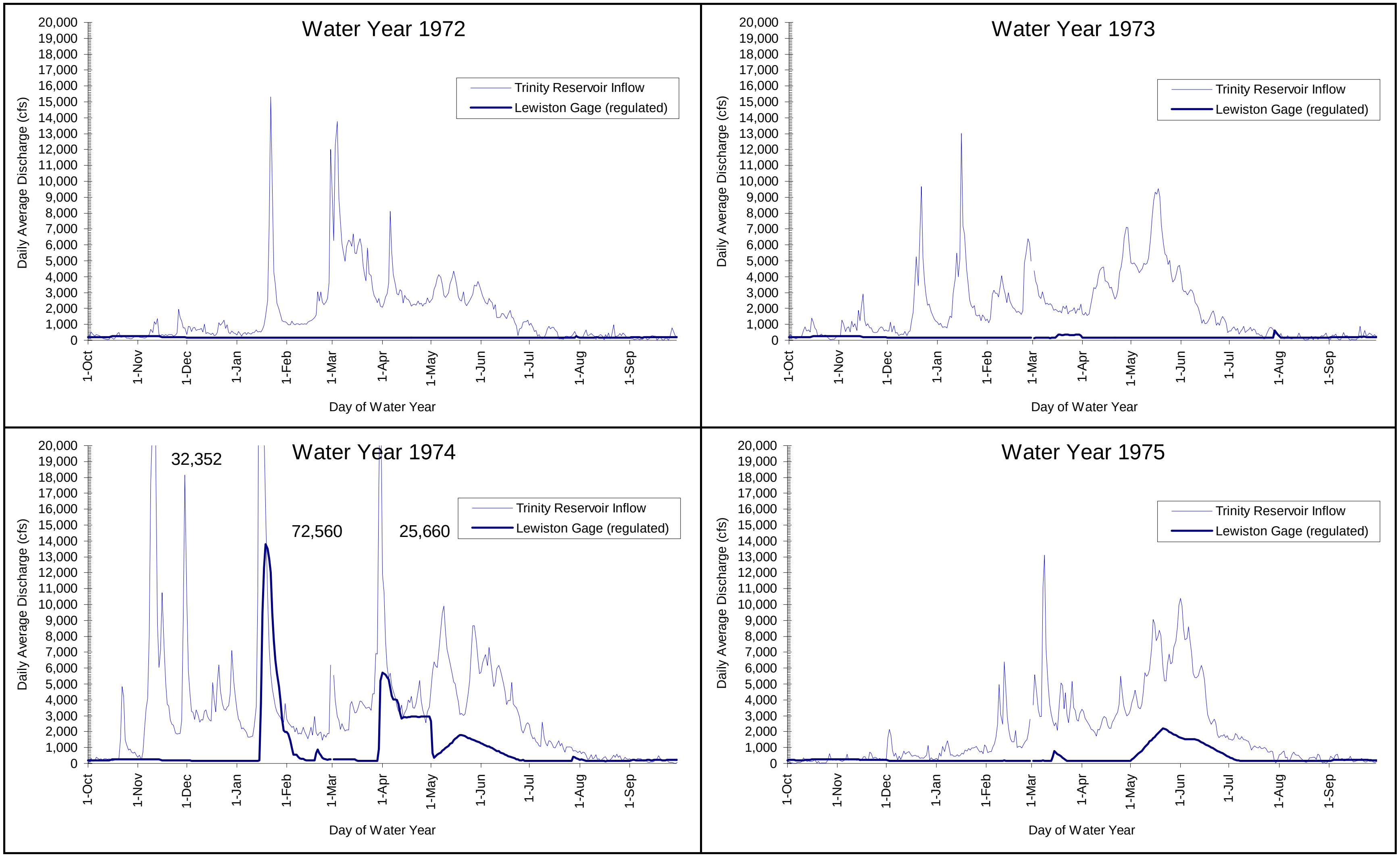

Water Year 1957
Daily Average Discharge (cfs)
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
Day of Water Year


Water Year 1958
26,100
24,400
Daily Average Discharge (cfs)
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
Day of Water Year


Water Year 1959
Daily Average Discharge (cfs)
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
Day of Water Year


Water Year 1960
Water Year 1965
Water Year 1966
Water Year 1967
74,785
Trinity Reservoir Inflow
Lewiston Gage (regulated)
Daily Average Discharge (cfs)
Day of Water Year
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep


Water Year 1968
Water Year 1969
Water Year 1970
Water Year 1971
Trinity Reservoir Inflow
Lewiston Gage (regulated)
Daily Average Discharge (cfs)
Day of Water Year
32,920
39,100
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep



Water Year 1972
Trinity Reservoir Inflow
Lewiston Gage (regulated)
Daily Average Discharge (cfs)
Day of Water Year
Water Year 1973
Trinity Reservoir Inflow
Lewiston Gage (regulated)
Daily Average Discharge (cfs)
Day of Water Year
Water Year 1974
32,352
72,560
25,660
Trinity Reservoir Inflow
Lewiston Gage (regulated)
Daily Average Discharge (cfs)
Day of Water Year
Water Year 1975
Trinity Reservoir Inflow
Lewiston Gage (regulated)
Daily Average Discharge (cfs)
Day of Water Year
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
17,000
18,000
19,000
20,000
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1-Nov
1-Dec
1-Jan
1-Feb
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1-Jun
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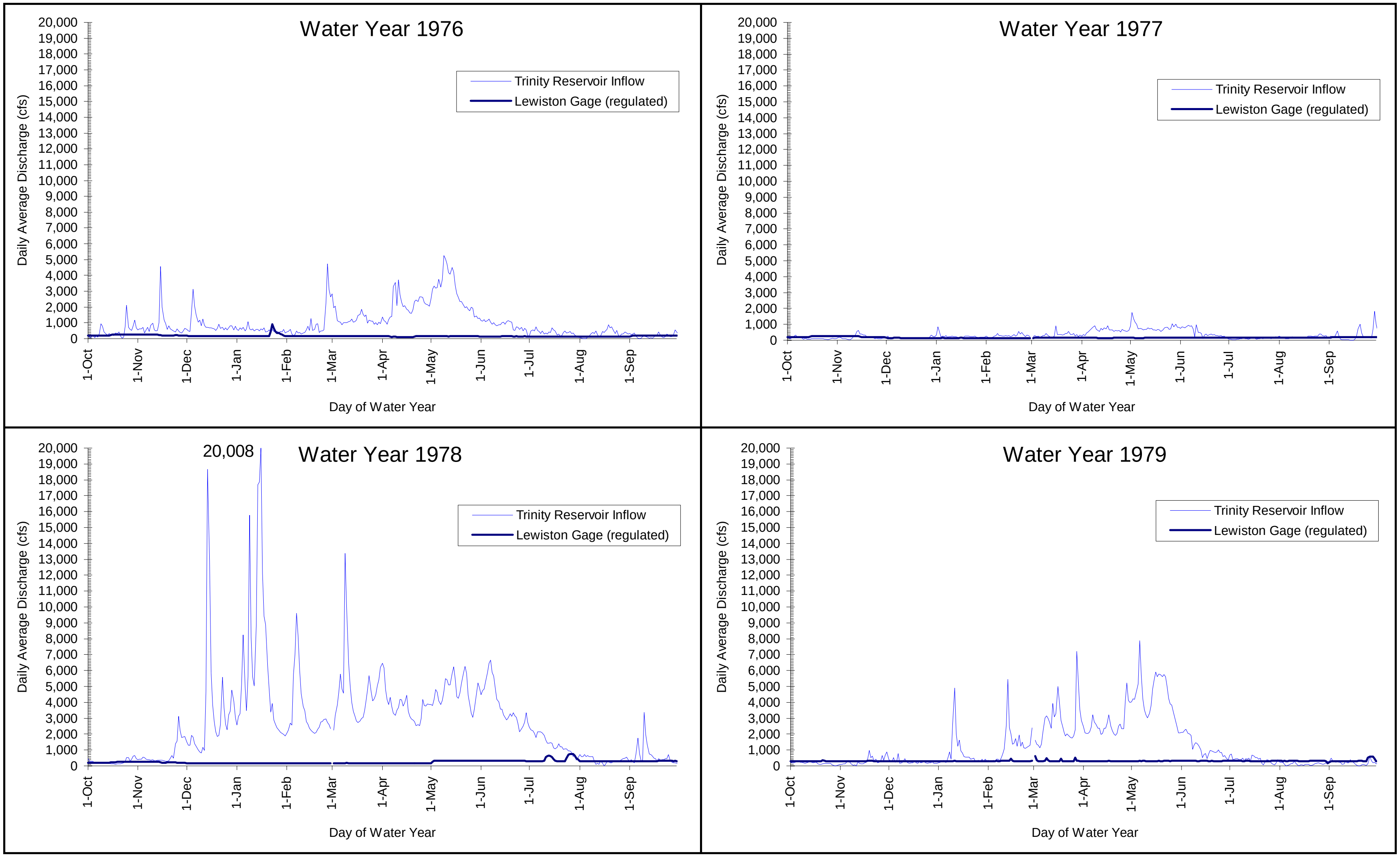
1-Aug
1-Sep


Water Year 1976
Trinity Reservoir Inflow
Lewiston Gage (regulated)
Daily Average Discharge (cfs)
Day of Water Year
Water Year 1977
Trinity Reservoir Inflow
Lewiston Gage (regulated)
Daily Average Discharge (cfs)
Day of Water Year
Water Year 1978
20,008
Trinity Reservoir Inflow
Lewiston Gage (regulated)
Daily Average Discharge (cfs)
Day of Water Year
Water Year 1979
Trinity Reservoir Inflow
Lewiston Gage (regulated)
Daily Average Discharge (cfs)
Day of Water Year
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
17,000
18,000
19,000
20,000
1-Oct
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1-May
1-Jun
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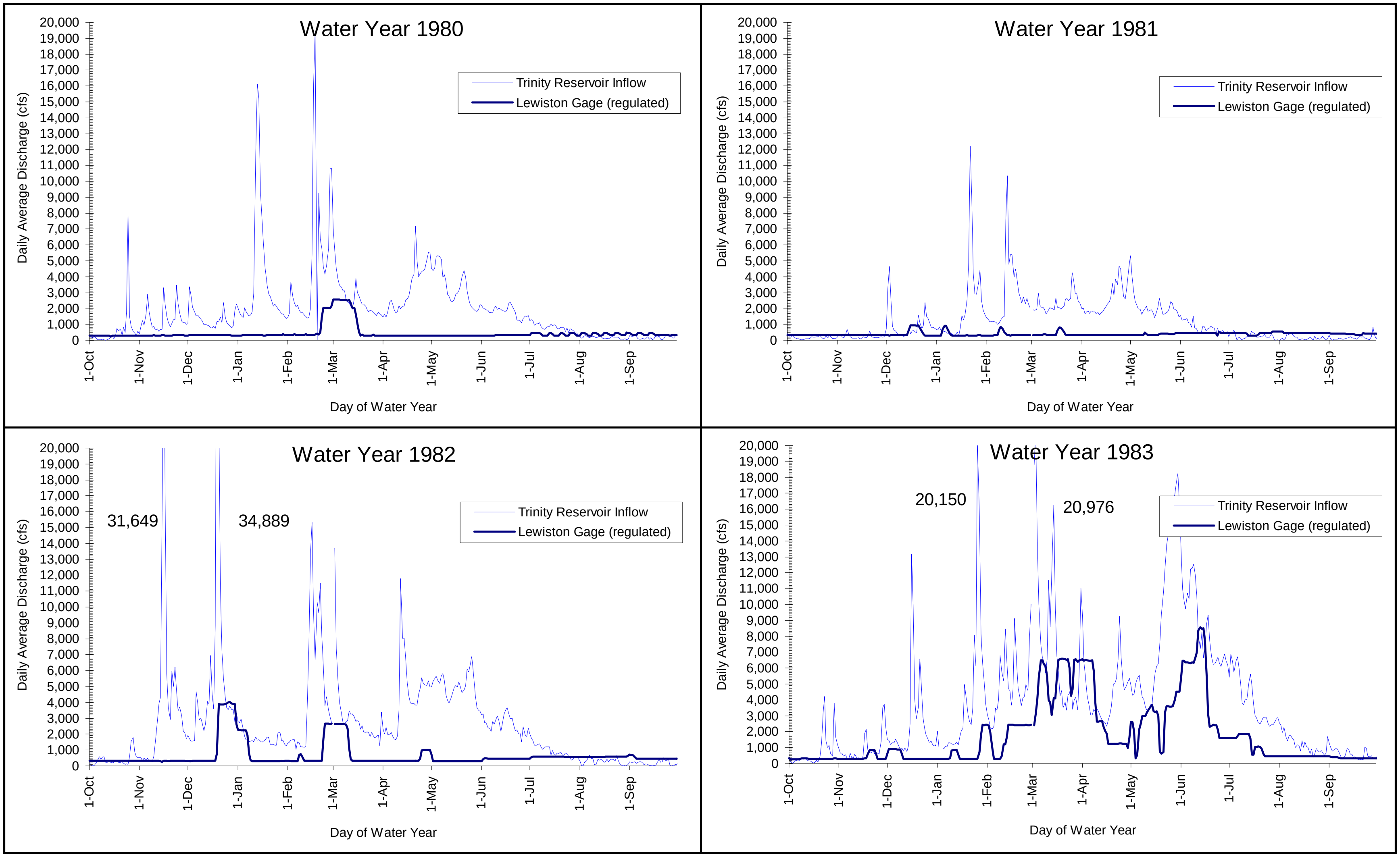
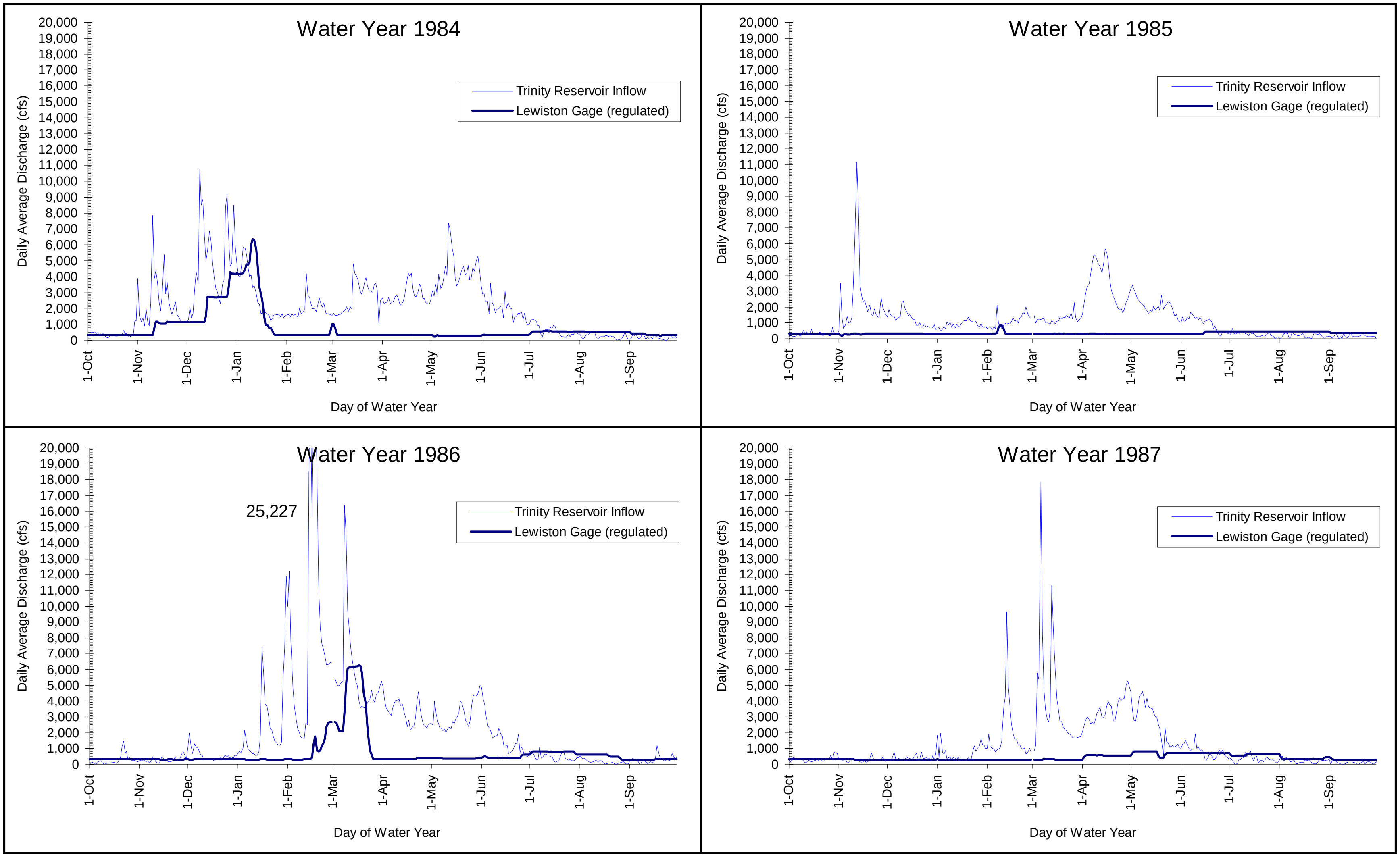
1-Aug
1-Sep


Water Year 1980
Trinity Reservoir Inflow
Lewiston Gage (regulated)
Daily Average Discharge (cfs)
Day of Water Year
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
Water Year 1981
Trinity Reservoir Inflow
Lewiston Gage (regulated)
Water Year 1982
31,649
34,889
Trinity Reservoir Inflow
Lewiston Gage (regulated)
Water Year 1983
20,150
20,976
Trinity Reservoir Inflow
Lewiston Gage (regulated)


Water Year 1984
Water Year 1985
Water Year 1986
Water Year 1987
25,227
Trinity Reservoir Inflow
Lewiston Gage (regulated)
Daily Average Discharge (cfs)
Day of Water Year
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
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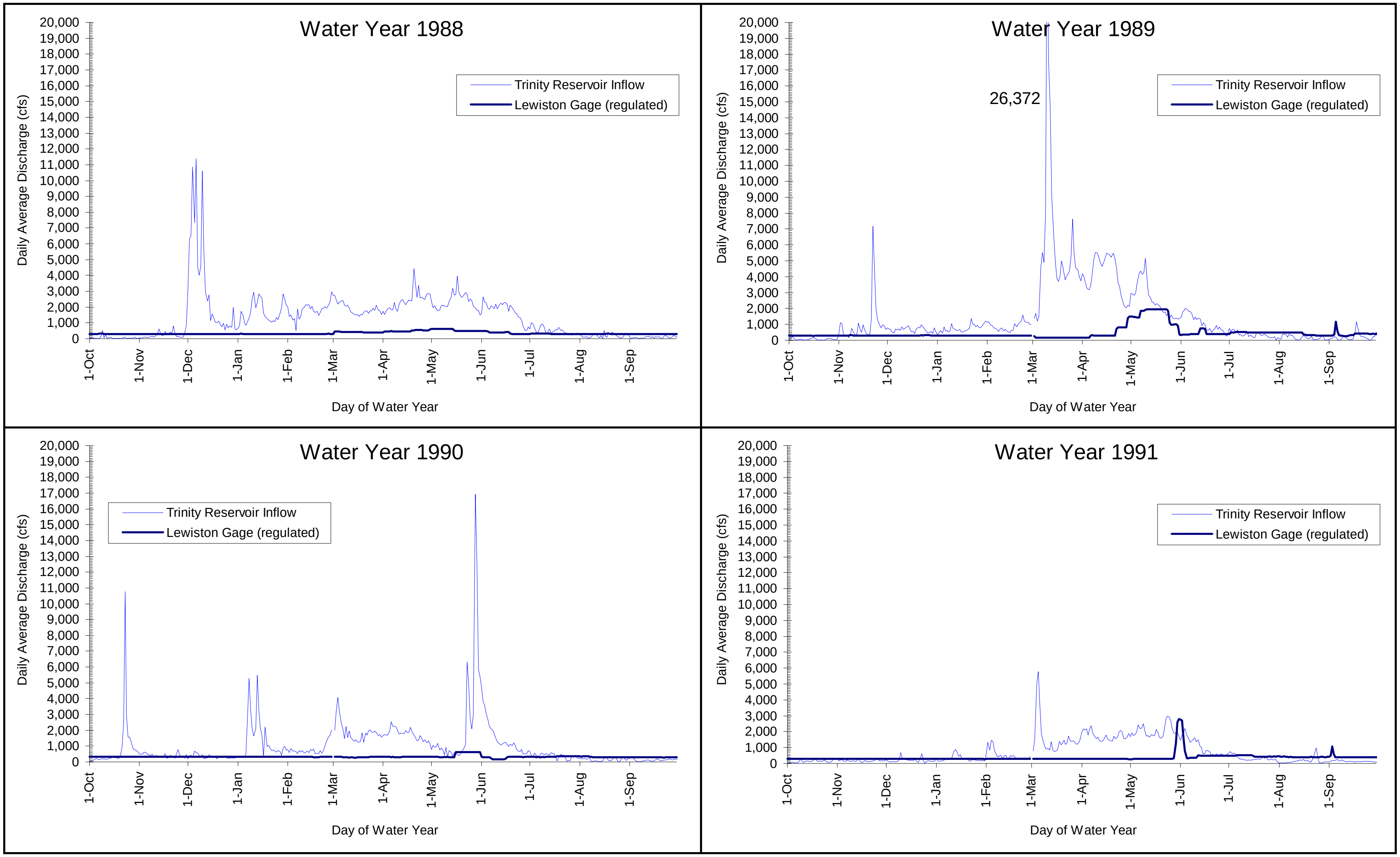
1-Aug
1-Sep


Water Year 1988
Water Year 1989
Water Year 1990
Water Year 1991
Trinity Reservoir Inflow
Lewiston Gage (regulated)
26,372
Daily Average Discharge (cfs)
Day of Water Year
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
17,000
18,000
19,000
20,000
1-Oct
1-Nov
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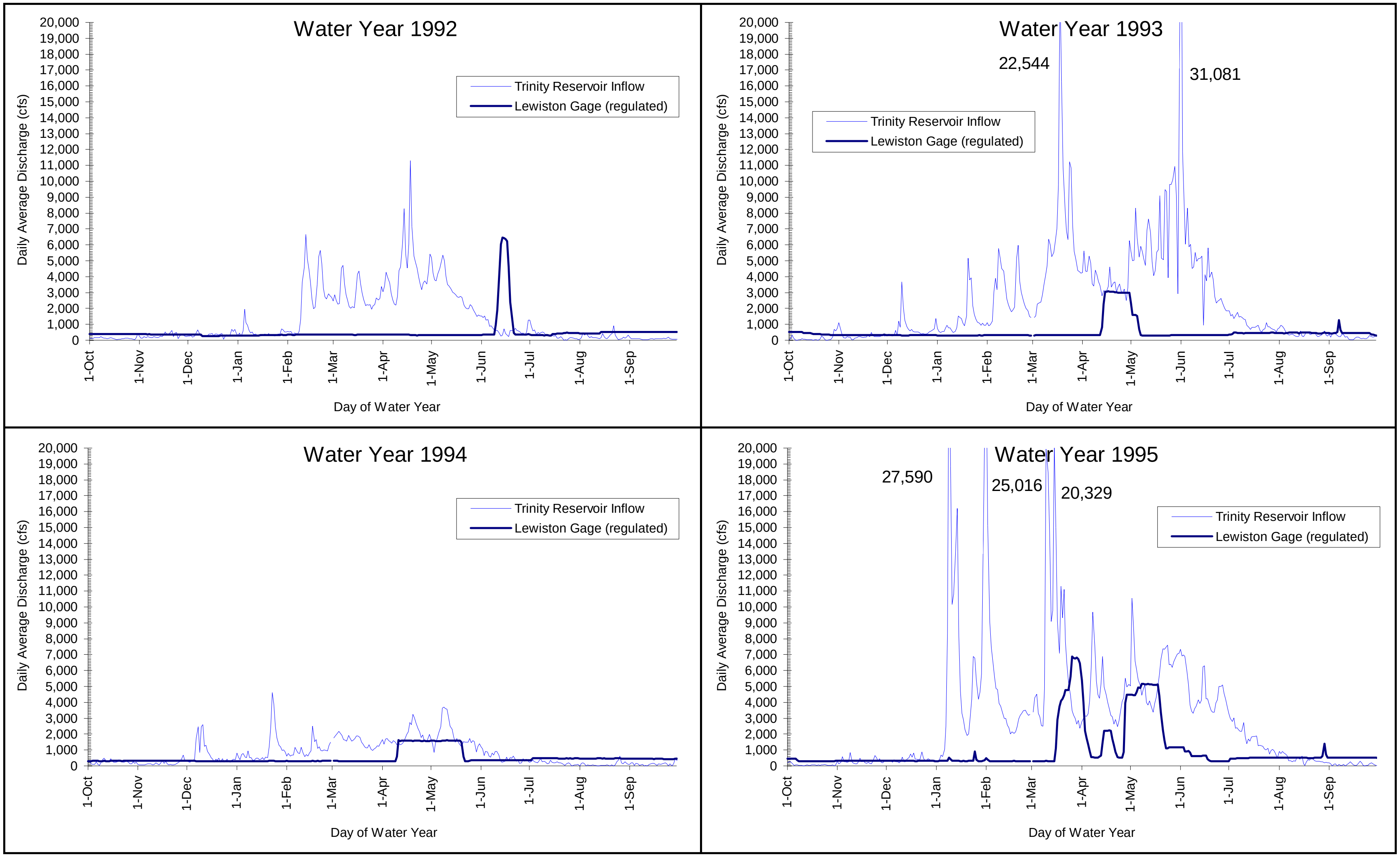
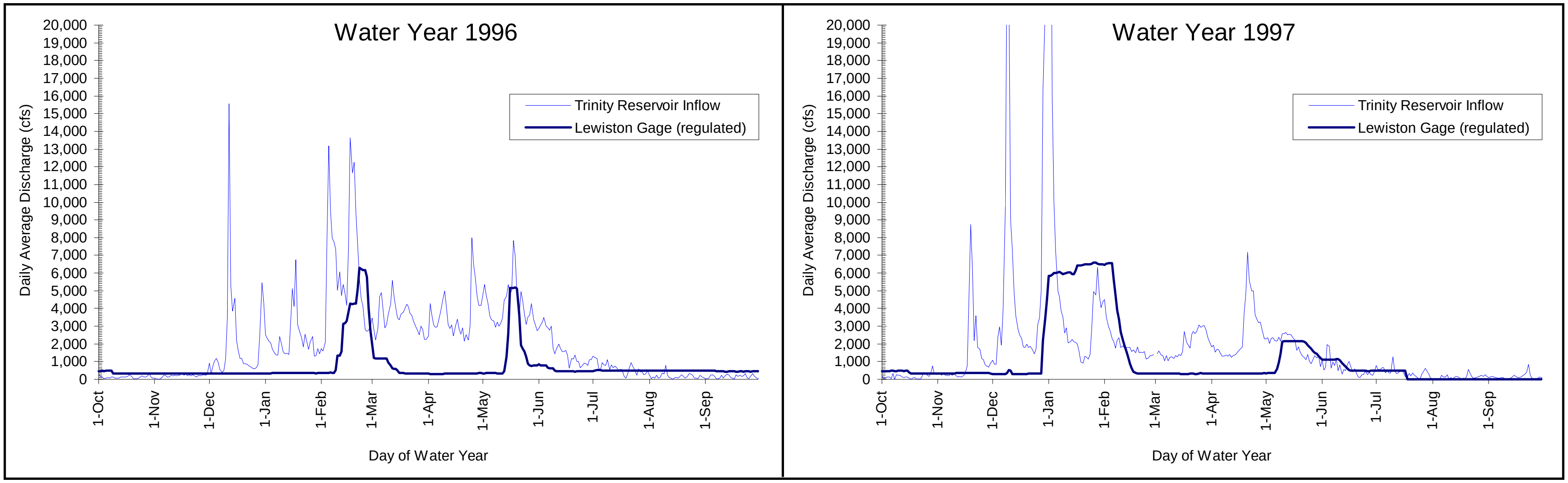
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep



