Water Quality and Water Quantity Needs for Chinook Salmon Production in the Upper Sacramento River

Prepared by the California Department of Fish and Game
for the 1992 Hearing Process on the
San Francisco Bay/Sacramento-San Joaquin Delta Estuary

WRINT-DFG Exhibit No. 14

INTRODUCTION

The current phase of the State Water Resources Control Board (Board) hearing process on the San Francisco Bay/Sacramento-San Joaquin Delta Estuary identifies issues relating to fishery resources in the Sacramento River upstream of its estuary. This report updates the 1987 exhibit on the upper Sacramento River above the confluence with the Feather River and below Keswick Dam (USFWS 1987 Exhibit 29). Recommendations are made for interim water rights actions that will allow attainment of the water quality objectives in the upstream segment.

The recommendations for project facilities include structural measures, such as permanent temperature control devices that release all available coldwater supplies. Operational measures recommended include carryover storage requirements that avoid release of warm water from the reservoir to the spawning area during dry conditions. Both carryover requirements and structural measures are needed. It is the Department of Fish and Game's (DFG) obligation as a trustee of the public's fishery resource to recommend methods of managing water project operations in a manner that allows maintenance and restoration of biological resources, especially threatened and endangered species and economically valuable species such as salmon.

Water quantity needs are considered in the upper Sacramento River and selected tributaries (Figure 1). Currently, fishery agencies are in the process of formulating biologically sound flows for the various life stages of chinook salmon in the main river and tributaries. Streamflow needs on the main river must be balanced with needs for maintaining carryover storage during dry periods.

Fluctuating instream flow rates have been a problem in the upper Sacramento River during salmon spawning and incubation periods. On some tributaries, diversions do not bypass sufficient water to allow passage of adult salmon upstream and juveniles downstream to the main river.

The basis of determinations for these upstream needs include fishery studies, review of historical water project operations, hydrology records, and modeling studies for temperature control alternatives. The experience gained during the ongoing drought has been especially valuable in identifying temperature control capability. The operational and structural measures for temperature control are specified and scheduled in Water Rights Order 90-5.

We recommend implementation of Water Rights Order 90-5 along with certain carryover storage in Shasta Reservoir for temperature control. Several actions to protect chinook salmon and steelhead are recommended including maintaining seasonal raising of the gates at Red Bluff Diversion Dam, flow stability criteria, and outmigration flows. In addition, recommendations are made for the management of spring-run chinook that are suffering consistent population declines on the main stem and tributaries.

<u>Status of the Chinook Salmon in the Upper Sacramento River</u>

The upper Sacramento River is a unique watershed in California in that it supports four separate races or runs of chinook salmon. The runs in the upper Sacramento River are identified by when they leave the ocean and enter the river system to spawn. The reproductive life cycles of the races of chinook salmon overlap such that each life cycle is present throughout the year (Figure 2).

The fall-run and late fall-run chinook enter the river and spawn upon arrival at the spawning grounds. The spring-run and winter-run chinook differ from the fall species by having unique physiology that allows them to hold for extended periods (months) in fresh water prior to spawning. Historically, all of the habitat for the winter-run and spring-run chinook salmon was located above Shasta Dam and their occurrence was documented at the turn of the century (Hallock 1991). At that time, spring-run appeared to be the predominant species of chinook in the upper Sacramento River.

Since the Board last examined the status of chinook salmon stocks in the upper Sacramento River in 1987, the populations have undergone dramatic declines. The decline of the winter-run chinook reached such low abundance that it had to be listed as a federally threatened species and a State endangered species. Populations of spring-run chinook on the main stem Sacramento River have reached the lowest recorded level and may require review of their status under the provisions of State and Federal endangered species acts. Fall-run populations have dropped to approximately one-quarter of their historical abundance 25 years ago compared to one-half of the historical abundance that was present in 1987.

Chinook salmon produced in the upper Sacramento River make a substantial contribution to the commercial fishery in the eastern Pacific Ocean. Based on tag returns for the chinook salmon throughout the Central Valley, it has been estimated that 47 percent of the San Francisco to Monterey ocean commercial landing, 21 percent of the California North Coast, and 3 percent of the Oregon ocean commercial landing originate in the Sacramento River above Colusa (NOAA 1989). Presently, due to the declines in the salmon stocks, the commercial fishing effort has been severely restricted by fishery regulatory agencies.