Water Year 1992
Water Year 1993
Water Year 1994
Water Year 1995
Trinity Reservoir Inflow
Lewiston Gage (regulated)
Daily Average Discharge (cfs)
Day of Water Year
22,544
31,081
27,590
25,016
20,329
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep


Water Year 1996
Trinity Reservoir Inflow
Lewiston Gage (regulated)
Daily Average Discharge (cfs)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
17,000
18,000
19,000
20,000
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
Day of Water Year
Water Year 1997
Trinity Reservoir Inflow
Lewiston Gage (regulated)
Daily Average Discharge (cfs)
Day of Water Year

APPENDIX G

Rehabilitation Projects

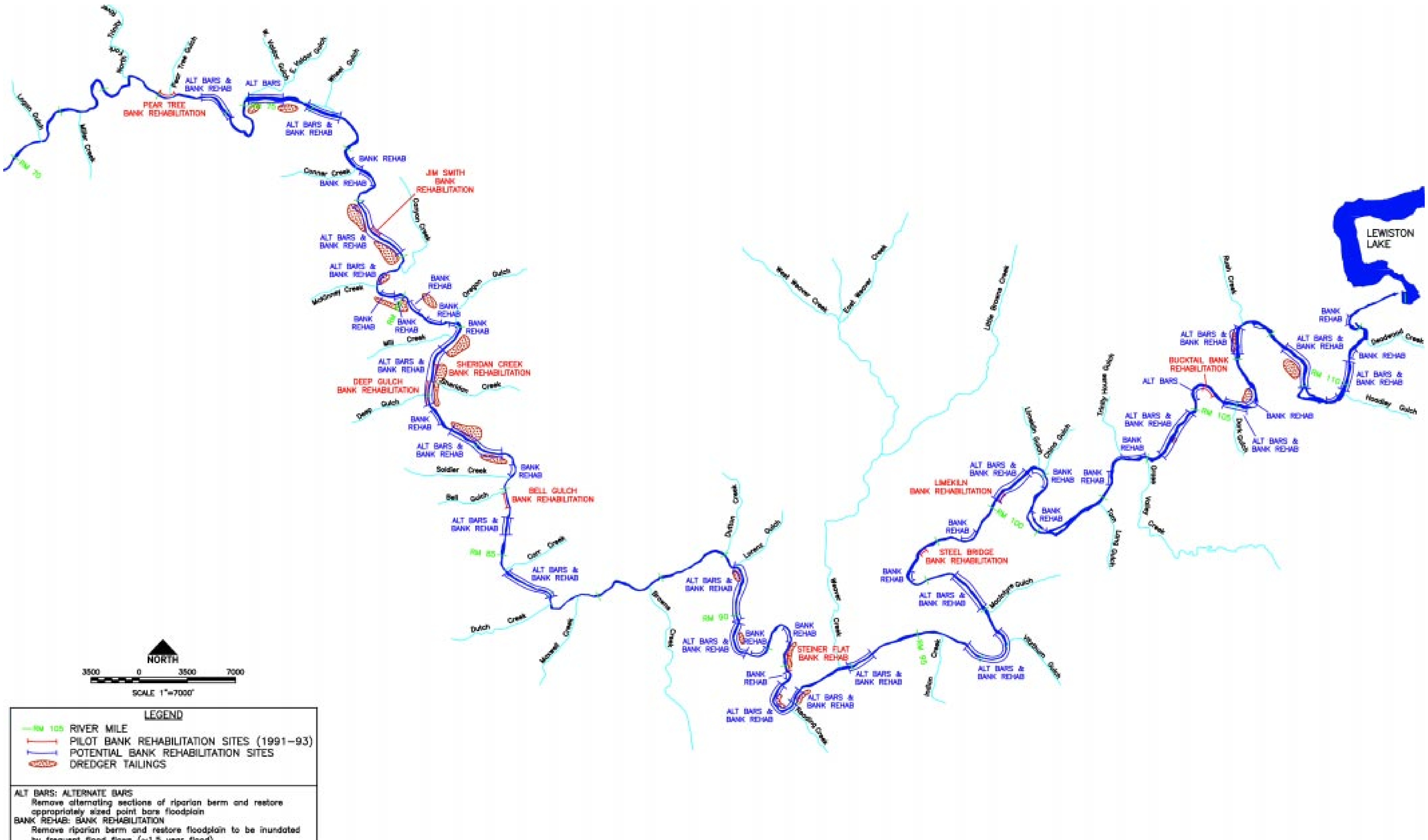


Plate 1. Existing and potential bank rehabilitation sites from Lewiston Dam (RM 112.0) to the North Fork Trinity River (RM 72.4).

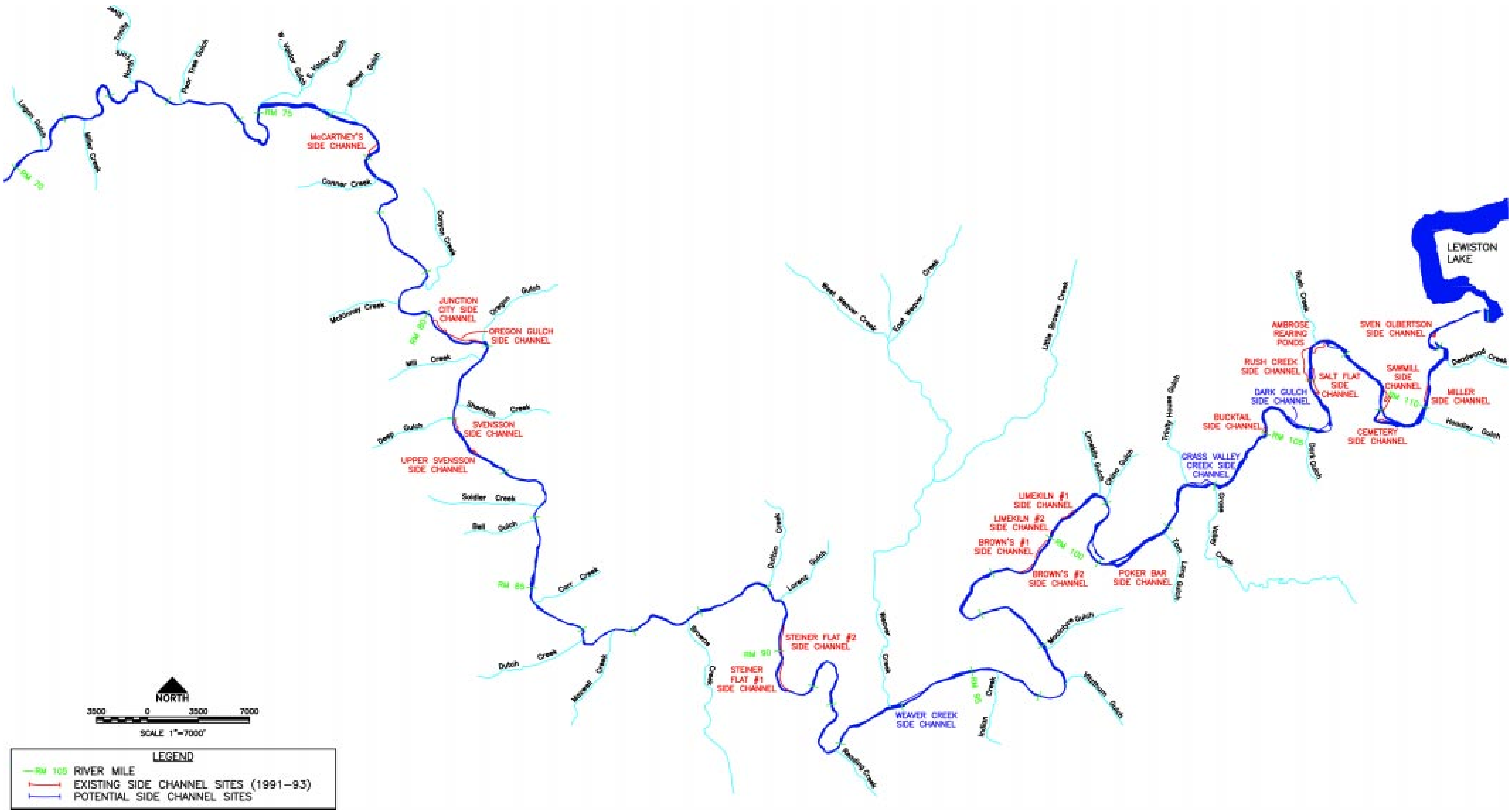


Plate 2. Existing and potential side channel construction sites from Lewiston Dam (RM 112.0) to the North Fork Trinity River (RM 72.4).

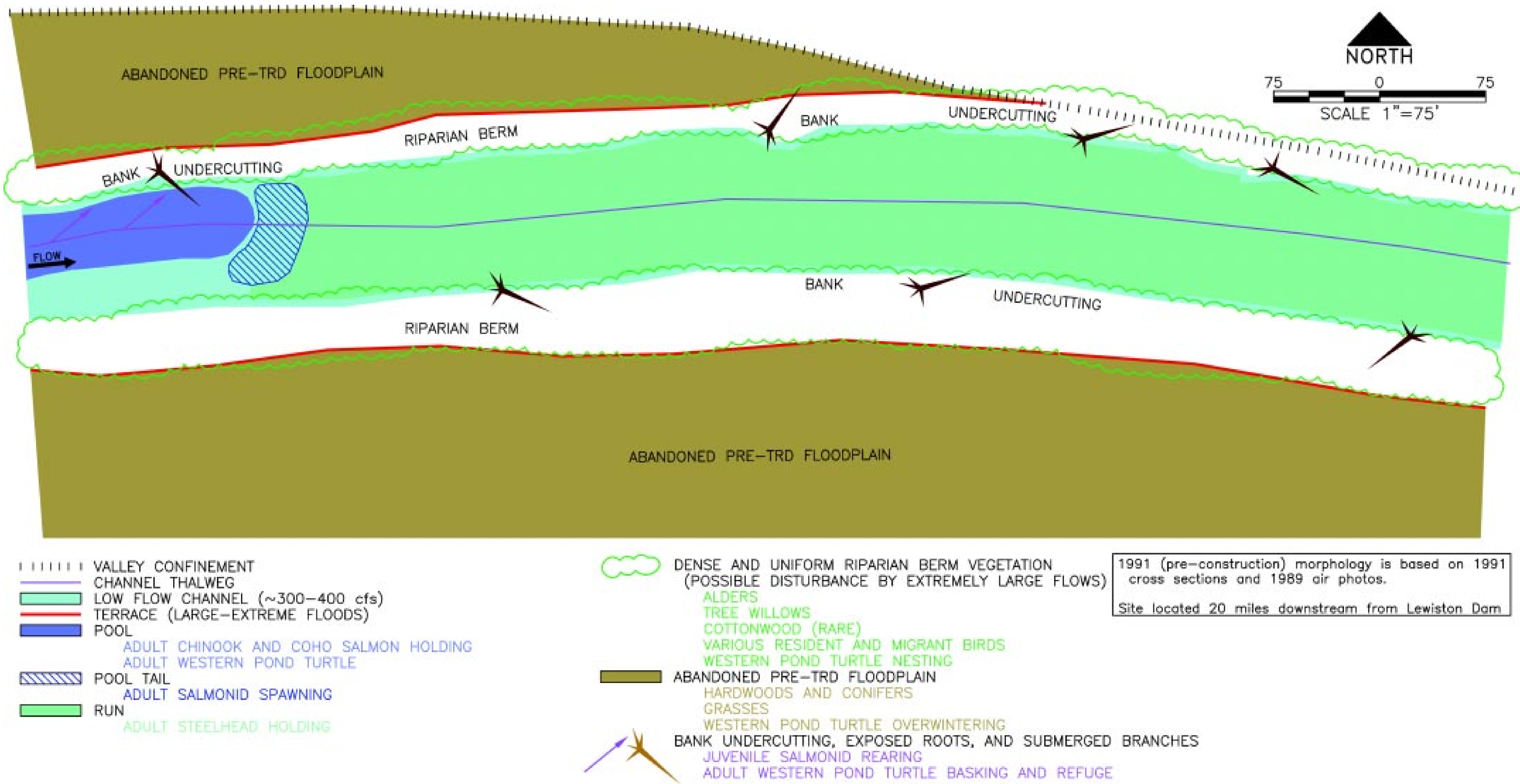


Plate 3. Example of channel morphology with riparian encroachment and low habitat diversity, Steiner Flat study site, 1991.

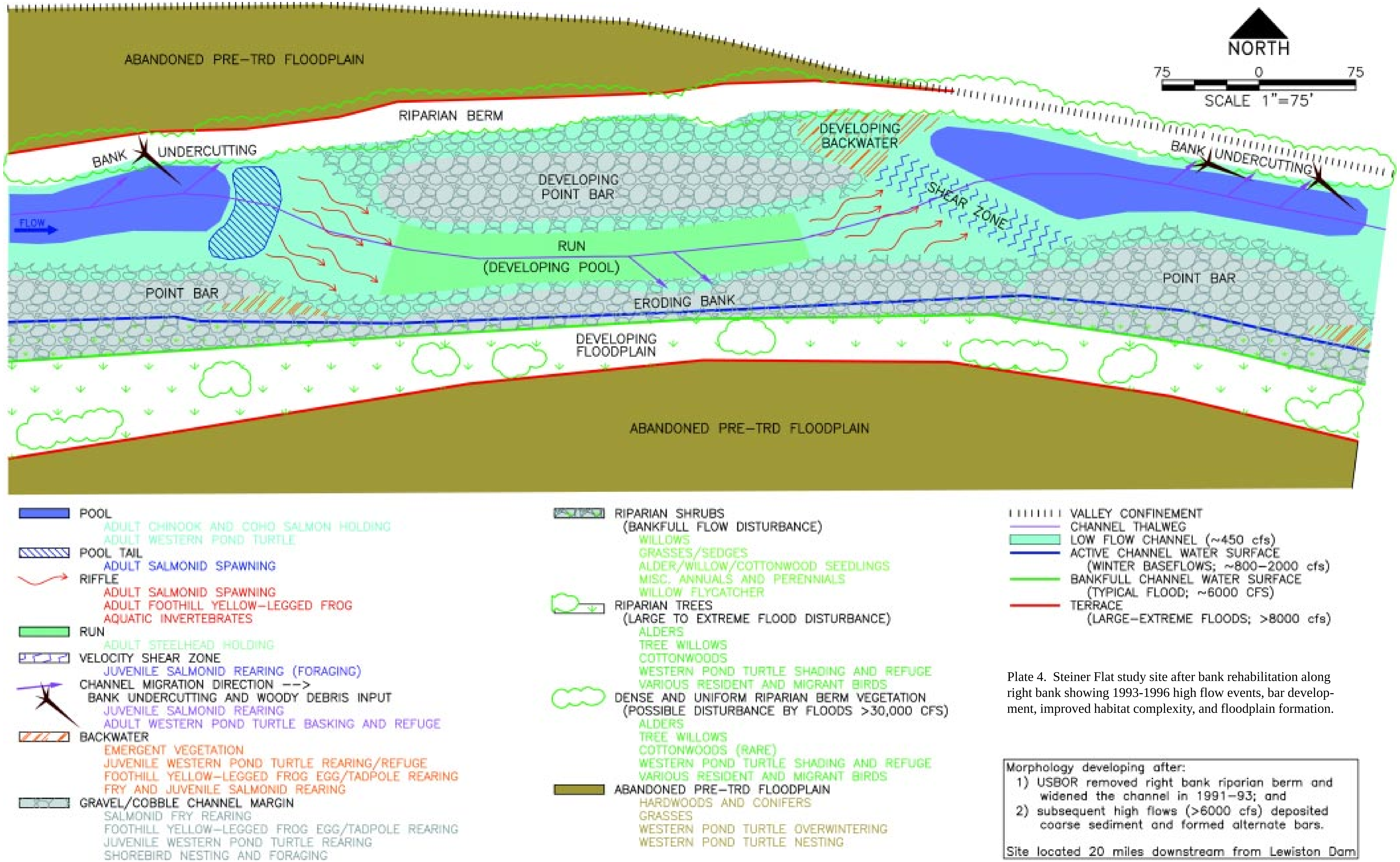


Plate 4. Steiner Flat study site after bank rehabilitation along right bank showing 1993-1996 high flow events, bar development, improved habitat complexity, and floodplain formation.

APPENDIX H

Attributes of Alluvial River Ecosystems

Attribute No. 1.
Spatially Complex Channel Morphology

No single segment of channelbed provides habitat for all species, but the sum of all channel segments provides high-quality habitat for native species. A wide range of structurally complex physical environments supports diverse and productive biological communities (Anderson and Nehring, 1985; Sullivan et al., 1987; Bisson et al., 1988; Hill et al., 1991).

***Desired Physical Responses*:**
- An alternate bar morphology extending upstream from the present alluvial transition zone near Indian Creek.
- Development of a functional floodplain, now missing from the post-TRD channel morphology.
- Asymmetrical cross-sections in a meandering channel with a sinuous thalweg pattern.

***Desired Biological Responses (if all annual hydrograph components are provided*)
- Riparian community with all stages of successional development.
- No loss of riparian habitat with channel migration.
- Diverse salmonid habitat available for all life stages over wide-ranging flows, flood and baseflow (Hill et al., 1991; Reeves et al., 1996; *in* Poff et al., 1997).

Attribute No. 2.
Flows and Water Quality Are Predictably Variable

Inter-annual and seasonal flow regimes are broadly predictable, but specific flow magnitudes, timing, duration, and frequencies are unpredictable because of runoff patterns produced by storms and droughts. Seasonal water-quality characteristics, especially water temperature, turbidity, and suspended-sediment concentration, are similar to those of regional unregulated rivers and fluctuate seasonally. This temporal "predictable unpredictability" is a foundation of river ecosystem integrity (Hill et al., 1991; Poff et al., 1997; Richter et al., 1997).

Objectives for Physical Processes:
- Inundate lower alternate bar features during dispersion of riparian plant seeds.
- Provide variable water depths and velocities over spawning gravels during salmonid spawning to spatially distribute redds.
- Inundate broader margins of alternate bars, including backside scour channels, to create shallow slack areas between late winter and snowmelt periods for early life stage of salmonids and amphibians.
- Provide a favorable range of baseflows for maintaining high-quality juvenile salmonid rearing and macroinvertebrate habitat within an alternate bar morphology.
- Provide late-spring outmigrant stimulus flows.
- Rapid post-snowmelt recession stage to strand/desiccate seedlings initiating/establishing on alternate bar surfaces.

Desired Physical Responses:

- Restore physical/riparian processes associated with a snowmelt peak and recession hydrograph components below Lewiston Dam.
- Optimize available physical habitat for anadromous salmonids for all seasons.
- Restore periodic inundation of the floodplain and groundwater dynamics.

Desired Biological Responses (if all annual hydrograph components provided):

- Elimination of most woody riparian cohorts from exposed surfaces of alternate bars.
- Establishment of early-successional riparian communities on floodplains and terraces.
- Improved anadromous salmonid egg survival.
- Natural seasonal timing of hydrograph components to complement life-history requirements of native plants and animals.
- Greater channel complexity, more habitat, and higher water quality for all freshwater life-history stages of salmonids.
- Increased macrobenthic invertebrate productivity.

Attribute No. 3.
Frequently Mobilized Channelbed Surface

Channelbed framework particles of coarse alluvial surfaces are mobilized by the bankfull discharge (Leopold et al., 1964; Richards, 1982; Nelson et al., 1987), which occurs on average every 1 to 2 years.

Objectives (every two of three years as an annual maximum):

- Achieve incipient condition for general channelbed surface.
- Surpass threshold for transporting sand through pools.
- Scour 1- to 2-year-old seedlings on alternate and medial bars.
- Frequently mobilize spawning gravel deposits.

Desired/Diagnostic Physical Responses:

- Mobilize surface rocks (D_{84}) in general channelbed surface and exposed portions of alternate bars.
- Reduce coarseness of surface layer above Indian Creek.
- Reduce sand storage in riffle/run habitat and pools.
- Create local scour depressions around large roughness elements.
- Mobilize spawning gravel deposits several surface layers deep.

Desired Biological Responses (if physical processes achieved):

- Higher survival of eggs and emerging alevins by reducing fines (Tagart, 1984; Sear, 1995; Poff et al., 1997).
- Greater substrate complexity in riffle and run habitats for improved macroinvertebrate production (Boles, 1976; Nelson et al., 1987; Ward, 1998).
- Scour 1-and 2-year-old woody riparian seedlings along margins of alternate bars.

- Greater habitat complexity (micro-habitat features).
- Deeper pool depths/volumes for adult fish cover and holding (Platts et al., 1983; Nelson et al., 1987; Sullivan et al., 1987; Bisson et al., 1988; Barnhart and Hillemeier, 1994).

Attribute No. 4.
Periodic Channelbed Scour and Fill

Alternate bars are scoured deeper than their coarse surface layers by floods exceeding 3- to 5-year annual maximum flood recurrences. This scour is typically accompanied by re-deposition, such that net change in channelbed topography following a scouring flood usually is minimal.

Objectives for Physical Processes:

- Rejuvenate spawning gravel deposits.
- Kill 2- to 4-year-old seedlings establishing on alternate bar surfaces.
- Deposit fine substrate onto upper alternate bar and floodplain surfaces.

Desired Physical Responses:

- Close to dam, reduction in surface-to-subsurface D_{50} and D_{84} particle-size ratios.
- Significant scouring (several surface layers deep) of most alluvial features, including steeper riffles.
- Formation of alternate bar sequences upstream from Indian Creek.
- More alternate bars and developing bar sequences downstream from Douglas City.
- Increased diversity of surface particle-size distributions.
- Greater topographic complexity of side channels associated with alternate bars, especially distal portions.
- Increased pool depths.

Desired Biological Responses (if physical processes achieved):

- Improved anadromous salmonid spawning and rearing habitat (Hill et al., 1991).
- Reestablishment of dynamic riparian plant stands in various stages of succession on higher elevations of alternate bars.
- Mortality of 3- to 4-year-old saplings on alternate bar surfaces to discourage riparian plant encroachment and riparian berm formation.
- Rehabilitation of habitat for riparian-dependent amphibian, bird, and mammal species.

Attribute No. 5.
Balanced Fine and Coarse Sediment Budgets

River reaches export fine and coarse sediment at rates approximately equal to sediment inputs. The amount and mode of sediment storage within a given river reach fluctuates, but channel morphology is sustained in dynamic quasi-equilibrium when averaged over many years (Sear, 1994; Poff et al., 1997).

Objectives for Physical Processes:

- Reduce fine sediment storage in the mainstem.
- Maintain coarse sediment storage in the mainstem.
- Route mobilized D_{84} through alternate bar sequence every two of three years, on average.
- Prevent mainstem accumulation of tributary bed material.
- Eliminate bedload impedance reaches.

Desired Physical Responses:

- D_{84} tracer rocks should negotiate alternate bar sequences; i.e., larger particles from upstream riffles should not accumulate in downstream pools.
- Reduced storage of fine sediment in riparian berms.
- Eliminate aggradation, and encourage slight degradation of bed elevation at tributary deltas (smooth-out longitudinal profile through these reaches).
- Increases pool depths.
- Maintains physical complexity by sustaining alternate bar morphology.

Desired Biological Responses:

- Improves and maintain spawning and rearing habitat quality without reducing quantity (Poff et al., 1997).
- Increases adult salmonid cover and holding (Nelson et al., 1987).
- Reduces riparian berms.

Attribute No. 6.
Periodic Channel Migration

The channel migrates at variable rates and establishes meander wavelengths consistent with regional rivers with similar flow regimes, valley slopes, confinement, sediment supply, and sediment caliber (Williams and Wolman, 1984; Chien, 1985, in Poff et al., 1997; Sullivan et al., 1987; Johnson, 1994).

Objectives for Physical Processes:

- Promote bank erosion in alluvial reaches.
- Floodplain deposition every 3 to 5 years.
- Create channel avulsions every 10 years on average.

- Encourage meander wavelengths 8 to 10 bankfull-widths long.
- Stored sediment in the floodplain is slowly released downstream.

Desired Physical Responses:

- Maintain channel width while channel migrates.
- Create sloughs through infrequent channel avulsions.
- Create side channels through frequent alternate bar reshaping.
- Increase meander amplitude and expression of the thalweg.
- Create water temperature variability within alternate bar sequences.
- Increase input of large woody debris along channel margins.

Desired Biological Responses (if all physical objectives achieved):

- Diverse age class structure in stands of cottonwood and other species dependent on channel migration.
- Full range of seral stages in riparian plant communities.
- Increased habitat quality and quantity for native vertebrate species dependent on early successional riparian forests (Hartman, 1965; Bustard and Narver, 1975; Sullivan, 1987).
- High flow refuge and summer thermal refugia for amphibians and juvenile fish provided in rejuvenated scour channels.
- Increased habitat complexity by input of large woody debris from eroding banks.

Attribute No. 7.
A Functional Floodplain Floodplain

On average, floodplains are inundated once annually by high flows equaling or exceeding bankfull stage. Lower terraces are inundated by less frequent floods, with their expected inundation frequencies dependent on norms exhibited by similar, but unregulated river channels. These floods also deposit finer sediment onto the floodplain and low terraces (Leopold et al., 1964; Sullivan, 1987; Poff et al., 1997; Ward, 1998).

Objectives for Physical Processes:

- Inundate the floodplain on average once annually.
- Encourage local floodplain surface deposition and/or scour by less frequent but higher floods.
- Have floodplain construction keep pace with floodplain loss as the channel migrates across the river corridor.
- Provide sufficient channel confinement to maintain hydraulic processes (Attribute Nos. 3 and 4).

Desired Physical Responses:

- Maintain channel width as river migrates.
- Increase hydraulic roughness and greater flow storage during high-magnitude floods.

Desired Biological Responses (if all physical objectives achieved):

- Increased woody riparian overstory and understory species diversity, compensating for woody riparian stands lost along outside banks of eroding meander bends.
- Keeps physical processes conducive for maintaining early-successional riparian dependent species, especially for birds and amphibians.

Attribute No. 8.
Infrequent Channel-Resetting Floods

Single large floods (e.g., exceeding 10- to 20-year recurrences) cause channel avulsions, widespread rejuvenation of mature riparian stands to early-successional stages, side channel formation and maintenance, and off-channel wetlands (e.g., oxbows). Resetting floods are as critical for creating and maintaining channel complexity as are lesser magnitude floods (Sullivan et al., 1987; Poff et al., 1997; Ward, 1998).

Objectives for Physical Processes:

- Form/Reshape alternate bar surfaces every 10 to 20 years, on average.
- Improve bedload routing by minimizing impedance of bedload transport past tributary deltas.
- Eliminate or minimize extent of mature riparian vegetation stands on alternate bar surfaces and floodplains every 10 to 20 years.
- Deposit fine substrate on lower terrace surfaces once every 10 to 20 years.
- Provide infrequent deep scour high on alternate bars and on the floodplain.
- Construct and maintain (rejuvenate) natural side channels.
- Scour and redeposit entire alternate bar sequences every 10 to 20 years.

Desired Physical Responses:

- Deep scour (several D_{84} surface layers deep) in most alluvial features, including steeper riffles.
- Significant channel migration and infrequent channel avulsion.
- Alternate bar scour and redeposition.
- Extensive removal of saplings and mature trees in riparian stands.
- Increase complexity of natural side channels.

Desired Biological Responses (if physical processes achieved):

- Improve anadromous salmonid spawning and rearing habitats.
- Increase adult fish cover and holding habitat (Nelson et al., 1987).
- Create dynamic riparian stands in various stages of succession on higher elevations of alternate bars.
- Control populations of 3- to 4-year-old saplings on alternate bar surfaces close to channel center, and scour stands of mature riparian vegetation.

Attribute No. 9.
Self-Sustaining Diverse Riparian Plant Communities

Natural woody riparian plant establishment and mortality, based on species life history strategies, culminate in early- and late-successional stand structures and species diversities (canopy and understory) characteristic of self-sustaining riparian communities common to regional unregulated river corridors (Beschta and Platts, 1986; Ligon et al., 1995; Poff et al., 1997).

Objectives for Riparian Processes:

- Prevent woody riparian plant encroachment.
- Maintain early-successional woody riparian communities.
- Remove mature riparian trees established in the riparian berms.
- Eliminate widespread presence of riparian berms.
- Rehabilitate off-channel wetland communities.

Desired Biological Responses (if all physical objectives achieved):

- Floods periodically scour seedlings and saplings.
- Channel migration initiates new riparian cohorts.
- Channel avulsion creates oxbows and off-channel wetland habitats, initiating diverse patches of riparian stands.
- Woody riparian overstory and understory species diversity and age class distribution increases in floodplains.
- Greater habitat availability for wildlife dependent on early seral stages of riparian plant communities.

Attribute No. 10.
Naturally-fluctuating Groundwater Table

Inter-annual and seasonal groundwater fluctuations in floodplains, terraces, sloughs, and adjacent wetlands occur in a manner similar to that in regional unregulated river corridors (Stanford et al., 1996; Ward, 1998).

Objectives for Physical Processes:

- Naturally fluctuating seasonal groundwater elevation and surface-water elevations in scour channels and off-channel wetlands.

Desired Physical Responses:

- Maintenance of off-channel habitats, including overflow channels, oxbow channels, and flood-plain wetlands.

Desired Biological Responses (if physical processes achieved):

- High diversity of habitat types within the entire river corridor (Poff et al., 1997; Ward, 1998).

APPENDIX I

Plan of Study for Trinity River Fishery Flow Evaluations

Plan of Study
For Trinity River
Fishery Flow Evaluations

Trinity River, Northwestern California

Lead Agency: U. S. Fish and Wildlife Service
Assisting Agencies: Members of the Trinity River Basin
Fish and Wildlife Task Force

Approved: /sgd/ Ronald Lambertson DEC 8- 1983
Acting Director, U.S. Fish and Wildlife Service Date

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Study Goal: The goal of this study is to monitor the rehabilitation of fishery habitat in the Trinity River below Lewiston Dam in northwestern California. The information from this study together with harvest and escapement information from other ongoing studies will be used to advise the Secretary whether the Department is operating the Trinity River Division consistent with its authorizing provisions for the protection and propagation of fishery resources. This study will meet the intent of the Secretarial decision of January 1981 pertaining to increased flow releases for anadromous fishery protection in the Trinity River downstream of Lewiston Dam - a major feature of the Trinity River Division, Central Valley Project, operated by the U.S. Bureau of Reclamation.

Backqround and Overview: The Trinity River is a major tributary of the Klamath River in northwestern California. The natural resources of the Trinity River Basin sustain many important resource-based social and economic interests. Historically, the Trinity has been recognized as a major producer of chinook and coho salmon and steelhead trout. Indian, sport and commercial salmon fisheries have operated on these runs. Mineral, timber and water resources have also been developed in the Trinity Basin. These developments together with fisheries harvest, are believed to have caused major declines in fall-run chinook and steelhead trout populations over the past two decades. Specific user groups dependent on the fisheries stocks as well as the general northern coastal economics have suffered as a result of the fisheries declines.

These losses are of high concern to this Department for two reasons:
First, the Department has Indian Trust responsibilities which extend to protection of Indian fisheries rights and resources and, second, the act authorizing the construction of the Trinity River Division of the Central Valley Project directs the Secretary to preserve and propagate anadromous fish in the basin.

The Trinity River Division which is the only major water development project in the Trinity River Basin serves to export water from the Trinity River to the Central Valley of California. Since its operation began in 1963, the project has annually exported about 75-90 percent of the runoff at Lewiston Dam. The reminder of flow has been released downstream either for fisheries purposes (about 10 percent annually 1963-73 and somewhat higher in more recent years) or as water surplus to the project's immediate needs.

Coincident with construction and operation of the Trinity River Division, logging accelerated within the Trinity Basin. Higher watershed erosion rates and lowered stream flows downstream of Lewiston Dam resulted in extensive sedimentation of fish habitat. Maintenance of minimum stream-flow releases and construction and operation of a fish hatchery were not sufficient to sustain fisheries populations. Declines in some stocks have exceeded 90 percent of former levels.

In December of 1980, the Fish and Wildlife Service and the Bureau of Reclamation reached an agreement to increase releases to the Trinity River below Lewiston Dam to aid in the rehabilitation of the important and rapidly dwindling anadromous fishery resources. The agreement was approved by the former Secretary Andrus in January 1981 and has been supported by Secretary Watt.

In addition to increasing flow releases for fishery purposes, the agreement also provides for a special study over a 12-year period during which improved releases would be maintained. The Fish and Wildlife Service is to conduct the study in consultation with the Bureau of Reclamation and the California Department of Fish and Game. At the end of the 12-year period, a report will be made to the Secretary describing the effectiveness of the improved flows and any other habitat rehabilitation measures (such as those contained in the proposed Trinity River Basin Fish and Wildlife Management Program) in restoring fishery populations and habitat below Lewiston Dam.

The fishery flow agreement and study are necessary because the congressional authorization for construction and operation of the Trinity River Division provides for the preservation and propagation of the Trinity's indigenous fishery resources by the Secretary and, as previously indicated, these resources are declining.

A number of factors in combination, including overharvest, are thought to be responsible for fishery declines, but not all are within the jurisdiction of the Secretary of the Interior to correct. Habitat losses due to low river flows and sediment accumulation in the main stem Trinity River can be restored in part by increasing flows, trapping sediments, and mechanically rehabilitating spawning and rearing areas, and by reducing erosion through improved watershed management in tributary streams. The Department of the Interior is focusing effort on these tasks.

The Secretary has taken the first step towards rehabilitation of fish runs by improving fishery flow releases (at the expense of other project water uses). A sediment control project (Buckhorn Mtn. Dam-Grass Valley Creek Sediment Control Project) has been authorized by Congress and Interior will likely begin work on the project during Fiscal Year 1984. The Trinity River Basin Fish and Wildlife Task Force - a 13-member group of Government specialists advisory to the Bureau of Reclamation - has developed a comprehensive plan for the rehabilitation and management of fish and wildlife resources throughout the Trinity Basin. With the cooperative assistance of the Bureau of Reclamation and Bureau of Indian Affairs, Fish and Wildlife Service is preparing an Environmental Impact Statement on the Task Force management program. Legislation to authorize and fund the program has been introduced in Congress.

The efforts described above will largely rehabilitate salmon and steelhead habitat in the Trinity River system. Restoration of the fish populations themselves, however, will also be dependent on effective harvest management. This year (1983) the Pacific Fisheries Management Council has adopted a 20-year plan to rebuild salmon runs in the Klamath-Trinity Basin through controlled ocean harvests. Adherence to that plan or even tougher standards, as well as the effective management of Indian and sport fisheries, is vital to the successful replenishment of the anadromous runs.

Although the 12-year study plan presented here addresses habitat restoration, it is clear that consideration will have to be given to the role of harvest management in allowing run goals to be met. It is anticipated that relevant data and evaluations from other monitoring efforts (harvests and escapements) will be considered and included in developing reports and recommendations to the Secretary during this study.

Study Description: The study will span 12 years and consist of 6 major tasks:

1. Study plan review and modification
2. Habitat preference criteria development
3. Habitat availability and need
4. Fish population characteristics and life history relationships
5. Study coordination
6. Reports

The study will require a maximum of 8.8 full-time-equivalent positions depending on work in progress and will require annual funding ranging from $116,431 to $359,273. The study will focus on the main stem Trinity River from Lewiston Dam to its confluence with the Klamath River at Weitchpec. Each study task is described in the following section. Efforts and funding estimates for each task are presented. Effort is shown in biologist days and total staff days (A biologist-day includes biotechnicians). It is assumed that the Fish and Wildlife Service will be the lead agency. There is opportunity for (and interest in) participation by the California Department of Fish and Game and Water Resources and Hoopa Valley Business Council. Their cooperation will be solicited. Interagency participation may alter effort and funding requirements somewhat.

A matrix table showing task schedules and levels of effort throughout the study period is appended. It is intended that this study: 1) Be conducted by utilizing current scientific methodologies; 2) be flexible to meet changing fishery resource conditions; 3) be closely coordinated with other studies and resource management agencies; and 4) be reported on by performing timely data analyses, at regular intervals and at the conclusion of the study.

Consequences of Not Performing Study: Without this study the Department of the Interior will be unable to show how it is meeting its commitments and requirements to maintain and propagate fishery resources in the Trinity River Basin. The Department will continue to be challenged by Indian and other fishery resource management and interest groups and the Trinity River Division will continue to be viewed by these elements as a classic example of the incompatibility of water resource development with fishery maintenance and of the failure of the Federal Government to be responsive to area of origin concerns.

TASK 1. Annual Study Plan Review and Modification

Objective: The objective of TASK 1 is to assure that the study plan reflects current findings and data needs.

Need: As the study progresses certain study elements may require an approach modified from that originally envisioned. Changes will be made based on experience gained from previous efforts.

Methods: Each study year the project leader will review the study efforts and findings with the principal resource management agencies in the Trinity River Basin, including the Trinity River Basin Fish and Wildlife Task Force. Based on these meetings a final study plan for the following year will be prepared.

Effort: Work required to complete TASK 1 is estimated to be:

Study Year(s)	Biologist Days	Total Staff Days
1-11	55 (5/yr)	110 (10/yr)
12	0	0
Total	55 days	110 days

Funding: Funding required to complete TASK 1 is estimated to be:

Study Year(s)	Amount
1	$ 1,590
2- 11	16,630 ($1,663/yr)
12	0
Total	$18,223

TASK 2. Habitat Preference Criteria Development

Objective: The objective of Task 2 is to develop habitat preference criteria quantifying depths, velocities, substrates, and cover requirements for chinook and coho salmon and steelhead trout spawning, incubation, rearing, holding, and migration. Other factors such as water quality and temperature will also be considered under TASK 3.

Need: Improved preference criteria are needed to use with stream - flow hydraulic data to determine the amount of habitat presently existing for salmon and steelhead, to determine the amount required and types required to achieve target levels of natural fish production, and to monitor increases in habitat gained from flow management and mechanical habitat rehabilitation work.

Methods: Field data will be collected using a variety of techniques. Emphasis will be on visual observations through diving and snorkeling where possible. Other techniques may include electrofishing, seining, redd sampling, and other measures as necessary. Where sufficient data are available, a bivariate analysis will be performed using procedures outlined in Instream Flow Information Paper No. 12 (Bovee, FWS/OBS 82/26, 1982) to develop habitat preference criteria for the following species and life stages:

Species	Race	Life Stage
Chinook salmon	Spring run	Adult holding Spawning Incubation Rearing (fry) Juvenile migration
Chinook salmon	Fall run	Adult holding Spawning Incubation Rearing (fry) Juvenile migration
Coho salmon	Fall run	Adult holding Spawning Rearing (fry) Rearing (yearling) Juvenile migration
Steelhead trout	Summer run (possible)	Adult holding Spawning Rearing (fry) Rearing (yearling) Juvenile migration
Steelhead trout	Winter run	Adult holding Spawning Incubation Rearing (fry) Rearing (yearling) Juvenile migration

Effort: Effort needed to complete TASK 2 is estimated to be:

Study Year(s)	Biologist Days	Total Staff Days
1	178	356
2	200	400
3	145	290
4 -11	88 (11 / yr)	176 (22 / yr)
12	0	0
Total	611	1,222

Funding: Funding required to complete TASK 2 is estimated to be:

Study Year(s)	Amount
1	$ 54,604
2	64,532
3	48,236
4-11	29,272 ($3,659/yr)
12	0
Total	$200,646

TASK 3. Determination of Habitat Availability and Needs.

Objectives: There are two objectives for TASK 3. The first is to determine the amount of salmon and steelhead habitat available in the Trinity River downstream of Lewiston Dam under various flow conditions and the various levels of habitat rehabilitation that may be achieved either through the Trinity River Basin Fish and Wildlife Management Program or through other resource management actions. The second objective is to determine the amount of habitat required for each freshwater life stage of salmon and steelhead to sustain those portions of the fish populations in the Trinity Basin that were historically dependent on the Trinity River downstream of Lewiston Dam.

Need: The information from this TASK is needed to evaluate the effectiveness of river flows and other measures in providing adequate amounts and distribution of fish habitat.

Methods: The Incremental Instream Flow Methodology developed by the Fish and Wildlife Service will be utilized as the primary evaluation tool. The methodology and its uses are described in Instream Flow Information Paper No. 12 (Bovee, FWS/OBS 82/26, 1982) and other publications by the Service's Instream Flow and Aquatic Systems Group. The methodology uses hydraulic and biological data to simulate habitat conditions over a range of potential flows. Water temperatures and other water quality data will be collected and incorporated into the habitat evaluations.

Field data will be collected 3 to 4 times over the 12-year study period from representative study reaches between Lewiston and Weitchpec. This will allow a running tally of habitat conditions and make it possible to account for habitat changes due to flows and watershed restoration, as opposed to any instream habitat rehabilitation by mechanical means.

Calculations of available habitat will be based on habitat preference criteria developed under TASK 2. Determination of habitat needs will also consider population use data to be developed under TASK 4. Minor field and laboratory research investigations may be required to test the validity of assumptions on egg and fry survival under various sediment conditions. It is anticipated that this and other specialized work may be undertaken through cooperative arrangements with research institutions.

The major subtasks of TASK 3 are:

1. Selection, establishment and maintenance (minor brush clearing, surveying, etc.) of measurement stations.

2. Hydraulic data collection over a range of flows at each station - repeated 2 - 3 times after initial period depending on streamflows and channel conditions (rehabilitation work).

3. Data analysis and habitat projections assuming various channel and flow conditions, and temperature and other water quality conditions.

The field schedule and effort for each subtask is detailed in the appended table.

Effort: Work required to complete TASK 3 is estimated to be:

Study Year(s)	Biologist Days	Total Staff Days
1	444	888
2	390	780
4, 6, 8, 10	1,200 (300/yr)	2,400 (600/yr)
3, 5, 7, 9, 11	1,000 (200/yr)	2,000 (400/yr)
12	0	0
Total	3,034	6,068

Funding: Funding required to complete TASK 3 is estimated to be:

Study Year (s)	Amount
1	$ 141,192
2	129,737
4, 6, 8, 10	399.192 ($99,798/yr)
3, 5, 7, 9, 11	332,660 ($66,532/yr)
12	0
Total	$1,002,781

TASK 4. Determination of Fish Population Characteristics and Life History Relationships.

Objective: The objective of TASK 4 is to determine the relative levels of successful use by fish populations of available habitat in the Trinity River downstream of Lewiston Darn.

Need: Although some information is available on spawning escapements and spawning redd numbers in certain areas, very little is known about the total distribution of fish between Lewiston and Weitchpec or their spawning success and the subsequent survival and growth of juveniles. This type of information is needed to determine which habitat factors may be limiting the restoration of fish population.

Methods: Selected study reaches will be surveyed periodically to develop indices of habitat use, fish distribution, and the survival and growth of juveniles. Survey field methods will include snorkeling, seining, electroshocking, emergent fry trapping, and other techniques found suitable. Survey methods will be refined and standardized based on experimentation during the first year.

Benthic aquatic organisms will also be monitored to determine the overall health and productive capabilities of the Trinity in the established field study reaches. Food habits of juvenile salmonids will be examined to determine utilization of available food supply. Methods for this study element will be patterned after those developed by researchers with the U.S Forest Service and Brigham Young University (Biotic Condition Index: Integrated Biological, Physical and Chemical Stream Parameters for Management. Robert H. Winget and Fred A. Mangum. October 1979. Intermountain Region, Forest Service, U.S. Dept. of Agriculture) and others.

Effort: The effort required to complete TASK 4 is estimated to be:

Study Year(s)	Biologist Days	Total Staff Days
1	93	186
2,4,6,8,10,11	2,232 (372/yr)	4,464 (744/yr)
3,5,7,9	3,736 (664/yr)	7,472 (l,361/yr)
12	0	0
Total	6,061	12,122

Funding: Funding required to complete TASK 4 is estimated to be:

Study Year(s)	Amount
1	$ 29,574
2,4,6,8,10,11	742,500 ($123,750/yr)
3,5,7,9	910,158 ($227,539/yr)
12	0
Total	$1,682,230

TASK 5. Study Coordination

Objective: The objective of TASK 5 is to develop and maintain coordination with other study and resource management agencies in the Trinity River Basin to maximize effective use of available information (and to avoid duplication of work).

Need: Presently, the California Department of Fish and Game, Bureau of Indian Affairs, Forest Service, Bureau of Land Management, Hoopa Valley Business Council (Fisheries Department) and the Fish and Wildlife Service have fisheries studies and management programs underway. Additional study efforts will occur under this program and the comprehensive fish and wildlife management program proposed by the Trinity River Basin Fish and Wildlife Task Force. It is essential that studies be coordinated to prevent unintended interference and to make use of study results in planning future work and making management decisions.

Methods: Coordination will be maintained through both formal and informal contacts. Other study leaders and local fishery resource managers will be contacted on at least a bimonthly basis. Formal coordination meetings will, be scheduled twice yearly. Quarterly work progress reports (prepared under TASK 6) and preliminary fisheries reports will be provided to interested agencies.

Effort: The effort required to complete TASK 5 is estimated to be:

Study Year (s)	Biologist Days	Total Staff Days
1 - 11	220 (20/yr)	440 (40/yr)
12	10	20
Total	230	460

Funding: Funding required to complete TASKS is estimated to be:

Study Year (s)	Amount
1	$ 6,360
2 - 11	66,532 ($6,653/yr)
12	3,327
Total	$76,219

TASK 6. Reports (Progress, Findings and Recommendations)

Objective: The objectives of TASK 6 are: 1) To report on the analysis of information developed from field investigations (TASK 2, 3, and 4) and on relevant information from other studies which have a bearing on the levels of fishery resource rehabilitation achieved in the Trinity River between Lewiston and Weitchpec and 2) to develop recommendations to the Secretary and to other resource management agencies concerning future management options and needs.

Need: Fishery rehabilitation efforts achieved through improved flow releases from Lewiston Dam and from mechanical aquatic habitat and watershed rehabilitation should be monitored and critically analyzed.

Methods: Three types of reports will be prepared under TASK 6. The first type will be quarterly progress and planning reports detailing study activities and accomplishments during the past quarter and describing anticipated activities during the current quarter. These will generally be prepared and distributed within 2 weeks of the close of each quarter. The second type will be preliminary findings reports containing field data and analyses for major portions of one or more study elements. As an example, this type of report would be produced following completion of the habitat preference criteria study element (TASK 2) and at the end of each of the 3 to 4 periods of hydraulic streamflow data collection and computer analysis (TASK 3). The preliminary findings reports should be completed after data analysis and during the year following completion of field work. The final type of report will be the concluding report to the Secretary.

The concluding report will summarize the findings of each of the study elements (from various preliminary findings reports), evaluate the results of improved flows and other rehabilitation measures in an overall manner, and convey to the Secretary the Service's recommendations with respect to future management options and needs for the Trinity River downstream of Lewiston Dam.

Effort: Effort needed to complete TASK 6 is estimated to be:

Study Year(s)	Biologist Days	Total Staff Days
1	10	20
2	20	40
4,6,8,10	120(30/yr)	240 (60/yr)
3,5,7,9,11	130 (26/yr)	260 (52/yr)
12	340	680
Total	620	1,240

Funding: Funding required to complete TASK 6 is estimated to be:

Study Year(s)	Amount
1	$ 3,180
2	6,653
4,6,8,10	39,921 ($ 9,910/yr)
3,5,7,9,11	43,246 ($ 1,649/yr)
12	113,104
Total	$206,104

Table I-1. Schedule of Activities and Effort (Biologist Days) for Trinity River Fishery Flow Evaluations

Fiscal Year	85	86	87	88	89	90	91	92	93	94	95	96
Study Area	1	2	3	4	5	6	7	8	9	10	11	12
STUDY TASK												
Study Plan Review and Modification	5	5	5	5	5	5	5	5	5	5	5	
Habitat Preference Criteria	178	200	145	11	11	11	11	11	11	11	11	
Habitat Availability and Need	444	390	200	300	200	300	200	300	200	300	200	
Fish Population Characteristics and Relationships	93	372	604	372	684	372	684	372	684	372	372	
Study Coordination	20	20	20	20	20	20	20	20	20	20	20	10
Reports	10	20	26	30	26	30	26	30	26	30	26	340
Total Effort[a]	750	1,007	1,000	738	946	738	946	738	946	738	634	350
Funding	238,500	335,000	359,273	245,503	314,696	245,503	314,696	245,503	314,696	245,503	210,906	116,431
Grand Total	3,186,210											

[a] Effort in Biologist Days (1 Biologist Day = 2 Staff Days)

APPENDIX J

Calculation of the Descending Limb of the Snowmelt Hydrograph

One of the components of an annual hydrograph for the Trinity River is the descending limb of the snowmelt hydrograph. An analysis of Trinity River flow data was conducted to develop predictive equations for this component of the hydrograph.

Methods

Daily flow data for the Trinity River at Lewiston were obtained from USGS records. Annual flow data were stratified according to the water year classification presented in Chapter 4. For each water year class, years were identified in which the descending limb of the snowmelt hydrograph (typically April-June/July, depending on water year class) displayed a relatively smooth decrease throughout this period. Years in which large storm events occurred during the snowmelt period were excluded from analysis because of the disruption of the relation between flow and time due to these events.