Fall-Run Chinook Salmon

The best indicator of overall trends in the fall chinook run sizes for the entire upper Sacramento River system can be obtained from the California DFG's annual spawning stock surveys conducted since 1956. These data show substantial decline in fall-run stocks since the 1950s and 1960s (Figure 3). Declines have not stabilized.

Spring-Run Chinook Salmon

One of the concerns with present-day spring-run chinook salmon in the upper Sacramento River is that a large portion of the population may be hybridized with the fall-run (Slater 1963). Present day spring-run can no longer access historical spawning areas above Keswick and Shasta dams. These higher elevation reaches were largely isolated from the fall-run chinook and had a cooler temperature regime preventing spawning overlap with the fall-run.

The counts of salmon passing Red Bluff Diversion Dam (conducted since 1967) provide a very limited indication of the overall trend in spring-run population sizes. The hybridization problem probably limits the use of these data to gross trends. The values fluctuate greatly, but steady significant declines have occurred over the last five years, down to the lowest levels ever recorded. There still are genetically distinct spring-run as evidenced by aerial surveys of salmon spawning activity during September. These counts also indicate a significant declining occupance. During the past five years very damaging elevated temperature conditions occurred in September over most of the spawning area, indicating the decline of spring-run chinook will not stabilize and may accelerate.

Remaining areas where significant numbers of genetically pure strains of spring-run chinook exist are in Mill and Deer creeks (Figure 1). Populations in both Mill and Deer creeks have declined over 80 percent between the late 60s and the late 80s. Small populations of spring-run are present in Battle Creek, Butte Creek, and a number of smaller tributaries. There is excellent potential to develop a population of spring-run in Clear Creek below Clair Hill Dam where migration barriers have been removed and juveniles have been planted.

The DFG has recognized spring-run chinook as a species of special concern (DFG 1989) that requires immediate and in-depth status review to determine the need for listing under provisions of the California Endangered Species Act (DFG 1992).

Late Fall-Run Chinook Salmon

Late fall-run chinook have shown a dramatic decline in their run size over the last 20 years (Figure 3). Runs during the late 80s are only one-third of those observed during the late 60s.

Winter-Run Chinook Salmon

Winter-run chinook suffered a precipitous decline since the 1960s with numbers during the 1990s only about 5 percent of those observed during the late 1960s (Figure 3). The decline was so severe that the species was listed during 1989 as federally threatened (National Marine Fishery Service 1989) and State endangered (DFG 1989). Pursuant to State and Federal laws, special measures have been taken by a variety of project developers, water project operators, and commercial and sport fishermen to avoid further jeopardizing the existence of this species pursuant to State and Federal Endangered Species laws.

There is some indication that the measures taken during 1989 are having a positive effect on the recovery of the species. This year the number of adults estimated to be in the Sacramento River above Red Bluff Diversion Dam is approximately twice that of their parent year class from 1989.

Steelhead Trout

Since the late 1960s the steelhead trout have undergone a 90 percent decline in population (Figure 4).

Role of Coleman National Fish Hatchery

Coleman National Fish Hatchery was constructed in 1942 as one component of the Shasta Salmon Salvage Plan, a project mitigation plan adopted in the 1940s. To compensate for lost spawning and rearing habitat above the dam the plan resulted in fall-run production at the hatchery and a transfer of spring-run chinook to Mill and Deer creeks, which was later abandoned (US Fish and Wildlife Service 1987). Today this hatchery is funded by the US Fish and Wildlife Service and is the only remaining element of the Salmon Salvage Plan.

Coleman Hatchery is now being renovated to attain production goals for winter-run and spring-run chinook. Current plans call for an expenditure of 20 million dollars for the renovation. The partial expenditures, to date, are expected to increase winter-run production.

Based upon estimates by the DFG, the contribution of Coleman Hatchery to the fall-run chinook salmon spawning escapement above Red Bluff ranged between 10 and 30 percent. In recent years, the hatchery contribution to total escapement has increased only due to the rapidly declining natural escapements. At this time, the hatchery is one of the largest chinook production facilities in the United States; even so, the average annual escapement that it supports represents less than 10 percent of the lost natural production.