Once appropriate water years were identified, flow data for the range of flows of interest for each water year class were obtained. For all water year classes, the lower range of flows was approximately 450 cfs, the flow recommended to meet the summer/fall temperature criteria for the Trinity River. The upper range depended on water year class and was selected to correspond to approximately the peak flow recommended for a specific water year class to achieve fluvial geomorphic objectives. The upper ranges were: 11,000 cfs for Extremely Wet water years, 8,500 cfs for Wet water years, 6,000 cfs for Normal water years, 4,500 for Dry water years, and 1,500 for Critically Dry water years. For individual water years, the flow for each day was coupled with a corresponding day value (i.e.: day corresponding with the first day of the flow range was designated day 1, the second - day 2, etc.).

For each year, flow data were log transformed and regressed on corresponding day data. The slope and intercept parameters were then averaged for each water year class to develop composite predictive equations. After development of the composite equations, the intercept parameter was adjusted so the predicted flow on day 0 would equal the peak flow for that water year class.

Results

Regression statistics for each water year are presented in Table J.1. Parameters for the composite equations are presented in Table J.2. During the hydrograph refinement process, the slope parameters for the Extremely Wet and Wet water years were adjusted to increase the slope of the descending limb. This exercise was conducted to reduce the recommended releases during the descending limb of the hydrograph while still meeting smolt temperature criteria. The water not released during the descending limb of the hydrograph was used to increase recommended releases prior to the fluvial geomorphic peaks to meet smolt temperature criteria. The slope parameter was changed from -0.0176 to -0.0240 for the Extremely Wet water year class from -0.0179 to -0.0291 for the Wet water year class.

Table J-1. Regression statistics for the descending limb of individual water years.

Water Year Class	Year	Slope	Intercept	r^2	n
Critically Dry	1918	-0.0136	3.2614	0.91	39
	1939	-0.0131	3.2614	0.86	40
Dry	1922	-0.0138	3.8781	0.78	73
	1926	-0.0173	3.5262	0.95	49
	1933	-0.0276	3.6190	0.98	36
	1935	-0.0191	3.7203	0.95	53
Normal	1912	-0.0202	3.8252	0.98	58
	1919	-0.0172	3.8665	0.93	69
	1945	-0.0147	3.7649	0.96	74
	1949	-0.0141	3.9081	0.89	82
	1966	-0.0137	3.7343	0.95	88
Wet	1921	-0.0191	3.8789	0.97	63
	1942	-0.0190	3.9518	0.97	67
	1946	-0.0155	3.8834	0.98	77
	1969	-0.0198	3.9623	0.95	67
	1971	-0.0140	3.9316	0.93	87
	1973	-0.0197	3.8390	0.91	63
	1975	-0.0198	3.9000	0.80	74
	1984	-0.0155	3.8239	0.86	70
	1993	-0.0184	3.8040	0.91	63
Extremely Wet	1915	-0.0181	4.1252	0.98	78
	1938	-0.0193	4.0291	0.98	70
	1941	-0.0150	4.0860	0.95	94
	1956	-0.0184	3.9490	0.99	71
	1958	-0.0154	4.0898	0.98	98
	1974	-0.0131	4.0138	0.83	93

Table J-2. Slope, Intercept, number of years (n) and years used to develop flow predictive equations for the descending limb of the snowmelt hydrograph and parameters for the adjusted equations.

Water Year Class		Slope	Intercept	n	Years
Critically Dry	Actual	-0.0133	3.2360	2	1918, 1939
	Adjusted	-0.0133	3.1760		
Dry	Actual	-0.0191	3.7308	4	1922, 1926, 1933, 1935
	Adjusted	-0.0191	3.6532		
Normal	Actual	-0.0160	3.8259	5	1912, 1919, 1945, 1949, 1966
	Adjusted	-0.0160	3.7782		
Wet	Actual	-0.0179	3.8962	9	1921, 1942, 1946, 1969, 1971,
	Adjusted	-0.0179	3.9294		1973, 1975, 1984, 1993
Extremely Wet	Actual	-0.0176	4.0488	6	1915, 1928, 1941, 1956, 1958,
	Adjusted	-0.0176	4.0414		1974

APPENDIX K
Temperatures

Temperature Evaluations of the Recommended Spring Hydrographs

This appendix provides detail of how recommended spring hydrographs, composed of dam releases for geomorphic, ramping, and water temperature related needs, are likely to influence water temperatures of the Trinity River. Using methods outlined in Section 5.5.2.2, composite schedules (Table K.1) were modeled in SNTEMP and predicted water temperatures were compared to optimal smolt temperatures (OST), marginal smolt temperatures (MST), and unsuitable smolt temperatures (UST) identified in Section 5.5.

Results

Extremely Wet Years

Simulations of the composite schedules for EXTREMELY WET years (n = 3) show that optimal smolt temperatures (OST) are generally met from April 15 to July 8 (Figures K.1A). While the peak release to meet geomorphic needs decreases water temperatures in the lower river, water temperatures still remain within OST. Ramping down from the peak results in a warming trend while maintaining OST through the week of July 8.

Summary information on longitudinal water temperature profiles indicate that on average the percentage of river meeting OST and MST from April 15 through July 8 would be 99 and 100 %, respectively (Table K.2).

Wet Years

Simulations of the composite schedules for WET years (n = 5) show that optimal smolt temperatures (OST) are generally met from April 15 to July 8 (Figure K.1B). Scheduled releases indicate that 300 cfs is adequate to meet OST on April 15, and that the increased releases that occur from this time until the peak release (May 20) result in OST. Although the peak release does decrease water temperatures, water temperatures still remain within OST. After the peak release, the recommended release pattern provides for a warming trend and meets OST through the week of July 8.

Summary information on longitudinal water temperature profiles indicates that on average the percentage of river meeting OST and MST from April 15 through July 8 would be 97 and 100 %, respectively (Table K.2).

Normal Years

While only one year was simulated with the NORMAL year schedule, results indicate that the recommended release schedule does generally meet the OST (Figure K.2A). Only during the weeks of April 15, June 3 and July 8 were recommended releases (300, 2,300, and 1,543 cfs, respectively) insufficient to meet OST. Similar to the wetter year schedules, the peak release (i.e., 5,683 cfs) decreases water temperatures although they still remain within OST. After the peak release, the recommended release pattern provides a warming trend while meeting OST until the week of July 8 after which water temperatures become marginal.

Summary information on longitudinal water temperature profiles indicates that on average the percentage of river meeting OST and MST from April 15 through July 8 would be 91 and 97 %, respectively (Table K.2).

Table K.1. Average weekly dam releases modeled in SNTEMP.

Week	Average Weekly Recommended Releases (cubic feet/sec)				
	Extremely Wet	Wet	Normal	Dry	Critically Dry
15-Apr	300	300	300	300	300
22-Apr	500	500	500	557	1,243
29-Apr	1,500	2,000	2,500	4,071	1,500
06-May	2,000	2,500	5,683	3,788	1,500
13-May	2,000	5,786	5,005	2,783	1,500
20-May	7,786	7,196	3,867	2,045	1,500
27-May	9,807	5,266	2,988	1,503	1,445
03-Jun	6,619	3,329	2,309	1,104	1,104
10-Jun	5,067	2,153	2,000	811	811
17-Jun	3,420	2,000	2,000	596	596
24-Jun	2,313	2,000	2,000	461	461
01-Jul	2,000	2,000	2,000	450	450
08-Jul	1,543	1,543	1,543	450	450

Dry Years

Simulations of the composite schedules for DRY years (n = 8) show that water temperatures can be temporally variable (Figure K.2B). On April 15, a release of 300 cfs results in a wide possible range of temperatures in the lower Trinity River, some of which may become UST. During the peak release (4,071 cfs) river water temperatures become optimal. Ramping down from the peak release provides for a gradual warming trend while providing at least MST until mid-June.

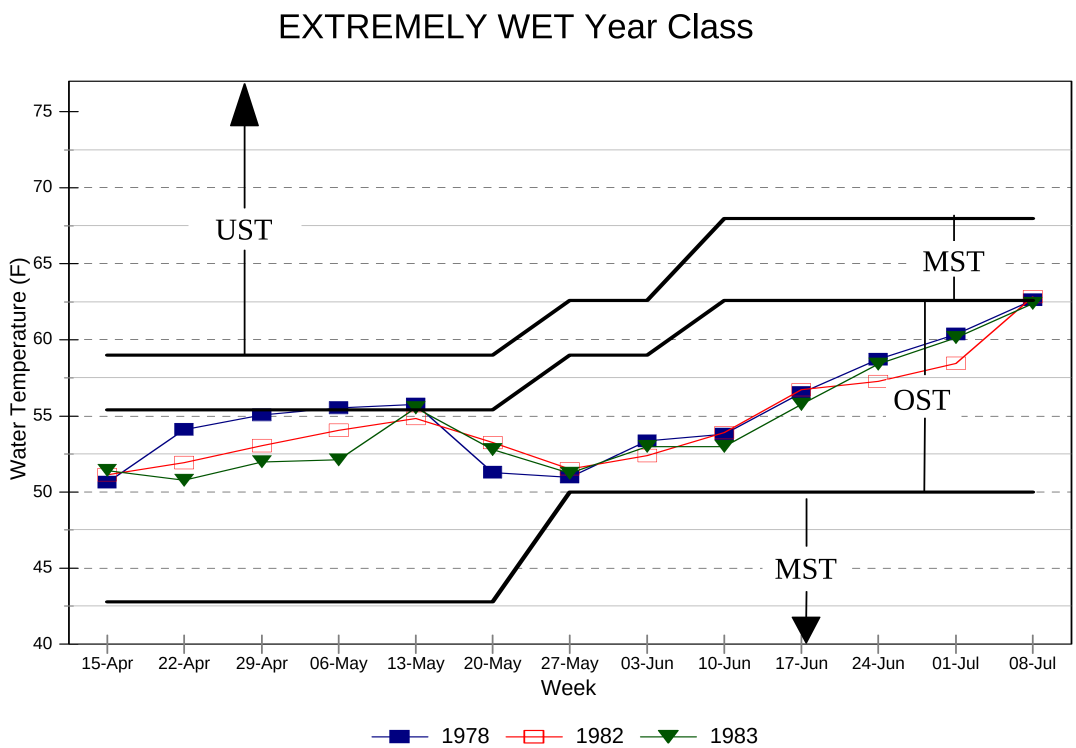
Summary information on longitudinal water temperature profiles indicate that on average the percentage of river meeting OST and MST from April 15 through July 8 would be 73 and 91%, respectively (Table K.2).

Critically Dry Years

Simulations of the composite schedules for CRITICALLY DRY years show that water temperatures also can be temporally variable (Figure K.3). While in some years this schedule could provide OST, there are other years that UST could result. However, the recommended release schedule does provide a warming trend and generally provides at least MST from April to mid-June.

Summary information on longitudinal water temperature profiles indicate that on average the percentage of river meeting OST and MST from April 15 through July 8 would be 63 and 89 %, respectively (Table K.2).

A



B

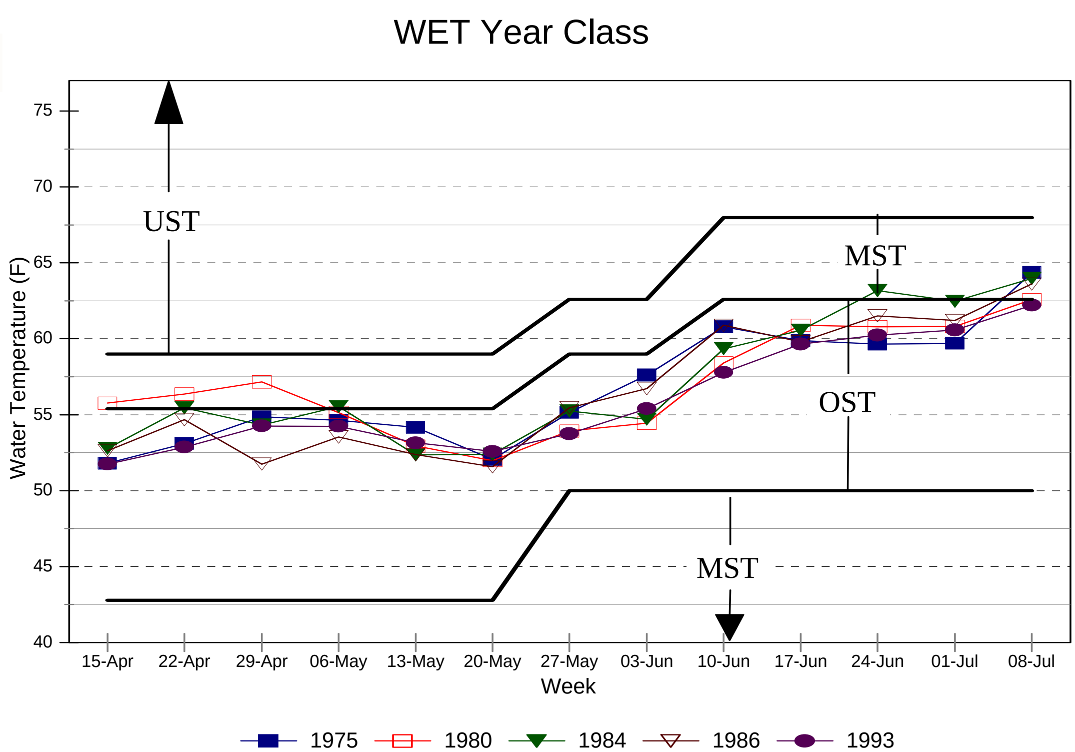


Figure K.1. Predicted water temperatures at Weitchpec (RM 0.0) during spring under EXTREMELY WET (A) and WET (B) water year schedules. UST = Unsuitable Smolt Temperatures, MST = Marginal Smolt Temperatures, and OST = Optimal Smolt Temperatures.

Table K.2. Average percentage of miles of the Trinity River from Lewiston Dam to the confluence of the Klamath River that meet temperature criteria presented in Section 5.5. Temp.--temperature; e.wet--extremely wet water year; wet--wet water year; normal--normal water year; dry--dry water year; c.dry--critically dry water year.

WEEK	TEMP. CRITERIA ^{0}F	AVERAGE PERCENTAGE OF MILES MEETING TEMPERATURE CRITERIA				
		E.WET n = 3	WET n = 5	NORM. n = 1	DRY n = 8	C.DRY n = 3
		Optimal Smolt Temperatures				
15-Apr	42.8 - 55.4	100	92	45	85	80
22-Apr	42.8 - 55.4	100	90	100	83	89
29-Apr	42.8 - 55.4	100	93	100	100	76
06-May	42.8 - 55.4	97	98	100	100	82
13-May	42.8 - 55.4	91	100	100	84	78
20-May	42.8 - 55.4	100	100	100	82	60
27-May	50.0 - 59.0	100	100	100	91	77
03-Jun	50.0 - 59.0	100	100	67	71	63
10-Jun	50.0 - 62.6	100	100	100	82	69
17-Jun	50.0 - 62.6	100	100	100	54	58
24-Jun	50.0 - 62.6	100	98	100	43	35
01-Jul	50.0 - 62.6	100	100	100	42	32
08-Jul	50.0 - 62.6	93	86	67	35	26
AVG		**99**	**97**	**91**	**73**	**63**
		Optimal and Marginal Smolt Temperatures				
15-Apr	42.8 - 59.0	100	100	67	100	89
22-Apr	42.8 - 59.0	100	100	100	96	100
29-Apr	42.8 - 59.0	100	100	100	100	100
06-May	42.8 - 59.0	100	100	100	100	95
13-May	42.8 - 59.0	100	100	100	100	100
20-May	42.8 - 59.0	100	100	100	100	86
27-May	50.0 - 62.6	100	100	100	100	100
03-Jun	50.0 - 62.6	100	100	100	93	100
10-Jun	50.0 - 68.0	100	100	100	100	100
17-Jun	50.0 - 68.0	100	100	100	85	100
24-Jun	50.0 - 68.0	100	100	100	72	76
01-Jul	50.0 - 68.0	100	100	100	78	60
08-Jul	50.0 - 68.0	100	100	100	62	47
AVG		**100**	**100**	**97**	**91**	**89**

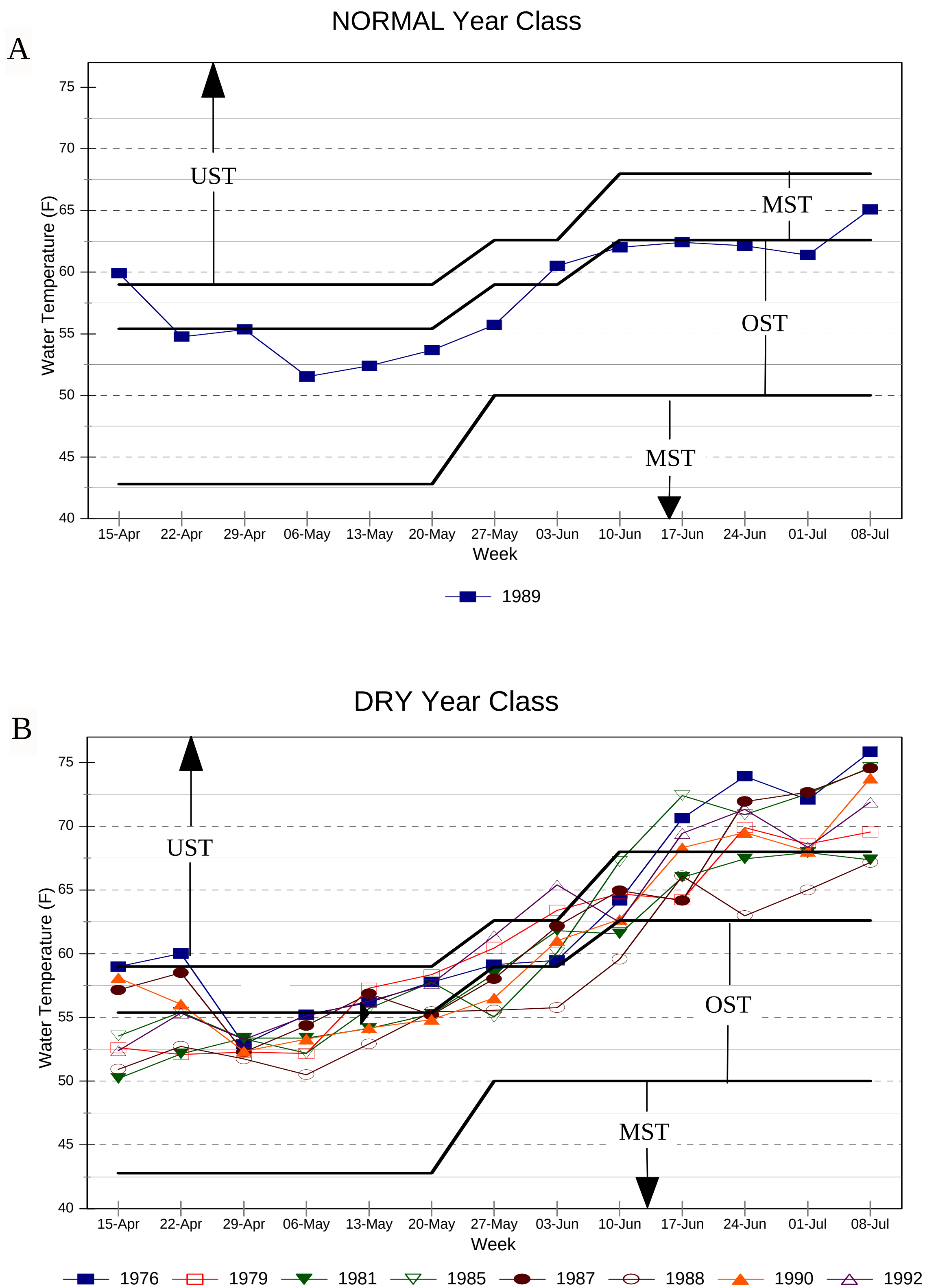


Figure K.2. Predicted water temperatures at Weitchpec (RM 0.0) during spring under NORMAL (A) and DRY (B) water year schedules. UST = Unsuitable Smolt Temperatures, MST = Marginal Smolt Temperatures, and OST = Optimal Smolt Temperatures.

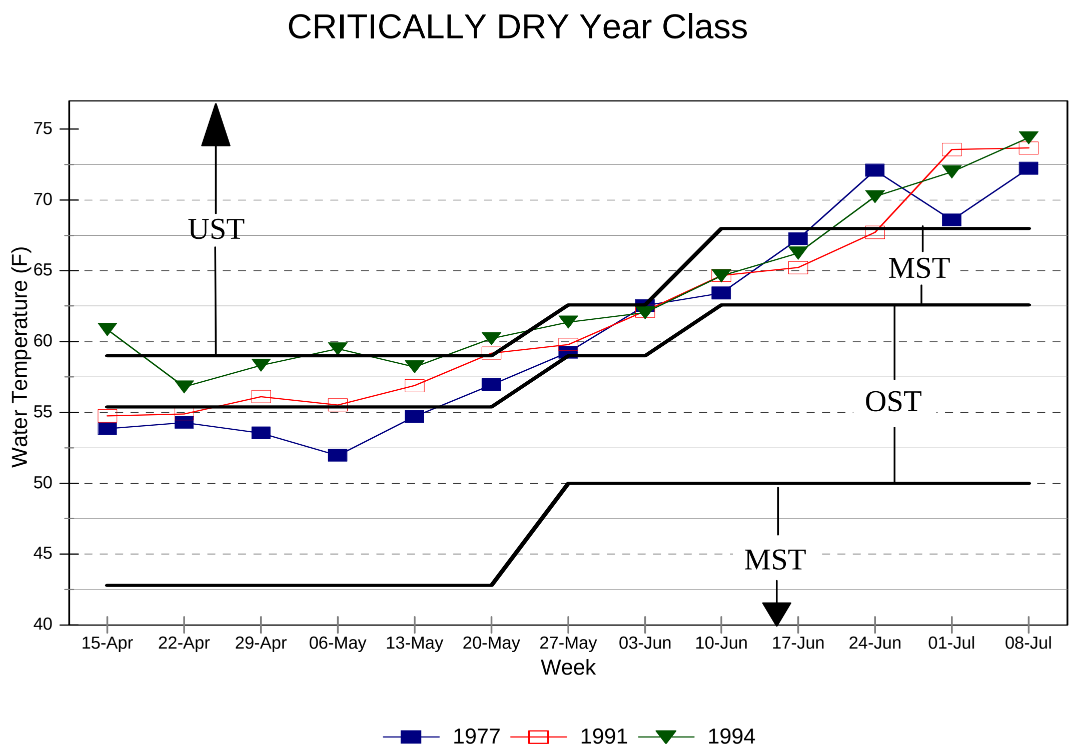


Figure K.3. Predicted water temperatures at Weitchpec (RM 0.0) during spring under the CRITICALLY DRY water year schedule. UST = Unsuitable Smolt Temperatures, MST = Marginal Smolt Temperatures, and OST = Optimal Smolt Temperatures.

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APPENDIX L

Temperature Evaluations at the Trinity River
Confluence with the Klamath River

Likely Differences in Water Temperature at the Confluence of the Trinity and Klamath Rivers due to the TRFE flow recommendations.

Introduction

Water temperature is perhaps the single most important variable affecting salmonid survival (Brett, 1952). One life-stage that is of particular concern on the Trinity River is the springtime and early summer outmigration of salmon and steelhead smolts that migrate through the Trinity River and into the Klamath River, and eventually to Pacific Ocean. In the absence of good water quality during this journey, the survival of smolts and parr may be jeopardized (See Section 5.5).

Because Lewiston Dam releases can affect water temperatures in the lower Trinity River during the spring outmigration period (Zedonis, 1997), the differences in water temperature of the Klamath River and the Trinity River at their confluence could be of concern. This analysis evaluated the likely value of these differences in water temperatures as a result of the increased dam releases associated with the TRFE release recommendations. Discussions of the likely effects of altered thermal regimes on salmonids are included.

Methods

Empirical Approach

The first approach to evaluating differences in water temperatures of the Trinity and Klamath Rivers before mixing was to simply compare water temperatures measured on each river just upstream of their confluence. Measurements taken in 1992, 1993, and 1994 were chosen for this evaluation since these years represent a variety of different water year types and complete data sets. Only the weeks from April 29 to July 15 were evaluated as these were the only weeks that large dam releases were recommended.

Water temperature data were taken at Weitchpec Falls (RM 0.7) for the Trinity River and at Big Bar (RM 49.7) on the Klamath River, which is approximately 6 miles upstream of the confluence with the Trinity River located at RM 43.5. Flow data were obtained from the Hoopa gage (RM 12.4) on the Trinity River, and Orleans gage (RM 59.6) on the Klamath River. Although temperature and flow data were not collected at the confluence area, these two variables were assumed to represent conditions at the confluence area.

Model Approach

The second approach was to use the SNTEMP model of the Trinity River (Zedonis, 1997) to predict how the TRFE releases might have altered the thermal regime at the confluence if they occurred during the years of 1992, 1993, and 1994. These three years were chosen because: (1) they were represented by a complete data set at the time of this assessment; and (2) they represent a range of different hydrometeorological conditions, but are representative of the conditions for which the SNTEMP model was calibrated (calibration years are 1991 to 1994). Using inflow volumes into Trinity Lake as an indicator of water year class (See Chapter 3: Background), 1992, 1993, and 1994 were considered dry, wet, and critically dry years, respectively.

Under the model approach, several simulations were performed. For each of the three years (1992, 1993, and 1994), all of the TRFE flow releases were evaluated for water temperature and flow at the mouth of the Trinity River. In addition, simulations were performed for a "baseflow" condition of 300 cfs. For each of the model runs, release water temperatures were set to 48.2° F for each week during the April 29 to July 15 time period. The SNTEMP model was run eighteen times, and flow and predicted water temperatures at the mouth of the Trinity River (RM 0.0) were then compared to actual Klamath River water temperature (RM 49.7) and flow conditions (RM 59.6) to predict what might have happened if the TRFE recommended releases had occurred.

Results

Empirical Approach

Evaluation of water temperatures during 1992, 1993, and 1994 (Figure L-1; Tables L-1, L-2, and L-3) indicates that the thermal regimes of the Klamath and Trinity Rivers at the confluence were generally within 2.0° F between the time period of April 29 to July 15. Exceptions to this did, however, occur. In 1992, Trinity River water temperatures were as much as 7.4° F colder than the Klamath River as a result of increased Lewiston Dam releases (6,000 cfs for 5 days) during the weeks of June 10th and 17th (Table L-1). In contrast, in 1993 Trinity River water temperatures were 3° F warmer than the Klamath River during the week of May 20th when Lewiston Dam releases were 300 cfs.

In 1993, weather patterns differed from those of 1992 and 1994. During this year more precipitation resulted in more flow accretion in the Klamath and Trinity Rivers. During this year, average weekly flow conditions at Weitchpec (RM 0.0) on the Trinity River from April 29 to July 15 ranged from 1,800 to 10,700 cfs. At the Orleans gaging station on the Klamath River, average weekly flows ranged from 2,900 to 21,700 cfs. Larger Klamath River flows typically associated with cooler and wetter conditions resulted in average weekly water temperatures to be 1.0° F colder than the Trinity River (Table L-2). Examination of 1994 water temperatures shows that the Trinity and Klamath River water temperatures were very similar. Water temperatures were always less than 1.0° F different and the average difference was 0.1° F (Table L.3). During this year, flow levels were very low in both the Trinity and Klamath Rivers.

Model Approach

1992

Under 1992 hydrometeorological conditions, the TRFE releases would have resulted in water temperatures in the lower Trinity River becoming much cooler than the Klamath River (Figure L-2, and Tables L-4 to L-9). Under an Extremely Wet schedule, water temperatures in the Trinity River would have become as much as 15° F cooler than the Klamath River. On average, weekly water temperatures would have been 8.8° F cooler.

Under Wet and Normal year release schedules Trinity River water temperatures would have also been considerably cooler than the Klamath River. For the Wet year schedule (Table L-5), water temperatures would have been as much as 12.9° F cooler and on average 8.2° F cooler. For the Normal year release schedule (Table L-6), water temperatures would have been as much as 9.5° F cooler and on average 7.8° F cooler.

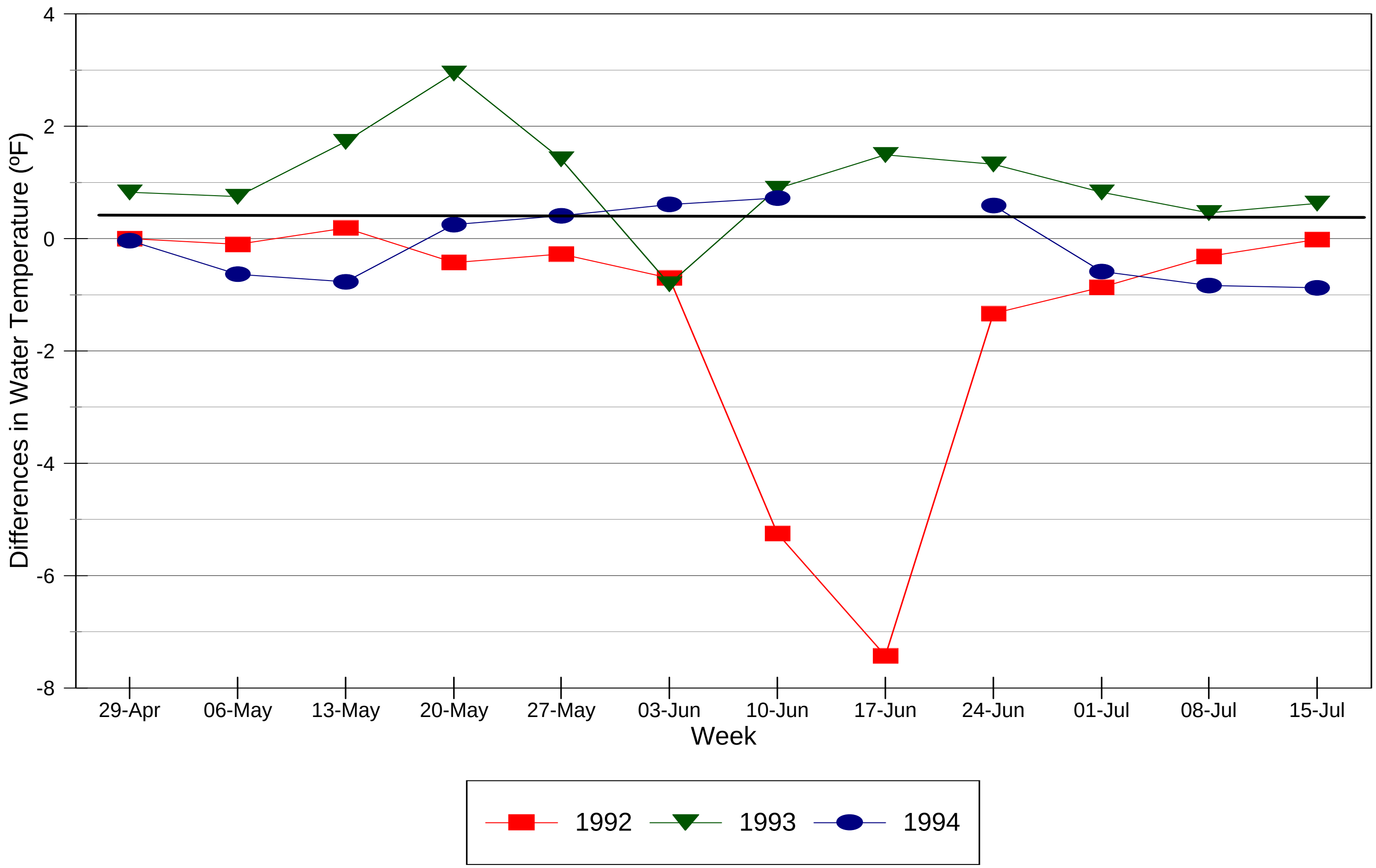

Figure L-1. Water temperature differences at the confluence of the Klamath and Trinity River for 1992, 1993, and 1994. Results are based upon real gage and temperature data. Refer to Tables L.1 - L.3 for information on dam releases, etc. Negative values indicate Trinity River water temperatures are colder than Klamath River water.

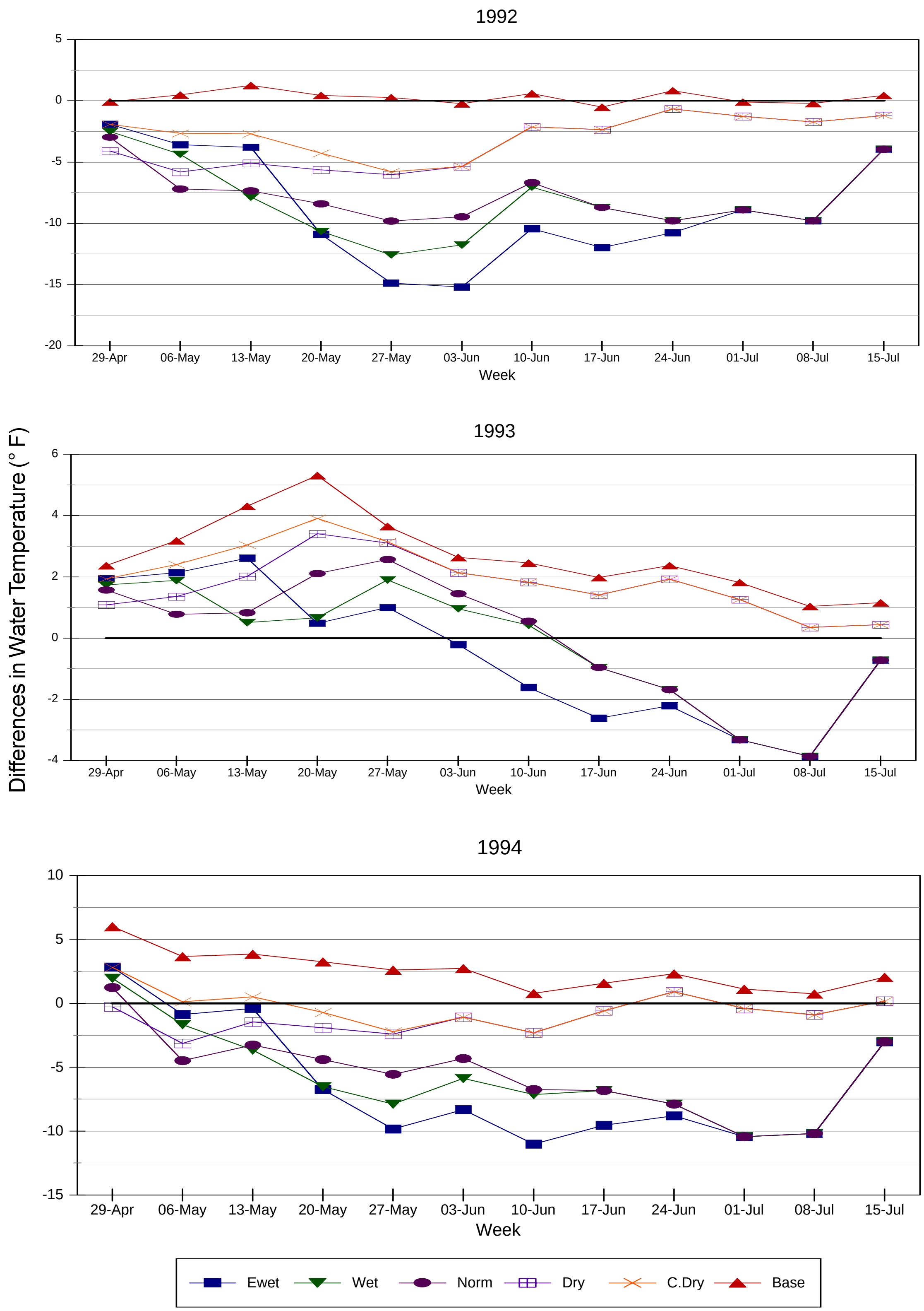

Figure L-2. Predicted water temperature differences at the confluence of the Klamath and Trinity Rivers for three years using five Trinity River Flow Evaluation Recommendation flow schedules. Base-flow conditions are a 300 cfs dam release. Negative values indicate that Trinity River water temperatures are colder.

Table L-1. Results of mixing of actual water temperature and river flows of the Klamath and Trinity Rivers, spring, 1992.

	Water Temperature (° F)			Flow (cfs)				Combined Rivers			
1992	Trinity R. @ Hoopa	Klamath R. @Big Bar	Difference (Trinity -	Trinity Confluence	Lewiston Dam	Klamath @ Orleans	Iron Gate Dam	Flow (cfs)			Water Temperatures (° F)
Week	Avg Week	Avg Week	Klamath)	Avg Week	Release	Avg Week	Release	Combined	%Trinity	%Klamath	Mixed
29-Apr	59.1	59.1	0.0	3231	321	4871	529	8103	40	60	59.1
06-May	62.6	62.7	-0.1	2541	327	3714	518	6256	41	59	62.7
13-May	63.3	63.2	0.2	1944	325	2766	515	4710	41	59	63.2
20-May	64.8	65.2	-0.4	1627	322	2410	503	4037	40	60	65.1
27-May	68.7	69.0	-0.3	1379	334	1987	490	3366	41	59	68.9
03-Jun	70.2	70.9	-0.7	1126	344	1676	486	2801	40	60	70.6
10-Jun	59.8	65.1	-5.2	4521	4549	1596	476	6117	74	26	61.2
17-Jun	64.6	72.0	-7.4	2662	2251	1679	651	4341	61	39	67.5
24-Jun	70.8	72.1	-1.3	961	363	1479	418	2439	39	61	71.6
01-Jul	68.7	69.6	-0.9	1050	322	1576	433	2626	40	60	69.3
08-Jul	73.3	73.7	-0.3	749	307	1337	426	2087	36	64	73.5
15-Jul	75.4	75.5	0.0	751	414	1129	437	1879	40	60	75.4
Average	66.8	68.2	-1.4	1879	848	2185	490	4063	44.5	55.5	67.3

Table L-2. Results of mixing of actual water temperature and river flows of the Klamath and Trinity Rivers, spring, 1993.

	Water Temperature (° F)			Flow (cfs)				Combined Rivers			
1993	Trinity R. @ Hoopa	Klamath R. @Big Bar	Difference (Trinity -	Trinity Confluence	Lewiston Dam	Klamath @ Orleans	Iron Gate Dam	Flow (cfs)			Water Temperatures (° F)
Week	Avg Week	Avg Week	Klamath)	Avg Week	Release	Avg Week	Release	Combined	%Trinity	%Klamath	Mixed
29-Apr	53.6	52.7	0.8	8784	1756	18629	3873	27413	32	68	53.0
06-May	53.6	52.8	0.8	5847	303	18657	4100	24504	24	76	53.0
13-May	55.9	54.2	1.7	4906	301	17029	2499	21934	22	78	54.5
20-May	56.8	53.9	2.9	4989	305	17400	1357	22389	22	78	54.5
27-May	54.1	52.7	1.4	10690	318	21129	1741	31819	34	66	53.2
03-Jun	54.4	55.2	-0.8	8860	336	21729	6023	30589	29	71	55.0
10-Jun	58.9	58.0	0.9	5684	324	12871	1601	18556	31	69	58.3
17-Jun	62.9	61.4	1.5	4336	320	9056	1067	13391	32	68	61.9
24-Jun	63.9	62.6	1.3	3134	324	5637	779	8771	36	64	63.0
01-Jul	65.7	64.9	0.8	2624	436	4127	738	6751	39	61	65.2
08-Jul	67.4	66.9	0.5	2177	447	3303	677	5480	40	60	67.1
15-Jul	66.1	65.4	0.6	1813	460	2867	683	4680	39	61	65.7
Avg	59.4	58.4	1.0	5320	469	12703	2095	18023	31.6	68.4	58.7

Table L-3. Results of mixing of actual water temperature and river flows of the Klamath and Trinity Rivers, spring, 1994. ND--no data.

	Water Temperature (° F)			Flow (cfs)				Combined Rivers			
1994	Trinity R.	Klamath R.	Difference	Trinity	Lewiston	Klamath @	Iron Gate	Flow (cfs)			Water Temperatures (° F)
Week	@ Hoopa Avg Week	@Big Bar Avg Week	(Trinity - Klamath)	Confluence Avg Week	Dam Release	Orleans Avg Week	Dam Release	Combined	%Trinity	%Klamath	Mixed
29-Apr	55.4	55.4	-0.0	3150	1574	3943	574	7093	44	56	55.4
06-May	59.0	59.6	-0.6	3439	1589	5817	853	9256	37	63	59.4
13-May	57.1	57.8	-0.8	3071	1576	4167	676	7239	42	58	57.5
20-May	61.3	61.1	0.2	1981	358	3399	869	5380	37	63	61.2
27-May	64.0	63.5	0.4	1543	345	2693	585	4236	36	64	63.7
03-Jun	63.2	62.6	0.6	1314	347	2406	854	3720	35	65	62.8
10-Jun	67.3	66.5	0.7	1130	345	2044	609	3174	36	64	66.8
17-Jun	ND	66.5	ND	961	347	1917	823	2879	33	67	44.3
24-Jun	69.6	69.0	0.6	851	357	1606	567	2457	35	65	69.2
01-Jul	71.4	72.0	-0.6	846	468	1454	570	2301	37	63	71.8
08-Jul	74.2	75.0	-0.8	798	483	1329	574	2127	38	62	74.7
15-Jul	75.6	76.5	-0.9	724	466	1236	571	1960	37	63	76.2
Avg	59.8	65.5	-0.1	1651	688	2668	677	4318	37.3	62.7	63.6

Table L-4. Hypothetical flows: Model results: TRFE EXTREMELY WET year flows and 1992 hydrometeorological conditions.

	Water Temperature (° F)			Flow (cfs)				Combined Rivers			
1992	Trinity R.	Klamath R.	Difference	Trinity	Lewiston	Klamath @	Iron Gate	Flow (cfs)			Water Temperatures (° F)
Week	@ Hoopa[a] Avg Week	@Big Bar [b] Avg Week	(Trinity - Klamath)	Confluence Avg Week	Dam Release	Orleans Avg Week	Dam Release	Combined	%Trinity	%Klamath	Mixed
29-Apr	57.1	59.1	-1.9	4407	1500	3943	529	8350	53	47	58.1
06-May	59.1	62.7	-3.6	4212	2000	5817	518	10030	42	58	61.2
13-May	59.4	63.2	-3.8	3623	2000	4167	515	7790	47	53	61.4
20-May	54.3	65.2	-10.9	9082	7786	3399	503	12480	73	27	57.3
27-May	54.1	69.0	-14.9	10844	9807	2693	490	13537	80	20	37.1
03-Jun	55.7	70.9	-15.2	7309	6619	2406	486	9715	75	25	59.4
10-Jun	54.6	65.1	-10.4	5639	5067	2044	476	7683	73	27	57.4
17-Jun	60.0	72.0	-12.0	4675	3420	1917	651	6592	71	29	63.5
24-Jun	61.4	72.1	-10.8	2913	2313	1606	418	4519	64	36	65.2
01-Jul	60.7	69.6	-8.9	2733	2000	1454	433	4187	65	35	63.8
08-Jul	63.9	73.7	-9.8	1977	1543	1329	426	3306	60	40	37.8
15-Jul	71.5	75.5	-4.0	1028	696	1236	437	2263	45	55	73.7
Avg	59.3	68.2	-8.8	4870	3729	2668	490	7538	62.4	37.6	62.2

Table L-5. Hypothetical flows: Model results: TRFE WET year flows and 1992 hydrometeorological conditions.

	Water Temperature (° F)			Flow (cfs)				Combined Rivers			
1992 Week	Trinity R. @ Hoopa[a] Avg Week	Klamath R. @Big Bar [b] Avg Week	Difference (Trinity - Klamath)	Trinity Confluence Avg Week	Lewiston Dam Release	Klamath @ Orleans Avg Week	Iron Gate Dam Release	Flow (cfs) Combined	%Trinity	%Klamath	Water Temperatures (° F) Mixed
29-Apr	56.6	59.1	-2.5	4908	2000	3943	529	8851	55	45	57.7
06-May	58.4	62.7	-4.4	4710	2500	5817	518	10527	45	55	60.8
13-May	55.3	63.2	-7.8	7405	5786	4167	515	11572	64	36	58.1
20-May	54.6	65.2	-10.7	8492	7196	3399	503	11891	71	29	57.6
27-May	56.4	69.0	-12.6	6306	5266	2693	490	8999	70	30	60.2
03-Jun	59.1	70.9	-11.8	4022	3329	2406	486	6428	63	37	63.5
10-Jun	58.0	65.1	-7.0	2726	2153	2044	476	4770	57	43	61.1
17-Jun	63.3	72.0	-8.7	3256	2000	1917	651	5173	63	37	66.5
24-Jun	62.3	72.1	-9.8	2602	2000	1606	418	4208	62	38	66.1
01-Jul	60.7	69.6	-8.9	2733	2000	1454	433	4187	65	35	63.8
08-Jul	63.9	73.7	-9.8	1977	1543	1329	426	3306	60	40	67.8
15-Jul	71.5	75.5	-4.0	1028	696	1236	437	2263	45	55	73.7
Avg	60.0	68.2	-8.2	4180	3039	2668	490	6848	60.1	39.9	63.1

Table L-6. Hypothetical flows: Model results: TRFE NORMAL year flows and 1992 hydrometeorological conditions.

	Water Temperature (° F)			Flow (cfs)				Combined Rivers			
1992 Week	Trinity R. @ Hoopa[a] Avg Week	Klamath R. @Big Bar [b] Avg Week	Difference (Trinity - Klamath)	Trinity Confluence Avg Week	Lewiston Dam Release	Klamath @ Orleans Avg Week	Iron Gate Dam Release	Flow (cfs) Combined	%Trinity	%Klamath	Water Temperatures (° F) Mixed
29-Apr	56.1	59.1	-3.0	5406	2500	3943	529	9349	58	42	57.4
06-May	55.5	62.7	-7.2	7892	5683	5817	518	13709	58	42	58.6
13-May	55.8	63.2	-7.3	6624	5005	4167	515	10791	61	39	58.6
20-May	56.8	65.2	-8.4	5166	3867	3399	503	8564	60	40	60.2
27-May	59.2	69.0	-9.8	4032	2988	2693	490	6725	60	40	63.1
03-Jun	61.4	70.9	-9.5	3001	2309	2406	486	5407	56	44	65.6
10-Jun	58.4	65.1	-6.7	2574	2000	2044	476	4618	56	44	61.3
17-Jun	63.3	72.0	-8.7	3256	2000	1917	651	5173	63	37	66.5
24-Jun	62.3	72.1	-9.8	2602	2000	1606	418	4208	62	38	66.1
01-Jul	60.7	69.6	-8.9	2733	2000	1454	433	4187	65	35	63.8
08-Jul	63.9	73.7	-9.8	1977	1543	1329	426	3306	60	40	67.8
15-Jul	71.5	75.5	-4.0	1028	696	1236	437	2263	45	55	73.7
Avg	60.4	68.2	-7.8	3858	2716	2668	490	6525	58.6	41.4	63.6

Table L-7. Hypothetical flows: Model results: TRFE DRY year flows and 1992 hydrometeorological conditions.

	Water Temperature (° F)			Flow (cfs)				Combined Rivers			
1992	Trinity R. @ Hoopa[a]	Klamath R. @Big Bar [b]	Difference (Trinity -	Trinity Confluence	Lewiston Dam	Klamath @ Orleans	Iron Gate Dam	Flow (cfs)			Water Temperatures (° F)
Week	Avg Week	Avg Week	Klamath)	Avg Week	Release	Avg Week	Release	Combined	%Trinity	%Klamath	Mixed
29-Apr	55.0	59.1	-4.1	6981	4071	3943	529	10924	64	36	56.4
06-May	56.9	62.7	-5.8	6003	3789	5817	518	11820	51	49	59.8
13-May	58.0	63.2	-5.1	4407	2782	4167	515	8574	51	49	60.5
20-May	59.6	65.2	-5.6	3347	2044	3399	503	6746	50	50	62.4
27-May	63.0	69.0	-6.0	2549	1504	2693	490	5242	49	51	66.1
03-Jun	65.5	70.9	-5.4	2060	1105	2406	486	4466	46	54	68.4
10-Jun	62.9	65.1	-2.1	1767	812	2044	476	3811	46	54	64.1
17-Jun	69.7	72.0	-2.4	1829	597	1917	651	3746	49	51	70.9
24-Jun	71.5	72.1	-0.7	1063	459	1606	418	2669	40	60	71.9
01-Jul	68.3	69.6	-1.3	1183	448	1454	433	2637	45	55	69.0
08-Jul	71.9	73.7	-1.7	883	448	1329	426	2211	40	60	73.0
15-Jul	74.2	75.5	-1.2	780	448	1236	437	2016	39	61	75.0
Avg	64.7	68.2	-3.4	2738	1542	2668	490	5405	47.4	52.6	66.5

Table L-8. Hypothetical flows: Model results: TRFE CRITICALLY DRY year flows and 1992 hydrometeorological conditions.

	Water Temperature (° F)			Flow (cfs)				Combined Rivers			
1992	Trinity R. @ Hoopa[a]	Klamath R. @Big Bar [b]	Difference (Trinity -	Trinity Confluence	Lewiston Dam	Klamath @ Orleans	Iron Gate Dam	Flow (cfs)			Water Temperatures (° F)
Week	Avg Week	Avg Week	Klamath)	Avg Week	Release	Avg Week	Release	Combined	%Trinity	%Klamath	Mixed
29-Apr	57.1	59.1	-1.9	4410	1501	3943	529	8353	53	47	58.1
06-May	60.1	62.7	-2.7	3715	1501	5817	518	8532	39	61	61.7
13-May	60.5	63.2	-2.7	3125	1501	4167	515	7292	43	57	62.0
20-May	60.9	65.2	-4.3	2804	1501	3399	503	6202	45	55	63.3
27-May	63.2	69.0	-5.8	2489	1444	2693	490	5182	48	52	66.2
03-Jun	65.5	70.9	-5.4	2060	1105	2406	486	4466	46	54	68.4
10-Jun	62.9	65.1	-2.1	1767	812	2044	476	3811	46	54	64.1
17-Jun	69.7	72.0	-2.4	1829	597	1917	651	3746	49	51	70.9
24-Jun	71.5	72.1	-0.7	1063	459	1606	418	2669	40	60	71.9
01-Jul	68.3	69.6	-1.3	1183	448	1454	433	2637	45	55	69.0
08-Jul	71.9	73.7	-1.7	883	448	1329	426	2211	40	60	73.0
15-Jul	74.2	75.5	-1.2	780	448	1236	437	2016	39	61	75.0
Avg	65.5	68.2	-2.7	2176	980	2668	490	4643	44.4	55.6	67.0

Table L-9. Hypothetical flows: Model results: BASE FLOW conditions of 300 cfs and 1992 hydrometeorological conditions.

Water Temperature (° F)				Flow (cfs)				Combined Rivers			
1992	Trinity R. @ Hoopa[a]	Klamath R. @Big Bar [b]	Difference (Trinity - Klamath)	Trinity Confluence	Lewiston Dam	Klamath @ Orleans	Iron Gate Dam	Flow (cfs)			Water Temperatures (° F)
Week	Avg Week	Avg Week		Avg Week	Release	Avg Week	Release	Combined	%Trinity	%Klamath	Mixed
29-Apr	59.0	59.1	-0.1	3210	300	3943	529	7153	45	55	59.0
06-May	63.2	62.7	0.5	2514	300	5817	518	8331	30	70	62.9
13-May	64.4	63.2	1.2	1924	300	4167	515	6092	32	68	63.5
20-May	65.7	65.2	0.5	1603	300	3399	503	5002	32	68	65.4
27-May	69.3	69.0	0.2	1345	300	2693	490	4038	33	67	69.1
03-Jun	70.6	70.9	-0.2	1255	300	2406	486	3661	34	66	70.8
10-Jun	65.7	65.1	0.6	1255	300	2044	476	3299	38	62	65.3
17-Jun	71.5	72.0	-0.5	1532	300	1917	651	3450	44	56	71.8
24-Jun	73.0	72.1	0.8	904	300	1606	418	2510	36	64	72.4
01-Jul	69.5	69.6	-0.1	1035	300	1454	433	2489	42	58	69.6
08-Jul	73.4	73.7	-0.2	734	300	1329	426	2063	36	64	73.6
15-Jul	75.9	75.5	0.5	632	300	1236	437	1868	34	66	75.6
Avg	68.4	68.2	0.3	1495	300	2668	490	4163	36.3	63.7	68.2

Dry and Critically Dry release schedules result in smaller differences in water temperatures than the Extremely Wet, Wet and Normal schedules (Tables L-7 and L-8). Using a Dry release schedule results in water temperatures that are as much as 6.0° F cooler than the Klamath River, but on average 3.4° F cooler. Using the Critically Dry release schedule results in water temperatures that are as much as 5.8° F different, but on average 2.7° F cooler.

Under baseflow conditions (a 300 cfs release from April 29 to July 15), the Trinity River water temperatures would have been very similar to the Klamath River water temperatures (Table L-9). Water temperatures would have only differed by as much as 0.8° F and on average would have been 0.3° F warmer than the Klamath River.

1993

Under an Extremely Wet release schedule, Trinity River water temperatures during the spring would have initially been warmer than the Klamath River, then colder later (Figure L-2, Table L-10). During the peak Lewiston Dam release of 9,807 cfs (week of May 27th), water temperatures of the Trinity River would have been about 1.0° F warmer than the Klamath. By early July water temperatures of the Trinity River would have become up to 3.9° F cooler than the Klamath River. On average, Trinity River water temperatures would have only been only 0.5° F cooler than the Klamath River.

Results of simulations under Wet and Normal release schedules are similar to that of the Extremely Wet release schedule. The only differences that occur between these releases are subtle changes in flows and thus water temperatures. On average, the Wet and Normal release schedules resulted in water temperatures that were 0.2° F (Table L-11) and 0.1° F (Table L-12) cooler than the Klamath River. In both of these years, Trinity River water temperatures would have been colder during the months of June and July.

Results of simulations using Dry and Critically Dry and base flow schedules (Tables L-13 and L-14) indicated that water temperatures of the Trinity River would have been warmer than the Klamath River. The Dry release schedule would have resulted in water temperatures that were as much as 3.4° F warmer and on average 1.7° F warmer than the Klamath River. The Critically Dry release schedule would have resulted in water temperatures that were as much as 3.9° F warmer and on average 2.0° F warmer than Klamath River water temperatures. Under baseflow conditions, water temperatures would have risen further, as much as 5.3° F warmer and on average 2.7° F warmer than the Klamath River (Table L-15).

1994

Simulation results for this year were fairly similar to those of 1992. Simulations for Extremely Wet, Wet, and Normal release schedules indicate that the high flows associated with these year types would result in Trinity River temperatures being considerably colder than the Klamath River (Figure L-2; Tables L-16 to L-18).

Dry and Critically Dry release schedules, however, would have resulted in water temperatures fairly similar to those in the Klamath River. A Dry release schedule would have resulted in water temperatures as much as 3.1° F colder, but on average 1.1° F colder than the Klamath River (Table L-19). A Critically Dry release schedule would have resulted in water temperatures less than 2.8° F colder and on average 0.3° F colder than the Klamath River (Table L-20).

Table L-10. Hypothetical flows: Model results: TRFE EXTREMELY WET year flows and 1993 hydrometeorological conditions.

Water Temperature (° F)				Flow (cfs)				Combined Rivers			
1993 Week	Trinity R. @ Hoopa[a] Avg Week	Klamath R. @Big Bar [b] Avg Week	Difference (Trinity - Klamath)	Trinity Confluence Avg Week	Lewiston Dam Release	Klamath @ Orleans Avg Week	Iron Gate Dam Release	Flow (cfs) Combined	Flow (cfs) %Trinity	Flow (cfs) %Klamath	Water Temperatures (° F) Mixed
29-Apr	54.7	52.7	1.9	8538	1500	18629	3873	27167	31	69	53.3
06-May	55.0	52.8	2.1	7549	2000	18657	4100	26206	29	71	53.5
13-May	56.8	54.2	2.6	6607	2000	17029	2499	23635	28	72	54.9
20-May	54.4	53.9	0.5	12464	7786	17400	1357	29864	42	58	54.1
27-May	53.7	52.7	1.0	20180	9807	21129	1741	41308	49	51	53.2
03-Jun	55.0	55.2	-0.2	15144	6619	21729	6023	36873	41	59	55.2
10-Jun	56.4	58.0	-1.6	10434	5067	12871	1601	23306	45	55	57.3
17-Jun	58.8	61.4	-2.6	7436	3420	9056	1067	16492	45	55	60.2
24-Jun	60.4	62.6	-2.2	5123	2313	5637	779	10761	48	52	61.5
01-Jul	61.6	64.9	-3.3	4188	2000	4127	738	8315	50	50	63.2
08-Jul	63.1	66.9	-3.9	3270	1543	3303	677	6573	50	50	65.0
15-Jul	64.7	65.4	-0.7	2048	696	2867	683	4915	42	58	65.1
Avg	57.9	58.4	-0.5	8582	3729	12703	2095	21285	41.6	58.4	58.0

Table L-11. Hypothetical flows: Model results: TRFE WET year flows and 1993 hydrometeorological conditions.

Water Temperature (° F)				Flow (cfs)				Combined Rivers			
1993 Week	Trinity R. @ Hoopa[a] Avg Week	Klamath R. @Big Bar [b] Avg Week	Difference (Trinity - Klamath)	Trinity Confluence Avg Week	Lewiston Dam Release	Klamath @ Orleans Avg Week	Iron Gate Dam Release	Flow (cfs) Combined	Flow (cfs) %Trinity	Flow (cfs) %Klamath	Water Temperatures (° F) Mixed
29-Apr	54.5	52.7	1.7	9039	2000	18629	3873	27668	33	67	53.3
06-May	54.7	52.8	1.9	8047	2500	18657	4100	26704	30	70	53.4
13-May	54.7	54.2	0.5	10388	5786	17029	2499	27417	38	62	54.3
20-May	54.6	53.9	0.7	11875	7196	17400	1357	29275	41	59	54.2
27-May	54.6	52.7	1.9	15642	5266	21129	1741	36771	43	57	53.5
03-Jun	56.2	55.2	1.0	11857	3329	21729	6023	33586	35	65	55.6
10-Jun	58.5	58.0	0.4	7521	2153	12871	1601	20392	37	63	58.2
17-Jun	60.4	61.4	-1.0	6017	2000	9056	1067	15073	40	60	61.0
24-Jun	60.9	62.6	-1.7	4813	2000	5637	779	10450	46	54	61.8
01-Jul	61.6	64.9	-3.3	4188	2000	4127	738	8315	50	50	63.2
08-Jul	63.1	66.9	-3.9	3270	1543	3303	677	6573	50	50	65.0
15-Jul	64.7	65.4	-0.7	2048	696	2867	683	4915	42	58	65.1
Avg	58.2	58.4	-0.2	7892	3039	12703	2095	20595	40.3	59.7	58.2

Table L-12. Hypothetical flows: Model results: TRFE NORMAL year flows and 1993 hydrometeorological conditions.

Water Temperature (° F)				Flow (cfs)				Combined Rivers			
1993	Trinity R. @ Hoopa[a]	Klamath R. @Big Bar[b]	Difference (Trinity -	Trinity Confluence	Lewiston Dam	Klamath @ Orleans	Iron Gate Dam	Flow (cfs)			Water Temperatures (° F)
Week	Avg Week	Avg Week	Klamath)	Avg Week	Release	Avg Week	Release	Combined	%Trinity	%Klamath	Mixed
29-Apr	54.3	52.7	1.6	9537	2500	18629	3873	28166	34	66	53.3
06-May	53.6	52.8	0.8	11229	5683	18657	4100	29886	38	62	53.1
13-May	55.0	54.2	0.8	9608	5005	17029	2499	26636	36	64	54.5
20-May	56.0	53.9	2.1	8549	3867	17400	1357	25949	33	67	54.6
27-May	55.3	52.7	2.6	13368	2988	21129	1741	34497	39	61	53.7
03-Jun	56.7	55.2	1.5	10837	2309	21729	6023	32565	33	67	55.7
10-Jun	58.6	58.0	0.5	7369	2000	12871	1601	20241	36	64	58.2
17-Jun	60.4	61.4	-1.0	6017	2000	9056	1067	15073	40	60	61.0
24-Jun	60.9	62.6	-1.7	4813	2000	5637	779	10450	46	54	61.8
01-Jul	61.6	64.9	-3.3	4188	2000	4127	738	8315	50	50	63.2
08-Jul	63.1	66.9	-3.9	3270	1543	3303	677	6573	50	50	65.0
15-Jul	64.7	65.4	-0.7	2048	696	2867	683	4915	42	58	65.1
Avg	58.3	58.4	-0.1	7569	2716	12703	2095	20272	39.7	60.3	58.3

Table L-13. Hypothetical flows: Model results: TRFE DRY year flows and 1993 hydrometeorological conditions.

Water Temperature (° F)				Flow (cfs)				Combined Rivers			
1993	Trinity R. @ Hoopa[a]	Klamath R. @Big Bar[b]	Difference (Trinity -	Trinity Confluence	Lewiston Dam	Klamath @ Orleans	Iron Gate Dam	Flow (cfs)			Water Temperatures (° F)
Week	Avg Week	Avg Week	Klamath)	Avg Week	Release	Avg Week	Release	Combined	%Trinity	%Klamath	Mixed
29-Apr	53.8	52.7	1.1	11112	4071	18629	3873	29741	37	63	53.1
06-May	54.2	52.8	1.4	9339	3789	18657	4100	27997	33	67	53.3
13-May	56.2	54.2	2.0	7390	2782	17029	2499	24419	30	70	54.8
20-May	57.3	53.9	3.4	6730	2044	17400	1357	24130	28	72	54.8
27-May	55.8	52.7	3.1	11885	1504	21129	1741	33014	36	64	53.8
03-Jun	57.4	55.2	2.1	9636	1105	21729	6023	31365	31	69	55.9
10-Jun	59.9	58.0	1.8	6183	812	12871	1601	19054	32	68	58.6
17-Jun	62.8	61.4	1.4	4615	597	9056	1067	13671	34	66	61.9
24-Jun	64.5	62.6	1.9	3273	459	5637	779	8910	37	63	63.3
01-Jul	66.1	64.9	1.3	2638	448	4127	738	6765	39	61	65.4
08-Jul	67.3	66.9	0.3	2175	448	3303	677	5478	40	60	67.1
15-Jul	65.9	65.4	0.4	1801	448	2867	683	4668	39	61	65.6
Avg	60.1	58.4	1.7	6398	1542	12703	2095	19101	34.7	65.3	59.0

Table L-14. Hypothetical flows: Model results: TRFE CRITICALLY DRY year flows and 1993 hydrometeorological conditions.

	Water Temperature (° F)			Flow (cfs)				Combined Rivers			
								Flow (cfs)			Water Temperatures (° F)
1993 Week	Trinity R. @ Hoopa[a] Avg Week	Klamath R. @Big Bar [b] Avg Week	Difference (Trinity - Klamath)	Trinity Confluence Avg Week	Lewiston Dam Release	Klamath @ Orleans Avg Week	Iron Gate Dam Release	Combined	%Trinity	%Klamath	Mixed
29-Apr	54.7	52.7	1.9	8541	1501	18629	3873	27170	31	69	53.3
06-May	55.2	52.8	2.4	7051	1501	18657	4100	25709	27	73	53.5
13-May	57.2	54.2	3.0	6109	1501	17029	2499	23137	26	74	55.0
20-May	57.8	53.9	3.9	6186	1501	17400	1357	23586	26	74	54.9
27-May	55.9	52.7	3.1	11825	1444	21129	1741	32954	36	64	53.9
03-Jun	57.4	55.2	2.1	9636	1105	21729	6023	31365	31	69	55.9
10-Jun	59.9	58.0	1.8	6183	812	12871	1601	19054	32	68	58.6
17-Jun	62.8	61.4	1.4	4615	597	9056	1067	13671	34	66	61.9
24-Jun	64.5	62.6	1.9	3273	456	5637	779	8910	37	63	63.3
01-Jul	66.1	64.9	1.3	2638	448	4127	738	6765	39	61	65.4
08-Jul	67.3	66.9	0.3	2175	448	3303	677	5478	40	60	67.1
15-Jul	65.9	65.4	0.4	1801	448	2867	683	4668	39	61	65.6
Avg	60.4	58.4	2.0	5836	980	12703	2095	18539	33.2	66.8	59.0

Table L-15. Hypothetical flows: Model results: BASE FLOW CONDITIONS of 300 cfs and 1993 hydrometeorological conditions.

	Water Temperature (° F)			Flow (cfs)				Combined Rivers			
								Flow (cfs)			Water Temperatures (° F)
1993 Week	Trinity R. @ Hoopa[a] Avg Week	Klamath R. @Big Bar [b] Avg Week	Difference (Trinity - Klamath)	Trinity Confluence Avg Week	Lewiston Dam Release	Klamath @ Orleans Avg Week	Iron Gate Dam Release	Combined	%Trinity	%Klamath	Mixed
29-Apr	55.1	52.7	2.4	3150	300	18629	3873	21779	14	86	53.1
06-May	56.0	52.8	3.2	3439	300	18657	4100	22096	16	84	53.3
13-May	58.5	54.2	4.3	3071	300	17029	2499	20100	15	85	54.8
20-May	59.2	53.9	5.3	1981	300	17400	1357	19381	10	90	54.4
27-May	56.4	52.7	3.6	1543	300	21129	1741	22671	7	93	53.0
03-Jun	57.9	55.2	2.6	1314	300	21729	6023	23043	6	94	55.4
10-Jun	60.5	58.0	2.5	1130	300	12871	1601	14001	8	92	58.2
17-Jun	63.4	61.4	2.0	961	300	9056	1067	10017	10	90	61.6
24-Jun	64.9	62.6	2.4	851	300	5637	779	6488	13	87	62.9
01-Jul	66.7	64.9	1.8	846	300	4127	738	4974	17	83	65.2
08-Jul	67.9	66.9	1.0	798	300	3303	677	4101	19	81	67.1
15-Jul	66.6	65.4	1.2	724	300	2867	683	3591	20	80	65.7
Avg	61.1	58.4	2.7	1651	300	12703	2095	14354	13.0	87.0	58.7

Table L-16. Hypothetical flows: Model results: TRFE EXTREMELY WET year flows and 1994 hydrometeorlogical conditions.

	Water Temperature (° F)			Flow (cfs)				Combined Rivers			
								Flow (cfs)			Water Temperatures (° F)
1994 Week	Trinity R. @ Hoopa[a] Avg Week	Klamath R. @Big Bar [b] Avg Week	Difference (Trinity - Klamath)	Trinity Confluence Avg Week	Lewiston Dam Release	Klamath @ Orleans Avg Week	Iron Gate Dam Release	Combined	%Trinity	%Klamath	Mixed
29-Apr	58.3	55.4	2.8	3076	1500	3943	574	7018	44	56	56.7
06-May	58.7	59.6	-0.9	3849	2000	5817	853	9666	40	60	59.3
13-May	57.4	57.8	-0.4	6496	2000	4167	676	7663	46	54	57.6
20-May	54.3	61.1	-6.8	9407	7786	3399	869	12805	73	27	56.1
27-May	53.7	63.5	-9.9	10996	9807	2693	585	13688	80	20	55.6
03-Jun	54.3	62.6	-8.3	7585	6619	2406	854	9990	76	24	56.3
10-Jun	55.5	66.5	-11.0	5851	5067	2044	609	7895	74	26	58.4
17-Jun	57.0	66.5	-9.5	4032	3420	1917	823	5950	68	32	60.0
24-Jun	60.2	69.0	-8.8	2807	2313	1606	567	4413	64	36	63.4
01-Jul	61.6	72.0	-10.4	2373	2000	1454	570	3827	62	38	65.5
08-Jul	64.8	75.0	-10.2	1857	1543	1329	574	3186	58	42	69.1
15-Jul	73.5	76.5	-3.0	953	696	1236	571	2189	44	56	75.2
Avg	59.1	65.5	-6.4	4690	3729	2668	677	7358	60.7	39.3	61.1

Table L-17. Hypothetical flows: Model results: TRFE WET year flows and 1994 hydrometeorlogical conditions.

	Water Temperature (° F)			Flow (cfs)				Combined Rivers			
								Flow (cfs)			Water Temperatures (° F)
1994 Week	Trinity R. @ Hoopa[a] Avg Week	Klamath R. @Big Bar [b] Avg Week	Difference (Trinity - Klamath)	Trinity Confluence Avg Week	Lewiston Dam Release	Klamath @ Orleans Avg Week	Iron Gate Dam Release	Combined	%Trinity	%Klamath	Mixed
29-Apr	57.4	55.4	2.0	3577	2000	3943	574	7520	48	52	56.4
06-May	58.0	59.6	-1.7	4347	2500	5817	853	10164	43	57	58.9
13-May	54.2	57.8	-3.6	7277	5786	4167	676	11445	64	36	55.5
20-May	54.5	61.1	-6.5	8817	7196	3399	869	12215	72	28	56.4
27-May	55.7	63.5	-7.9	6458	5266	2693	585	9151	71	29	58.0
03-Jun	56.7	62.6	-5.9	4297	3329	2406	854	6703	64	36	58.8
10-Jun	59.4	66.5	-7.1	2938	2153	2044	609	4982	59	41	62.3
17-Jun	59.7	66.5	-6.8	2613	2000	1917	823	4530	58	42	62.6
24-Jun	61.1	69.0	-7.9	2696	2000	1606	567	4102	61	39	64.2
01-Jul	61.6	72.0	-10.4	2373	2000	1454	570	3827	62	38	65.5
08-Jul	64.8	75.0	-10.2	1857	1543	1329	574	3186	58	42	69.1
15-Jul	73.5	76.5	-3.0	953	696	1236	571	2189	44	56	75.2
Avg	59.7	65.5	-5.8	4000	3039	2668	677	6668	58.5	41.5	61.9

Table L-18. Hypothetical flows: Model results: TRFE NORMAL year flows and 1994 hydrometeorlogical conditions.

	Water Temperature (° F)			Flow (cfs)				Combined Rivers			
								Flow (cfs)			Water Temperatures (° F)
1994 Week	Trinity R. @ Hoopa[a] Avg Week	Klamath R. @Big Bar [b] Avg Week	Difference (Trinity - Klamath)	Trinity Confluence Avg Week	Lewiston Dam Release	Klamath @ Orleans Avg Week	Iron Gate Dam Release	Combined	%Trinity	%Klamath	Mixed
29-Apr	56.7	55.4	1.2	4075	2500	3943	574	8018	51	49	56.1
06-May	55.1	59.6	-4.5	7528	5683	5817	853	13345	56	44	57.1
13-May	54.6	57.8	-3.3	6497	5005	4167	676	10664	61	39	55.8
20-May	56.7	61.1	-4.4	5491	3867	3399	869	8889	62	38	58.3
27-May	58.0	63.5	-5.5	4184	2988	2693	585	6877	61	39	60.2
03-Jun	58.3	62.6	-4.3	3277	2309	2406	854	5682	58	42	60.1
10-Jun	59.8	66.5	-6.8	2786	2000	2044	609	4830	58	42	62.6
17-Jun	59.7	66.5	-6.8	2613	2000	1917	823	4530	58	42	62.6
24-Jun	61.1	69.0	-7.9	2496	2000	1606	567	4102	61	39	64.2
01-Jul	61.6	72.0	-10.4	2373	2000	1454	570	3827	62	38	65.5
08-Jul	64.8	75.0	-10.2	1857	1543	1329	574	3186	58	42	69.1
15-Jul	73.5	76.5	-3.0	953	696	1236	571	2189	44	56	75.2
Avg	60.0	65.5	-5.5	3678	2716	2668	677	6345	57.4	42.6	62.2

Table L-19. Hypothetical flows: Model results: TRFE DRY year flows and 1994 hydrometeorlogical conditions.

	Water Temperature (° F)			Flow (cfs)				Combined Rivers			
								Flow (cfs)			Water Temperatures (° F)
1994 Week	Trinity R. @ Hoopa[a] Avg Week	Klamath R. @Big Bar [b] Avg Week	Difference (Trinity - Klamath)	Trinity Confluence Avg Week	Lewiston Dam Release	Klamath @ Orleans Avg Week	Iron Gate Dam Release	Combined	%Trinity	%Klamath	Mixed
29-Apr	55.2	55.4	-0.3	5650	4071	3943	574	9592	59	41	55.3
06-May	56.5	59.6	-3.1	5639	3789	5817	853	11456	49	51	58.1
13-May	56.4	57.8	-1.5	4280	2782	4167	676	8447	51	49	57.1
20-May	59.2	61.1	-1.9	3672	2044	3399	869	7071	52	48	60.1
27-May	61.1	63.5	-2.4	2701	1504	2693	585	5394	50	50	62.3
03-Jun	61.5	62.6	-1.1	2076	1105	2406	854	4482	46	54	62.1
10-Jun	64.2	66.5	-2.3	1600	812	2044	609	3644	44	56	65.5
17-Jun	65.9	66.5	-0.6	1211	597	1917	823	3128	39	61	66.3
24-Jun	69.9	69.0	0.9	957	459	1606	567	2563	37	63	69.3
01-Jul	71.6	72.0	-0.4	823	448	1454	570	2277	36	64	71.9
08-Jul	74.1	75.0	-0.9	763	448	1329	574	2091	36	64	74.7
15-Jul	76.7	76.5	0.2	706	448	1236	571	1942	36	64	76.5
Avg	64.4	65.5	-1.1	2506	1542	2668	677	5174	44.7	55.3	64.9

Table L-20. Hypothetical flows: Model results: TRFE CRITICALLY DRY year flows and 1994 hydrometeorlogical conditions.

	Water Temperature (° F)			Flow (cfs)				Combined Rivers			
1994 Week	Trinity R. @ Hoopa[a] Avg Week	Klamath R. @Big Bar [b] Avg Week	Difference (Trinity - Klamath)	Trinity Confluence Avg Week	Lewiston Dam Release	Klamath @ Orleans Avg Week	Iron Gate Dam Release	Flow (cfs) Combined	Flow (cfs) %Trinity	Flow (cfs) %Klamath	Water Temperatures (º F) Mixed
29-Apr	58.3	55.4	2.8	3079	1501	3943	574	7022	44	56	56.7
06-May	59.7	59.6	0.1	3351	1501	5817	853	9168	37	63	59.7
13-May	58.3	57.8	0.5	2998	1501	4167	676	7165	42	58	58.0
20-May	60.4	61.1	-0.7	3128	1501	3399	869	6527	48	52	60.7
27-May	61.3	63.5	-2.2	2641	1444	2693	585	5334	50	50	62.4
03-Jun	61.5	62.6	-1.1	2076	1105	2406	854	4482	46	54	62.1
10-Jun	64.2	66.5	-2.3	1600	812	2044	609	3644	44	56	65.5
17-Jun	65.9	66.5	-0.6	1211	597	1917	823	3128	39	61	66.3
24-Jun	69.9	69.0	0.9	957	459	1606	567	2563	37	63	69.3
01-Jul	71.6	72.0	-0.4	823	448	1454	570	2277	36	64	71.9
08-Jul	74.1	75.0	-0.9	763	448	1329	574	2091	36	64	74.7
15-Jul	76.7	76.5	0.2	706	448	1236	571	1942	36	64	76.5
Avg	65.2	65.5	-0.3	1944	980	2668	677	4612	41.2	58.8	65.3

Baseflow conditions would have resulted in water temperatures that were considerably warmer than the Klamath River (Table L-21). Under this scenario, water temperatures would have been as much as 6.0 °F warmer than the Klamath River and on average 2.6 °F warmer.

Discussion

Water Temperature Differences

These analyses have provided information that betters our understanding of the differences in Trinity and Klamath River water temperature regimes that have occurred in 1992, 1993, and 1994, and of those that might occur under the Trinity River Flow Recommendations. While this analysis does not evaluate a large number of years, the three years chosen represented a wide range of hydrologic conditions, from Wet (1993) to Dry (1992) and Critically Dry (1994).

Comparison of real data indicated that the thermal differences of the Trinity and Klamath Rivers were very small except when Lewiston Dam releases were large, (i.e., a 6,000 cfs release during June 1992) (Table L-1)relative to flows in the Klamath River, that resulted in a 7.4° F temperature differential. Because this year was a Dry year, flow accretion in the Trinity River below Lewiston Dam during the time of the 6,000 cfs release was less than 400 cfs. Similarly, flow accretion in the Klamath River between Iron Gate Dam (Klamath River Mile 190.1) and the Orleans gage (Klamath River Mile 59.2) was approximately 1,000 cfs. In contrast to the effects of this high flow, simulations with a base release of 300 cfs on May 20, 1993, indicate that Trinity River water temperatures could have been 2.9° F warmer than the Klamath River.

Model simulations using the Trinity River Flow Evaluation Recommendations also provide interesting information about what could be expected under a variety of flow schedules and different water year types. These analyses indicated that the temperature differential between the Klamath River and the Trinity River lessens when year types are matched with the corresponding TRFE release schedules. For example, if in the years 1992, 1993, and 1994, flows were based upon the TRFE recommendations, temperature differences would have been on average 3.4°, 0.2°, and 0.3° F cooler, respectively. Conversely, the differential becomes greatest when the extremes are mismatched (e.g., using an Extremely Wet year schedule in a Critically Dry year, which may result in water temperatures being as great as 11° F cooler: Table L-16). Again, because the TRFE recommendations are based upon hydrologic conditions, water temperature differentials should be small.

Water Temperature Differences and Salmonids

Although the recommendations are matched to year types that lessen temperature differentials between the Trinity and the Klamath Rivers, the innate error in predicting runoff patterns that largely influence water temperature dictates that there will be times that flow patterns will result in temperature differences. Although matching the recommendations to year types will lessen temperature differentials between the Trinity and the Klamath River, runoff patterns largely influence water temperature and are innately difficult to predict. However, the following generalities about the salmonid thermal requirements and the nature of stream dynamics do provide enough information to conclude that the TRFE recommendations will likely not result in any adverse conditions for salmonids. First, water temperature differences of less than 10° F (e.g., 55° to 65° F) are considered safe to stock chinook salmon juveniles (K. Rushton, Iron Gate Hatchery Manager, pers. comm). Stocking of salmon from one location to the other often leads to an

Table L-21. Hypothetical flows: Model results: BASE FLOW CONDITIONS of 300 cfs and 1994 hydrometeorlogical conditions.

Water Temperature (° F)				Flow (cfs)				Combined Rivers			
1994 Week	Trinity R. @ Hoopa[a] Avg Week	Klamath R. @Big Bar [b] Avg Week	Difference (Trinity - Klamath)	Trinity Confluence Avg Week	Lewiston Dam Release	Klamath @ Orleans Avg Week	Iron Gate Dam Release	Flow (cfs)			Water Temperatures (° F)
								Combined	%Trinity	%Klamath	Mixed
29-Apr	61.4	55.4	6.0	1878	300	3943	574	5821	32	68	57.4
06-May	63.3	59.6	3.7	2150	300	5817	853	7968	27	73	60.6
13-May	61.7	57.8	3.8	1797	300	4167	676	5964	30	70	59.0
20-May	64.3	61.1	3.2	1928	300	3399	869	5326	36	64	62.2
27-May	66.1	63.5	2.6	1497	300	2693	585	4190	36	64	64.5
03-Jun	65.3	62.6	2.7	1271	300	2406	854	3677	35	65	63.6
10-Jun	67.3	66.5	0.8	1088	300	2044	609	3132	35	65	66.8
17-Jun	68.1	66.5	1.6	915	300	1917	823	2832	32	68	67.0
24-Jun	71.3	69.0	2.3	798	300	1606	567	2404	33	67	69.7
01-Jul	73.1	72.0	1.1	674	300	1454	570	2129	32	68	72.4
08-Jul	75.7	75.0	0.7	614	300	1329	574	1943	32	68	75.2
15-Jul	78.5	76.5	2.1	558	300	1236	571	1794	31	69	77.1
Avg	68.0	65.5	2.6	1264	300	2668	677	3932	32.5	67.5	66.3

abrupt immersion into a completely different environment and therefore probably represents a worse case scenario. Boyd (1990) recommends that transfer of fish between waters occur only when water temperatures are less than 5.4° to 7.2° F, and that a rate of change of 0.4° F per minute can be tolerated.

Salmonids in a stream system generally do not experience abrupt changes in water temperatures like those that hatchery planted fish might experience. Rather, fish traveling downstream are apt to be slowly exposed to warming or cooling conditions. At the confluence of the Trinity and Klamath Rivers, thermal differences would vary over space and time. Fish traveling down the Trinity River into the Klamath River may experience slightly warmer water temperatures. At the confluence, it is expected that when differences do occur that fish will be able to move in and out of the gradients at will until they have acclimated to the new thermal regime or moved to more desirable locations.

While it appears that there is little chance of having large temperature differences at the confluence area, the Adaptive Environmental Assessment and Management Program (AEAMP) should evaluate the influences of dam releases on water temperatures and salmonids encountering these conditions. Modified operation scenarios could include the construction of a multilevel outlet works on Trinity Dam, altered diversion patterns, and the modified use of the water temperature curtain in Lewiston Reservoir. Through these modifications more variable release temperatures could be attained. As previously mentioned, however, perhaps there are benefits in providing cooler water to the Klamath River. Only by exploring these conditions through the AEAMP will we better understand the consequences of our actions.

APPENDIX M

Recommended Daily Releases from Lewiston Dam

Table M1. Recommended daily releases (cfs) from Lewiston Dam

Date	Extremely Wet	Wet	Normal	Dry	Critically Dry
01-Oct to 15 Oct	450	450	450	450	450
16-Oct to 21-Apr	300	300	300	300	300
22-Apr	500	500	500	300	300
23-Apr	500	500	500	300	900
24-Apr	500	500	500	300	1,500
25-Apr	500	500	500	300	1,500
26-Apr	500	500	500	300	1,500
27-Apr	500	500	500	900	1,500
28-Apr	500	500	500	1,500	1,500
29-Apr	1,500	2,000	2,500	2,500	1,500
30-Apr	1,500	2,000	2,500	3,500	1,500
01-May	1,500	2,000	2,500	4,500	1,500
02-May	1,500	2,000	2,500	4,500	1,500
03-May	1,500	2,000	2,500	4,500	1,500
04-May	1,500	2,000	2,500	4,500	1,500
05-May	1,500	2,000	2,500	4,500	1,500
06-May	2,000	2,500	4,000	4,306	1,500
07-May	2,000	2,500	6,000	4,121	1,500
08-May	2,000	2,500	6,000	3,943	1,500
09-May	2,000	2,500	6,000	3,773	1,500
10-May	2,000	2,500	6,000	3,611	1,500
11-May	2,000	2,500	6,000	3,455	1,500
12-May	2,000	2,500	5,784	3,307	1,500
13-May	2,000	2,500	5,574	3,164	1,500
14-May	2,000	3,000	5,373	3,028	1,500
15-May	2,000	4,000	5,178	2,897	1,500
16-May	2,000	6,000	4,991	2,773	1,500
17-May	2,000	8,500	4,811	2,653	1,500
18-May	2,000	8,500	4,637	2,539	1,500
19-May	2,000	8,500	4,469	2,430	1,500
20-May	3,000	8,500	4,307	2,325	1,500
21-May	4,000	8,500	4,151	2,225	1,500
22-May	6,000	7,666	4,001	2,129	1,500
23-May	8,500	6,833	3,857	2,037	1,500
24-May	11,000	6,000	3,717	1,950	1,500
25-May	11,000	6,000	3,583	1,866	1,500
26-May	11,000	6,000	3,453	1,785	1,500
27-May	11,000	6,000	3,328	1,708	1,500
28-May	11,000	6,000	3,208	1,635	1,500
29-May	10,444	5,690	3,092	1,564	1,500
30-May	9,889	5,322	2,980	1,497	1,497
31-May	9,333	4,977	2,872	1,433	1,433
01-Jun	8,778	4,655	2,768	1,371	1,371
02-Jun	8,222	4,354	2,668	1,312	1,312
03-Jun	7,667	4,072	2,572	1,255	1,255
04-Jun	7,111	3,809	2,479	1,201	1,201
05-Jun	6,556	3,562	2,389	1,150	1,150
06-Jun	6,000	3,332	2,303	1,100	1,100

Table M1. continued.

Date	Extremely Wet	Wet	Normal	Dry	Critically Dry
07-Jun	6,000	3,116	2,219	1,053	1,053
08-Jun	6,000	2,915	2,139	1,007	1,007
09-Jun	6,000	2,726	2,062	964	964
10-Jun	6,000	2,550	2,000	922	922
11-Jun	5,664	2,385	2,000	883	883
12-Jun	5,359	2,230	2,000	845	845
13-Jun	5,071	2,086	2,000	808	808
14-Jun	4,798	2,000	2,000	774	774
15-Jun	4,540	2,000	2,000	740	740
16-Jun	4,295	2,000	2,000	708	708
17-Jun	4,064	2,000	2,000	678	678
18-Jun	3,845	2,000	2,000	649	649
19-Jun	3,638	2,000	2,000	621	621
20-Jun	3,443	2,000	2,000	594	594
21-Jun	3,257	2,000	2,000	568	568
22-Jun	3,082	2,000	2,000	544	544
23-Jun	2,916	2,000	2,000	521	521
24-Jun	2,759	2,000	2,000	498	498
25-Jun	2,611	2,000	2,000	477	477
26-Jun	2,470	2,000	2,000	450	450
27-Jun	2,337	2,000	2,000	450	450
28-Jun	2,212	2,000	2,000	450	450
29-Jun	2,093	2,000	2,000	450	450
30-Jun	2,000	2,000	2,000	450	450
01-Jul	2,000	2,000	2,000	450	450
02-Jul	2,000	2,000	2,000	450	450
03-Jul	2,000	2,000	2,000	450	450
04-Jul	2,000	2,000	2,000	450	450
05-Jul	2,000	2,000	2,000	450	450
06-Jul	2,000	2,000	2,000	450	450
07-Jul	2,000	2,000	2,000	450	450
08-Jul	2,000	2,000	2,000	450	450
09-Jul	2,000	2,000	2,000	450	450
10-Jul	1,700	1,700	1,700	450	450
11-Jul	1,500	1,500	1,500	450	450
12-Jul	1,350	1,350	1,350	450	450
13-Jul	1,200	1,200	1,200	450	450
14-Jul	1,050	1,050	1,050	450	450
15-Jul	950	950	950	450	450
16-Jul	850	850	850	450	450
17-Jul	750	750	750	450	450
18-Jul	675	675	675	450	450
19-Jul	600	600	600	450	450
20-Jul	550	550	550	450	450
21-Jul	500	500	500	450	450
22-Jul to 30 Sep	450	450	450	450	450

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APPENDIX N

Adaptive Environmental Assessment and Management

What is AEAM?

Adaptive Environmental Assessment and Management (AEAM) is a formal, systematic, and rigorous program of learning from the outcomes of management actions, accommodating change, and improving management (Holling, 1978). Such a program combines assessment and management. Most agency and task force structures do not allow both to go on simultaneously (International Institute for Applied Systems Analysis, 1979). The basis of adaptive environmental assessment and management is the need to learn from past experience, data analysis, and experimentation. AEAM combines experience with operational flexibility to respond to future monitoring and research findings and varying resource and environmental conditions. AEAM uses conceptual and numerical models and the scientific method to develop and test management choices. Decision makers use the results of the AEAM process to manage environments characterized by complexity, shifting conditions, and uncertainty about key system component relations (Haley, 1990; McLain and Lee, 1996).

The AEAM approach to management relies on teams of scientists, managers, and policymakers to jointly identify and bound management problems in quantifiable terms (Holling, 1978; Walters, 1986). In addition, the adaptive approach to management "recognizes that the information we base our decisions on is almost always incomplete" (Lestelle et al., 1996). This recognition encourages managers to treat management actions as experiments, whose results can better guide future decisions. AEAM must not only monitor changes in the ecosystem, but also must develop and test hypotheses of the causes of those changes to promote desired outcomes. The results are informed decisions and increasing certainty within the management process.

Modern management strategies must have explicit and measurable outcomes. There are not many unambiguous clear-cut answers to complex hydraulic, channel-structure, and water-quality changes, but the AEAM process allows managers to adjust management practices (such as reservoir operations) and integrate information relating to the riverine habitats and the system response as new information becomes available.

Alluvial river systems are complex and dynamic. Our understanding of these systems and our predictive capabilities are limited. Together with changing social values, these knowledge gaps lead to uncertainty over how to best implement habitat maintenance or restoration efforts on regulated rivers. Resource managers must make decisions and implement plans despite these uncertainties. AEAM promotes responsible progress in the face of uncertainty. AEAM provides a sound alternative to either "charging ahead blindly" or being "paralyzed by indecision". Holling (1978) states that, "AEAM avoids the pitfall of requiring the costly amassing of more descriptive data before proceeding with policy initiatives. Instead, strategies are adopted as learning experiments in a fluid feedback structure that mandates vigorous self-critiquing and peer review at every stage, such that evaluation and corrective information is disclosed quickly and strategies modified or discontinued accordingly."

A well-designed AEAM program (1) defines goals and objectives in measurable terms; (2) develops hypotheses, builds models, compares alternatives, and designs system manipulations and monitoring programs for promising alternatives; (3) proposes modifications to operations that protect, conserve and enhance the resources; and (4) implements monitoring and research programs to examine how selected management actions meet resource management objectives. The intention of the AEAM program is to provide a process for cooperative integration of water- control operations, resource protection, monitoring, management, and research.

AEAM is Linked with Appropriate Assessment

AEAM assesses the results and effects of reservoir operations and instream flow regimes on biotic resources. The results of the assessments sustain or modify future operations. Outlined in Figure N.1 is a generalized 10-step AEAM process applicable to any management situation. The remainder of this Appendix is a brief description of each step in the process.

Determine Ecosystem Goals and Objectives

Resource agencies and stakeholders form the ecosystem restoration goals through a watershed-planning process. A key to successful watershed planning and ecosystem restoration is a combination of democratic stakeholder processes, technical input, and leadership. It is an error to assume that people will protect a stream if "educated". Management should work toward creating common ground where there are win/win outcomes; consider competitiveness, environmental soundness, and social/political issues; clarify areas of conflict and view conflict as an opportunity to learn; maintain a policy-evaluation framework that assumes, and is adaptable to, changing objectives; and address clearly stated conflicting alternatives, not a single, presumed true social goal (Holling, 1977).

Once goals for restoring or sustaining the ecosystem are firmly in view, the technical processes may begin. The first step quantifies past trends and the current status of the ecosystem and watershed. Scientists must then translate the goals into a set of measurable end points (objectives for ecosystem response).

Determine the Ecosystem Baseline

The ecosystem baseline includes all relative data, past and present, describing physical, chemical, and biological features of the river system. This will become the reference condition from which progress toward the management goals is measured.

Hypothesize Biological/Physical System Behavior/Response

Develop hypotheses of system behavior and responses of the biological, chemical, and physical components of the river ecosystem to directed management actions.

Select Future Management Actions

Based upon past and current conditions of the ecosystem, and armed with hypotheses about the consequences of management actions, the adaptive philosophy applies two processes for changing management activities. The first is to identify alternative management procedures to achieve the stated habitat and biota response objectives, and the second is to compare and select from the alternatives those that appear to move the system toward management objectives. For regulated rivers this should be an annual process along with a review of current system operating criteria and procedures. If alternative actions are proposed to achieve the same response, then designed experiments compare the alternatives (perhaps in consecutive years) leading to selection of the action that most efficiently achieves the measurable objective(s).

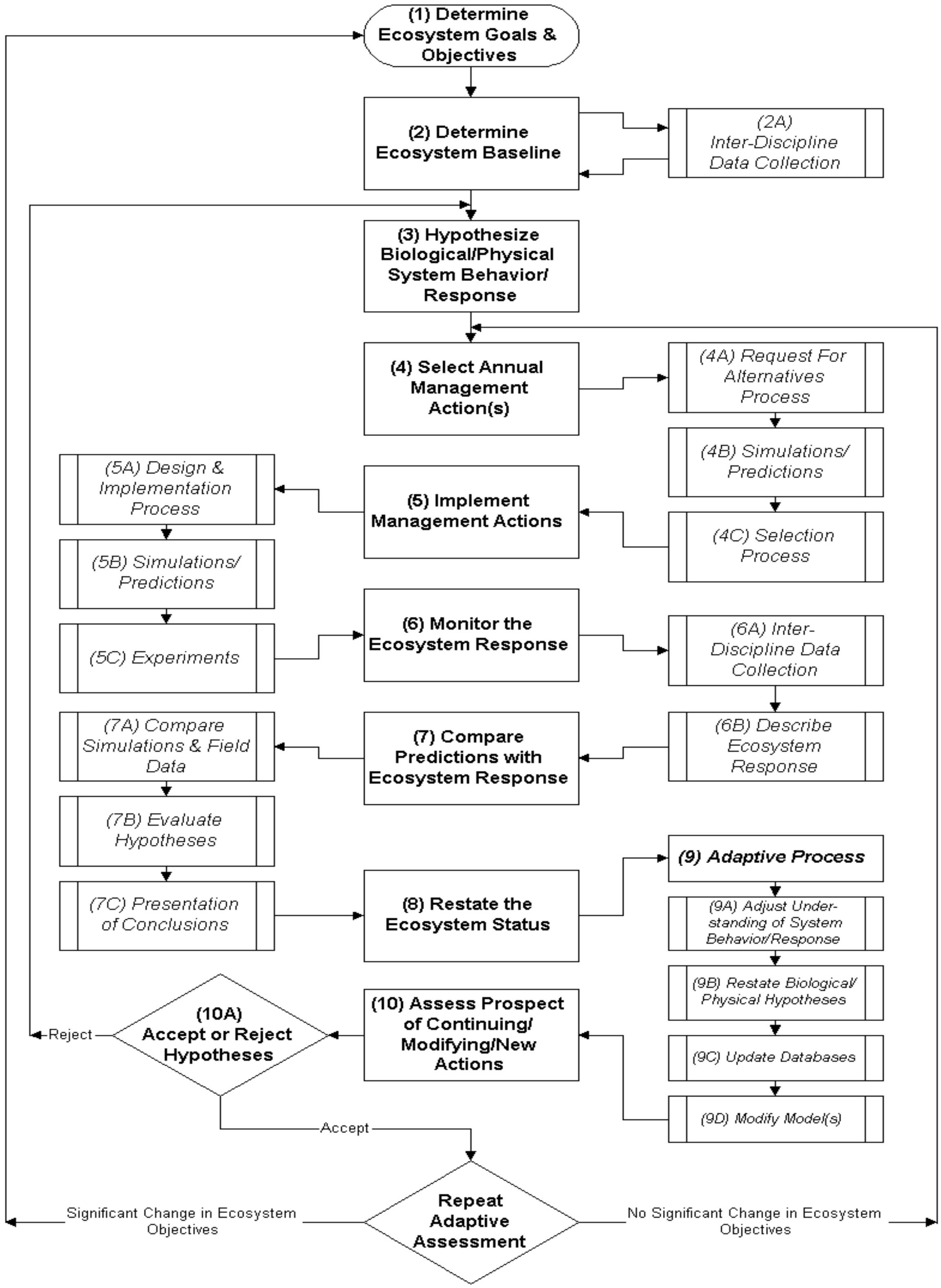

Figure N.1. Adaptive Environmental Assessment and Management process.

Simulations/Predictions - Using state-of-the-art models, the inter-disciplinary scientists simulate and predict the outcomes of the proposed management action alternatives. The results of the simulations and predictions form the basis for selecting the best management alternative.

Selection Process - Examine water-supply forecasts, status of the biota, and anticipated life-history needs of keystone species. The selection process must be a rational, well-regulated process, open to review and control by the management authority. The alternative selected should have the highest probability for successful implementation and achieve the annual management objectives based upon the water supply (e.g., water year type) and hypotheses for the system response.

Implement Management Actions

Design and Implementation - The inter-disciplinary scientists and management collectively are responsible for the design of the operating criteria and procedures for implementing the management actions prescribed by the selection process.

Simulations/Predictions - Experts at modeling, simulating, experimental design, and predicting the outcome of management actions will endeavor to forecast seasonal responses to the selected annual operating criteria and procedures. The task is to expertly simulate and predict measurable physical, chemical, and biological responses of the river ecosystem to the selected management actions. Rigorous application of the scientific method tests each iteration (annual forecasts/predictions) of simulation models through post-audit comparisons of observed versus expected results.

Experiments - Management must support short-term and long-term scientific experiments as part of an operations post-audit evaluation program. Experiments may be necessary to compare alternative hypotheses or alternative operating protocols that advocates present to achieve identical (or very similar) measurable objectives. When uncertainty in system response leads to differing scientific opinions, experiments are set up as alternative management actions compared between years.

Monitoring the Ecosystem Response

Data Collection - The purpose of the data is to continue adding to the understanding of the ecosystem and its current status.

Database Updates - Annual monitoring data are summarized and incorporated into an open and shared database.

Experimental Design - Annual monitoring programs designed to test results of annual operating procedures are essential to establish scientific validity of the management actions taken.

Description of Ecosystem Responses - Data collected during the monitoring process are used to describe the response of the ecosystem to imposed management actions. The purpose is to establish scientific validity for the management program, gain management control over the causal processes, understand how management actions cause changes in the ecosystem, support or refute ecosystem-response hypotheses, and improve model predictions.

Compare Predictions with Ecosystem Response

Post-Audit Comparison of Simulations and Field Data - Comparisons of model predictions with field observations are made, and recommendations are given for model improvement, changes to the operating criteria and procedures, and monitoring program as appropriate. Replace model validation with invalidation - the process of establishing a degree of belief for each of a set of alternative model simulations (Holling, 1978). The scientific objective is to offer opinions on an annual basis of acceptance or rejection of the system-response hypotheses and to continually improve predictive capability.

Presentation of Conclusions - Sharing the conclusions in an open atmosphere will encourage participation and input from stakeholders. When scientific debate challenges management actions, stakeholders with differing opinions on operating criteria and procedures are requested to offer testable alternative hypotheses rather than simply argue to discredit the selected management procedures.

Restate the Ecosystem Status

After the implementation of specific operating criteria and procedures, the status of the ecosystem is reassessed and described. The new state is compared to the baseline state in order to measure progress toward ecosystem objectives. This should be done in winter just prior to the annual February to May water-supply forecasting period.

Adaptive Process

The adaptive component of the management process is the learning and evolution of understanding. This process encourages stakeholders to gain an understanding of the ecosystem, its behavior and response to management actions, and the potential for achieving stated objectives.

Adjust Understanding of Ecosystem Behavior/Response - The most difficult part of the AEAM process is for individual stakeholders to adjust their understanding to a different point of view concerning how the ecosystem functions. To accomplish this, assessment must be viewed as an ongoing process and not as a one-time screening prior to a resource development decision (Holling, 1978). Given each annual water-supply forecast, the suite of models is utilized to predict physical, chemical, and biological responses under the annual operating criteria and procedures, or designed experimental releases, as appropriate. The adjustment takes honest examination of the data and scientific analyses following careful, deliberate management actions.

Modify Model(s) - Based upon the degree of congruence between model predictions and post- audit observations certain models may be recalibrated, modified by reformulating certain relations, or, if necessary, replaced with new models. Following the annual updating of the suite of models, the next round of management actions can commence. Models are simply recalibrated or slightly modified to increase predictive ability as long as data support model projections.

Assess Prospect of Continuing/Modifying/New Actions

Restate Biological/Physical Hypotheses - An ongoing element of the process is to constantly challenge the stated system hypotheses and improve the ability to predict the behavior and response of the ecosystem so that progress toward the management objective is rapid. If certain hypotheses of system response are not supported, then new hypotheses must be proposed, modeled, and in turn tested.

The scientists must offer an annual statement of the system hypotheses presenting evidence in support or rejection of tested hypotheses.

Recycle Through Adaptive Processes - Design annual management actions (operating criteria and procedures). If system hypotheses are supported (not rejected), then recycle through the process by going back to step 4 and selecting annual operating criteria and procedures for the forecasted water supply (water year class).

If system hypotheses are rejected, recycle through the process by going back to step 3, stating alternative hypotheses to achieve the same management goals.

Redefine Ecosystem Goals when Appropriate - On occasions such as natural disasters, toxic spills, or major legislative actions, the ecosystem management (social) goals may change. In such events, recycle through the adaptive process by going back to step 1. Restate the system goals, perhaps requiring a different or modified baseline and certainly the generation of new hypotheses of system response translated to new measurable system objectives.

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APPENDIX O

AEAM Tasks for Improving Understanding of the Alluvial River Attributes and Biological Responses in the Trinity River

Introduction

Considerable effort was put forth by the authors of this Trinity River Flow Evaluation Report. This involved searching the scientific literature, examining the completed Trinity River studies, compiling data, and conducting additional analyses specifically for this report.

The recommendations for the initial reservoir release schedules and river corridor management actions were built upon a series of workshop discussions. This led to a listing of hypotheses about how the Trinity system had responded since the construction and operation of the TRD and what would be required to reverse these trends and rehabilitate the habitats. This appendix summarizes many of the hypotheses, potential competing hypotheses, management objectives, what is known specifically about the Trinity River, and the major unknown or unquantified issues that need to be addressed. This listing is organized by season of year and is directed to the appropriate hydrograph component (release schedule) as is presented in Tables 8.5 to 8.9 in the chapter on recommendations. This listing is not meant to be exhaustive but to provide a summary of the major issues discussed during the evolution of the recommended Trinity River flow management strategy. The logic and initial recommendations represented here are a foundation upon which the Adaptive Management Team can further improve understanding of the system, accomplish validation of management models, and increase the overall certainty of management decisions.

Summer/Fall Baseflow

All water years - June 26 to October 15

Hypothesis:

- If water temperatures are less than 60° F degrees downstream to Douglas City (through June 26-Oct 15), then no temperature-related mortality will occur to adult spring chinook salmon, and impacts to spring chinook salmon eggs developing *in vivo* will be negligible.
- If water temperatures are near optimal, then juvenile coho salmon and steelhead growth rates and size at age will increase, increasing smolt-to-adult success.
- Lewiston releases of 450 cfs for temperature needs provide a greater benefit to adult spring chinook salmon, juvenile coho salmon, and juvenile steelhead, than the benefits associated with releases of 300 cfs. Releases of 450 cfs would provide additional spring chinook salmon spawning habitat, juvenile coho salmon rearing habitat, and juvenile steelhead rearing habitat.

Potential competing hypotheses:

- Reducing Lewiston releases below summer low flows will cause pools to stratify, providing optimal water temperatures in bottoms of deep pools.
- Spring chinook salmon habitat (thus production) can be increased, and redd dewatering can be decreased, by releasing 300 cfs from mid-September through early April.

Objectives:

- Provide near-optimal water temperatures from Lewiston Dam to Douglas City.

What we know:

- Studies of the survival of Sacramento River chinook salmon eggs developing *in vivo* as a function of temperature showed that temperatures between 38° F and 60° F are needed (Boles, 1988).
- Spring chinook salmon over-summering distribution is most concentrated from Lewiston to Douglas City (USFWS, 1988).
- Lewiston release of 450 cfs achieves temperature targets at Douglas City and North Fork, the basis of empirical evidence (Zedonis, pers. comm.).
- Microhabitat-to-flow relations within the riparian berms of the existing channel indicate relatively low levels of suitable habitat for young-of-year anadromous salmonids. The habitat quality generally declines at flows approaching the top of the bank (berms) owing to increasing velocities.

What we don't know:

- What temperatures are necessary for protection of Trinity River adult spring-run chinook salmon as well as their eggs developing *in vivo*?
- What temperatures are necessary for protection of various life stages of Trinity River anadromous fishes, including chinook salmon, coho salmon, steelhead, green sturgeon, and lamprey.
- What were summer temperatures at locations used by holding spring chinook salmon prior to the construction of the dam?
- What Lewiston releases (if any) would lead to thermal stratification of pools above the North Fork?
- How will spring-through-fall temperatures provided by the recommendations impact amphibians?
- How will these temperatures impact other aquatic vertebrates?
- What will the habitat—discharge relation be in the rehabilitated mainstem channel?

Potential Management Actions

- Monitor temperatures at downstream control points (Douglas City, North Fork, Weitchpec), and manage Lewiston releases to provide appropriate downstream temperatures if temperature thresholds are approached.
- Develop and test criteria specific to Trinity River adult chinook salmon, coho salmon, and steelhead physiology.
- Evaluate growth rates for juvenile coho salmon and steelhead as a function of summer/fall water temperatures.

- Monitor adult spring chinook salmon distributions under stratified and unstratified conditions in pools of the mainstem Trinity and/or the South Fork Trinity River to document carrying capacity as a function of pool volume and water near optimal temperatures.
- Monitor juvenile coho salmon and steelhead density under pool stratified and unstratified conditions in pools of the mainstem Trinity and/or the South Fork Trinity River to document carrying capacity as a function of pool volume and water temperatures.
- Monitor adult spring chinook salmon distributions during holding and spawning periods.
- Evaluate competing hypotheses regarding water-temperature management (e.g., can we achieve fish production objectives if pools are allowed to stratify?; can Trinity River fish thrive at temperatures other than those now thought necessary?).
- Conduct real-time temperature modeling/monitoring to evaluate whether flows can be reduced from 450 cfs to 300 cfs in early/mid-September, which may increase the hydraulic suitability of microhabitat in the rehabilitated channel.

Winter Baseflow

- All water years - October 16 to April 22-May 17

Hypotheses:

- By maximizing suitable spawning habitat area for chinook salmon, coho salmon, and steelhead, we are increasing spawning success and fry production.
- By maximizing suitable rearing habitat area for chinook salmon, coho salmon, and steelhead, we are increasing growth rates, size at age, and production.
- By increasing the availability of high-quality over-winter habitat for steelhead and coho salmon (by increasing the availability of large interstitial spaces within the streambed), survival to age one-plus will increase, and smolt production will increase.
- Real-time flow management will allow optimization of Lewiston releases to maximize production within a given year (emergence timing, number and distribution of redds, spatial differences in discharge versus habitat area).

Competing hypotheses:

- Gradually increasing Lewiston releases from September to December will better distribute salmonid spawners, increasing spawning success.
- Broader distribution of redds will decrease risk of cohort loss from redd scour during tributary-generated flooding.
- Pulse flows can be effective in assisting adult salmon migrations into tributaries.

Objectives:

- Maximize suitable habitat area for chinook salmon, coho salmon, and steelhead spawning.
- Maximize habitat area for coho salmon and steelhead rearing and over-wintering habitat.
- Improve migration access into tributaries.

What we know:

- Flow-to-habitat relations within existing bermed channel morphology.
- Rearing habitat for fry chinook salmon is a primary limiting factor within the existing channel morphology.
- Over-winter habitat for juvenile steelhead and coho salmon is a primary limiting factor within the existing channel.
- Spawning habitat can soon become limiting within the existing channel morphology if escapement increases.
- Given the temperature regime, we can estimate the time of emergence for each species and race of anadromous salmonid.
- Optimal and marginal ranges of temperature for incubation and rearing, obtained from the literature, can be achieved with recommended flow releases.
- Distribution of chinook salmon spawners is well known from CDFG carcass counts.

What we don't know:

- Flow-to-habitat relations with a new channel morphology.
- Contribution of tributaries to basin-wide anadromous salmonid production, particularly upstream from the North Fork Trinity River.
- Whether access to tributaries is a problem as a result of delta aggradation, etc.
- Where do salmon spawn within channel morphology? How does this spatial distribution change with discharge within reaches?
- Relationship of redd scour and dewatering to releases.
- How tributary flow accretion impacts downstream habitat availability relationships in real-time.

Potential Management Actions

- Establish network of telemetered temperature and streamflow gages so that we can perform real-time habitat and temperature modeling to optimize incubation success (redd scouring, redd dewatering, egg survival, time of sac-fry emergence) and manage rearing habitat in synchronization with tributary accretions.

- Re-evaluate flow-to-habitat relations to refine microhabitat responses to flow releases.
- Utilize stratified sampling to allow for extrapolation to entire 40-mile reach of upper Trinity River.
- Annually update flow-to-habitat relations to improve management of releases for provision of microhabitat.
- Implement data-gathering between October and April 1 (sediment transport, redd counts and distribution, juvenile growth rates, habitat data, etc.).
- Recalibrate and update all predictive models for the antecedent conditions prior to April 1, to prepare and evaluate release schedule for the snowmelt peak and snowmelt runoff period based on these conditions.

Fall/Winter Flood Flows

Potential management Actions

- All water years - November to late February
- No high-flow releases are planned, but sychronization of peak releases with stormflows should be evaluated through the adaptive management program to assess opportunities to maximize benefits of high-flow releases while conserving water.

Hypotheses:

- A single high-flow release each year will accomplish necessary geomorphic work (sediment transport, fine sediment deposition on floodplains, channel migration, bed mobility and scour, riparian vegetation scour, etc.).
- Preventing fall/winter peak flows in reaches nearest to Lewiston will reduce egg/embryo mortality associated with redd scour.
- Peak flow releases redistribute juvenile salmonids throughout the mainstem, minimizing competition for habitat and food.
- Peak flow releases encourage outmigration of hatchery-released salmonids, minimizing competitive interactions with non-hatchery steelhead and coho salmon.
- Management objectives will be met without need to synchronize releases with tributary stormflows.
- Gravel introductions near Lewiston during peak flow releases will improve spawning and rearing habitat, leading to increased production.
- Fine sediment control efforts such as trapping at Hamilton Ponds will continue to be necessary.

Competing hypotheses:

- Synchronizing peak Lewiston releases with fall/winter peak flows in tributaries will transport fine sediment delivered by tributaries in suspension, deposit the fine sediment on floodplains, and will be less likely to reduce infiltration of mainstem alluvial deposits by fines.

- Synchronizing peak Lewiston releases with tributary flood events increases downstream coarse sediment transport capacity, which allows us to better balance reach-wide coarse sediment budgets.
- Synchronizing peak releases with tributary stormflows would increase the magnitude and frequency of scour events, increasing riparian vegetation mortality and improving success with rehabilitation of riparian plant community diversity.

What we know:

- Peak releases near 6,000 cfs are adequate to initiate scour and transport of channelbed sediment at many locations.
- Peak discharges in tributaries downstream from Lewiston Dam are driven predominantly by rainfall, rather than snowmelt events.
- Tributary-generated floods are large enough below Douglas City to mobilize the bed surface with regularity.
- Large flood events occurring during egg incubation cause scour-induced mortality.

What we don't know:

- Hydrology in several significant tributaries downstream from Indian Creek.
- Redd scour and egg mortality as a function of discharge and location in the mainstem channel.
- Distribution of salmon spawning within existing or rehabilitated channel morphology. How does this spatial distribution change with discharge within a reach?
- How much real-time modeling and monitoring could yield information that would reduce constraints/restraints to flow management.

Management Actions

- The network of telemetered streamflow- and temperature-monitoring stations needs to be expanded.
- Flood-routing models must be used to evaluate impacts/opportunities for synchronizing Lewiston releases with tributary stormflows for management of microhabitat, geomorphic processes, and water temperatures.

Ascending Limb of Snowmelt Peak

- April 22-May 24 depending on water year

Hypotheses:

- There are no substantial negative biological impacts to rapid up-ramping rates.
- There are no substantial negative biological impacts associated with timing of annual peak releases.
- Timing of ascending-limb releases is optimal for anadromous fish species.

Competing Hypotheses:

- Timing and rate of Lewiston release up-ramp will substantially impact early life stage of anadromous salmonids (eggs, sac fry, fry), as well as amphibians and other wildlife species.

What we know:

- Natural up-ramping rates during historical rainfall events was very rapid.
- Natural up-ramping rates during snowmelt runoff events was rapid, but not as rapid as during rainfall events.
- Timing of peak flows was highly variable prior to dam construction.

What we don't know:

- Impacts of rapid up-ramping to salmonids, yellow legged frogs, turtles.
- Biological impact of having peak flows (in the reach nearest the dam) at virtually the same time each year, rather than over a 6 month period as observed in the hydrological record.

Potential management Actions

- Monitor impact of release increases in real time, adjusting to limit hazards to early life stage of anadromous salmonids, amphibians, and other riparian/aquatic organisms.

Snowmelt Peak Flow

- All Water Years - April 24 - May 29

Hypotheses:

- A single snowmelt peak is sufficient to accomplish desired geomorphic work (sediment transport, fine sediment deposition on floodplains, channel migration, bed mobility and scour, riparian scour, etc.).
- Peak releases of 11,000 cfs will cause bed scour to a depth greater than two D_{84} on exposed alluvial surfaces, scouring and killing woody riparian vegetation up to two and a half years old (the previous 3 year's cohorts).
- Peak releases of 8,500 cfs will cause bed scour to a depth greater than one D_{84} on exposed alluvial surfaces, scouring and killing woody riparian vegetation up to one and a half years old (the previous 2 year's cohorts).
- Peak releases of greater than 6,000 cfs will cause bed mobilization of the D_{84} size class on exposed alluvial surfaces, scouring and removing woody riparian vegetation that established the previous year (the previous year's cohort).
- Peak flow releases greater than 6,000 cfs will access floodplains, depositing fine sediment on floodplain surfaces and improving natural riparian regeneration.

- Peak flow releases greater than 3,000 cfs will begin to move the most mobile of coarse alluvial deposits within the active channel (e.g., in locations such as pool tails, median bars).
- Recommended durations of peak releases will transport coarse sediment supplied by tributaries downstream through the mainstem. Routing coarse sediment downstream will replenish alluvial deposits, creating and maintaining spawning and rearing habitat, and increasing salmonid production.
- Bed scour to a depth greater than 2 D_{84}, combined with reduced fine sediment supply to the mainstem, will improve spawning and rearing habitat quality; improved spawning and rearing habitat will improve egg emergence and fry rearing success, increasing salmonid production.
- Peak releases greater than 6,000 cfs, combined with physical channel alteration, will encourage channel migration. Channel migration will assist in the creation of new floodplain surfaces, improve particle-sorting processes within the active channel, and recruit large woody debris into the channel. As a result, channel complexity will increase, juvenile rearing habitat will be enhanced, and salmonid productivity will increase.
- Scheduling peak releases from April 24 to May 29 reduces mortality of juvenile outmigrants by increasing turbidity, decreasing travel time, and reducing juvenile salmonid density (fish/yd^3 of water)
- Scheduling peak releases from April 24 to May 29 minimizes risk of scour mortality on incubating salmonid eggs, increasing fry production.
- Salmonid fry are more susceptible to stranding than are juveniles or smolts, and because most salmonids are juveniles and smolts in April through June, scheduling peak releases from April 24 to May 29 minimizes vulnerability of early life stages to stranding, increasing salmonid production.
- Staggering of peak releases will afford advantages to certain species if necessary. For example, in drier years, yellow-legged frog egg masses may have greater hatching success than in wetter years (instead of all years being poor or good).
- Existing fine sediment control efforts (Buckhorn Dam, Hamilton Ponds, and watershed-rehabilitation projects), combined with recommended releases, will transport fine sediment at a rate greater than input, decreasing fine sediment storage in the mainstem. Reduced storage of fine sediment in the mainstem will increase adult holding habitat (number and depth of pools), improve rearing habitat (lower embeddedness along channel margins and in riffles; increased availability of substrate interstices used for over-wintering), and improve spawning habitat (decreased fine sediment in spawning gravel).
- By inundating a bar during riparian seed-release period, establishment of riparian plants cannot occur.

Competing hypotheses:

- By failing to synchronize peak flow releases with tributary floods, fine sediment delivered by tributaries will be more likely to infiltrate mainstem alluvial deposits rather than depositing on floodplain surfaces.
- Pool dredging will be required to push the fine sediment budget into a deficit, because releases will be insufficient in many years to transport fine sediment volumes yielded to the mainstem.

- Transport during the peak flow will be insufficient to export fine sediment at a rate greater than input. An extended-duration medium-magnitude release will be required following annual peak releases.

What we know:

- Sediment inputs have been quantified for Deadwood Creek, Rush Creek, Grass Valley Creek, and Indian Creek for water years 1997 and 1998. Sediment transport has been quantified for the Trinity River at Lewiston and Limekiln Gulch gaging stations for water years 1997 and 1998.
- Streamflows have been quantified at above-mentioned sediment-monitoring sites.
- Bed-mobility thresholds have been quantified for most of existing channelbed between Lewiston Dam and the North Fork Trinity. Thresholds are reached at flows between 5,000 and 6,000 cfs.
- Bed-mobility thresholds for mobile deposits within the active channel between Lewiston Dam and the North Fork Trinity have been quantified. These occur at or above 3,000 cfs.
- Bed-mobility thresholds for the channelbed at evolving channel-rehabilitation sites have been quantified. These thresholds occur between 5,000 and 6,000 cfs.
- Yearly peak releases since 1995 (6,000 to 30,000 cfs) have prevented riparian re-encroachment on evolving bank-rehabilitation sites.
- Individual, short-duration peak flows less than 30,000 cfs do not appreciably disturb the existing riparian berms above the North Fork Trinity.

What we don't know:

- Whether recommended high-flow releases and existing fine sediment control efforts will significantly decrease fine sediment storage in the mainstem channel.
- Whether recommended high-flow releases in concert with a coarse sediment management program will provide for adequate distribution and amounts of coarse sediment in reaches near Lewiston.
- We are uncertain of specific requirements for durations of peak (sediment-transporting) flows because volumes of tributary-derived sediment will vary substantially from year to year. Yearly monitoring of tributary sediment delivery, combined with sediment transport and routing modeling (e.g., HEC-6), will be required to fine-tune yearly duration of flows on an annual basis.
- Will sequences of Critically Dry water years lead to encroachment by riparian vegetation?

Magnitude objectives:

- **Extremely Wet water years–**Cause bed scour to a depth greater than 2 D_{84} on newly formed alternate bar faces to discourage/prohibit encroachment by riparian vegetation. Empirical plots of discharge versus relative scour depth (D_{sc}/D_{84}) have variable results, with D_{sc}/D_{84} values of 2 ranging from 8,000 to 16,000 cfs. 11,000 cfs was chosen as the first discharge to be evaluated in the adaptive management program.

- **Wet water years-**- Cause bed scour to a depth greater than 1 D_{84} on newly formed alternate bar faces to discourage/prohibit encroachment of riparian vegetation. Empirical plots of discharge versus relative scour depth (D_{sc}/D_{84}) have variable results, with D_{sc}/D_{84} values of 1 ranging from 6,000 to 8,500 cfs. 8,500 cfs was chosen as a conservative estimate of releases to be evaluated in adaptive management program.

- **Normal water years-**- Cause general bed mobilization on most alluvial deposits within channel, particularly on alternate bar faces to discourage/prohibit encroachment of riparian vegetation. Experiments by Wilcock et al. (1995) on non-rehabilitated sites suggest that discharges between 5,000 cfs and 6,000 cfs accomplish this objective, and results from McBain and Trush (1997) on rehabilitated alternate bar surfaces were in general agreement. Therefore, 6,000 cfs was chosen as the release to be evaluated in the adaptive management program.

- **Dry water years-**- Cause bed mobilization of alluvial deposits within channel, such as pool tails, median bars, and lower portions of alternate bar faces. Results from McBain and Trush (1997) suggest that flows exceeding 2,700 cfs begin to mobilize these deposits. A release of 4,500 cfs was chosen as the initial release to be evaluated in adaptive management program.

- **Critically Dry water years-**- Inundate point bar surfaces of rehabilitated alternate bar sequences to preclude germination of seeds on exposed gravel/cobble surfaces. There is considerable concern that this approach will prevent formation of a riparian berm along the low water channel, but may result in the formation of a new riparian berm higher on the bank. Discharges that inundate newly formed point bars range from 1,300 to 3,300 cfs, with the variability caused by differing construction techniques, differing obstruction angles, and other factors. A release of 1,500 cfs was chosen as a first estimate to be evaluated in the adaptive management program.

Duration objectives (for all water years)

- Transport coarse sediment delivered to mainstem Trinity River from Deadwood Creek and Rush Creek at a rate equal to input for respective water years. Duration of the peak flow event is the most uncertain portion of the channel-forming flow recommendation because the volume of coarse sediment delivered to the mainstem Trinity River varies tremendously from year to year. An initial duration recommendation of 5 days is based on extrapolating two years of coarse sediment budget data to a longer term average for Extremely Wet years. However, the uncertainty associated with this estimate is large.

- Transport fine sediment (<5/16 inch) delivered to mainstem Trinity River from Deadwood Creek, Rush Creek, Grass Valley Creek, and others at a rate equal to or greater than input for respective water years, such that instream fine sediment storage decreases over time.

Management Actions

- Establish HEC-6 modeling reaches immediately downstream from tributary deltas (and Lewiston Dam).

- Establish network of flow gages sufficient for management of releases in synchronization with tributary stormflows.

- Establish index reaches to monitor fine sediment storage in channel (both surface and subsurface)

- Monitor/model rehabilitation sites to ensure that bed-mobility and bed-scour thresholds (and associated responses of riparian vegetation) achieve desired objectives.
- Continue Buckhorn Dam and Hamilton Pond fine sediment control efforts on Grass Valley Creek.
- Calculate, on an annual basis, the input of fine and coarse sediment from significant tributaries between Lewiston Dam and the North Fork Trinity. Apply estimates in scheduling of peak flow durations.

Descending Limb of Snowmelt Peak

All water years - May 5 to July 22

Hypotheses:

- Releases during this period can be used to control water temperatures between Lewiston Dam and Weitchpec within limits optimal for anadromous salmonids. Maintaining water temperatures near optimal levels will increase juvenile salmonid growth rates, increasing survival and production. Also, optimal water temperatures for outmigrating smolts will significantly increase total habitat for juvenile steelhead and coho salmon rearing in habitats throughout the mainstem.
- Gradually decreasing flow releases, timed with increasing ambient air temperatures, causes mainstem water temperatures to rise gradually throughout this period, initiating smolting. Gradually increasing water temperatures also encourages yellow-legged frogs to lay eggs, and increases tadpole growth rates.
- Gradually decreasing releases, timed with increasing ambient air temperatures, allows mainstem water temperatures to rise gradually throughout this period, encouraging upstream migration of adult spring chinook salmon.
- Ongoing fine sediment control efforts (Buckhorn Dam, Hamilton Ponds, and watershed rehabilitation), combined with recommended releases and duration during peak flow periods, will transport fine sediment at a rate greater than input, decreasing fine sediment storage in the mainstem, leading to substantial habitat improvements.
- Fine sediment transport accompanying peak releases will be sufficient. No additional flow releases will be needed to accomplish management goal (substantial decrease in fine sediment storage).
- Gradually decreasing releases will minimize salmonid stranding mortality, supporting increased production of anadromous fishes.
- A gradually receding snowmelt hydrograph will lead to germination of riparian plant species across large areas within the high-flow channel. Peak flow releases in subsequent years will be sufficient to limit success of newly established plants.
- Submerging point bars and other alluvial features during the seed-release periods will prevent seedling initiation/establishment along the low-water channel.
- Recommended ramping rates will minimize stranding-related mortality during the snowmelt runoff period.

- Recommended ramping rates will minimize desiccation mortality to yellow-legged frog egg masses during the snowmelt runoff period.
- Timing of peak flow releases minimizes impacts to fry life stage of salmonids. Peak flows occurring at recommended times will strand only insignificant numbers of anadromous salmonid fry.

Competing hypotheses:

- Smolt outmigration can be stimulated by one or more pulse flows that simulate freshets.
- Smolt outmigration is independent of flow and ramping rates.
- Fine sediment transport during the peak flow will be insufficient, requiring an extended flow at or above 5,000 to 6,000 cfs on the receding limb of the annual peak release during Normal-or-wetter water years.

What we know:

- Marginal and optimal water temperatures for anadromous salmonid life stages from other watersheds, as cited in scientific literature.
- Marginal and optimal water temperatures for maintaining juvenile salmonid growth rates from other watersheds, as cited in scientific literature.
- Smolt outmigration timing on the Trinity River.
- Inundation of the surface of alluvial features (e.g., gravel bars) during the seed-release periods will prevent germination of riparian plant species on these bars.
- Yellow-legged frogs lay eggs along margins of exposed cobble/gravel bars. To remain viable, frog egg masses must remain submerged throughout incubation period.
- Inundation/rapid stage change causes mortality to frog eggs.
- Pre-dam snowmelt hydrology provided conditions which allowed yellow-legged frogs to reproduce in mainstem habitats below Lewiston.
- Warming water temperatures improve egg mass survival and improve tadpole growth rates.
- In the existing channel between Lewiston and the North Fork Trinity, stranding of salmonid fry life stage is most likely when flows decline from 6,000 cfs to less than 2,000 cfs (dropping through berm elevation). As the channel in this reach evolves in response to rehabilitation projects, stranding of fry is likely to become insignificant.

What we don't know:

- Marginal and optimal water temperatures for life stage specific to Trinity River anadromous fishes, including salmonids.
- Adequacy of recommended flows in terms of transporting volumes of fine sediment that will be yielded to the mainstem during wetter water years.

- Will gradually descending flows on descending limb of annual peak releases lead to establishment of riparian plant species across entire bar surfaces? Would rapid decreases in releases at this time of year be a more effective tool?
- What rate of change in stage height causes biologically significant mortality of frog egg masses.
- Potential for stranding of salmonid fry life stage in rehabilitated channel morphology.

Management Actions

- Real-time temperature monitoring through a network of gaging stations at mainstem Trinity and tributary sites downstream to Weitchpec.
- Assessment of fish growth and survival as a function of water temperatures.
- Assessment of primary factors that influence smolting and outmigration (pulse flows, degree-days, water temperature), and evaluation of whether management actions can improve outmigration success.
- Incorporate fine sediment transport measurements during peak flows in order to assess additional transport during snowmelt recession limb.
- Assess basin-wide management strategies for yellow-legged frogs and western pond turtles.

Other Issues

- A potentially much longer list of hypotheses will be fully considered by the AEAM team as they consider the full range of objectives to be addressed. Hypothesis testing will be implemented with a view to those particular issues in which limits to knowledge are pertinent to management of the Trinity River Division as well as the Trinity ecosystem. Following is a list of assumptions made by the team in developing the recommendations for this report. These must be addressed by means of hypothesis testing under the AEAM program as required.
- Smolt survival in the Trinity and lower Klamath Rivers will increase as a result of better temperature conditions that promote smoltification.
- Test: On a short time scale, assess the abundance and health (size, growth, diseases, ATPase activity) of smolts utilizing cooler water-temperature conditions. Using rotary screw-traps placed at key locations (upper Trinity River, lower Trinity River and near the estuary), fish samples could be taken and evaluated. On a longer time scale, use adult returns as a measure of success.
- Smolt survival in the Trinity River and lower Klamath River is increased owing to reduced travel time associated with higher flows.
- Test: Tagging studies using natural and hatchery fish under varied flow patterns. A smolt production model for coho salmon needs to be developed and applied along with the chinook salmon model. Perhaps a model for steelhead as well.
- Recommendations that satisfy habitat needs of anadromous salmonids will also provide for adequate primary and secondary production (will support an adequate food base for anadromous fish species).

- Recommendations that satisfy needs of anadromous salmonids will satisfy needs of other fish species native to the Trinity River.
- Recommendations that satisfy needs of anadromous salmonids will provide for other species including riparian-dependent wildlife and organisms living in hyporheic zones.
- Sediment transport provided by release schedules will preclude the need for pool dredging.
- Temperatures provided throughout the River will be appropriate for locally adapted fish stocks.
- Temperature-control release requirements would not be appreciably different with temperature-control devices installed at Trinity Dam (i.e., a multi-level outlet structure).
- What are the thermal tolerances of Trinity River smolts? Test: Under controlled and natural setting, examine how water temperature affects smoltification of Trinity River parr and smolts. There could also be a need to examine the effects of low dissolved oxygen concentrations on parr and smolts.
- How does Trinity River water affect water quality of the Klamath River? There is evidence that water-quality conditions in the Klamath River may get really poor. Does this occur during spring outmigration, especially in Dry water years? If so, how is this affecting smolt survival? What about other life stages?
- The water-temperature model of the Trinity River must be refined and extended through its confluence with Klamath River.

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