Salmon Restoration Programs

There are several ongoing restoration programs for chinook salmon in the upper Sacramento River basin. Public involvement in restoration issues began in the mid 1970s with an Advisory Committee on Salmon and Steelhead Trout. The current version of this committee was authorized by resolution of the State legislature. This citizens committee addresses problems facing the salmon and steelhead trout resources, including those on the upper Sacramento River (Hallock 1987).

In the late 1980s legislation was enacted (SB 1086) to develop an upper Sacramento River fisheries and riparian habitat management plan. A consensus plan was completed in 1989 by a group comprised of 25 representatives from government agencies (Department of Water Resources 1989).

In 1990 the State legislature mandated (SB 2261) that the DFG make a major new effort to restore salmon, steelhead trout, and anadromous fish. The restoration goal for the upper Sacramento River is in Table 1. The general goals of the restoration plan include: (1) restore habitat to sustain population goals; (2) at least double the natural salmon production by the year 2000; (3) develop an annual steelhead run in the Sacramento River system of 100,000 fish; (4) ensure proper mitigation and compensation of existing and past project losses; (5) avoid and compensate fishery impacts on future projects; and (6) restore and enhance the quality of fishing opportunities, both for recreational and commercial (DFG 1990).

A joint cooperative agreement was entered into among the trustee agencies for the salmon fishery and the Bureau of Reclamation (Bureau) to improve the status of the winter-run chinook salmon. The purpose of the agreement was to implement actions to improve and restore the status of winter-run salmon.

Restoration efforts made by various parties, to date, include fish screen installations at harmful diversions, gravel placement at priority sites, and Mill Creek flow augmentation (DFG 1992). During the early 1980s, the California Advisory

Advisory Committee on Salmon and Steelhead Trout began advocating the opening of the gates at the Red Bluff Diversion Dam during the nonirrigation season to remedy this partial salmon migration barrier. The Bureau began seasonally opening the gates at Red Bluff Dam in the late 1980s allowing unimpeded access to the critical reach where temperature control is possible.

The Bureau instituted several temperature control measures in the upper Sacramento River and Trinity River salmon spawning areas. The Board formalized the Bureau's temperature control measures in Water Rights Order 90-5 and the basin plan for the Trinity River. Planning and environmental documentation was completed and congressionally authorized for a multilevel outlet for temperature control at Shasta Dam. Other temperature control devices have been planned for Whiskeytown and Lewiston reservoirs. As an interim remedy the Bureau has blended deep cold water with warmer, upper level powerhouse water to partially control temperatures.

The Environmental Protection Agency (EPA) Superfund program issued an emergency cleanup order throughout the drought for partial pollution control at the Iron Mountain Mine. A proposed plan is being decided on by EPA which would begin treating all of the worst point sources at the site with lime neutralization within 2 years (EPA 1992). Remaining sources of pollution on the site are being studied for cleanup remedies. The previous decision to enlarge the Spring Creek Debris Dam (EPA 1986) is being considered for implementation.

Potential Effects of the 1987 Hearing on Fishery Beneficial Uses in the Upper Sacramento River Basin

The allocation of water from the Shasta-Trinity unit of the Central Valley Project through the Bay/Delta Hearing Process may affect fishery beneficial uses in the upper Sacramento River in the following areas:

1. Water projects ability to attain Central Valley Regional Water Quality Control Board Basin Plan objectives for control of temperature toxicity and dissolved metal concentrations.

2. Availability of minimum instream flows for various salmon life stages.

The mechanism by which these two areas are affected by increased water allocations is through decreased water availability and/or operational flexibility due to decreased carryover storage. The Water Code sections 1257 and 1258 require consideration be given to the relative benefit derived from all beneficial uses of water, including recreation and preservation and enhancement of fish and wildlife, in water right matters. The beneficial uses that must be considered include uses specified in relevant water quality control plans. These plans specify coldwater fish spawning as a beneficial use in the reaches of the Sacramento River system specified as spawning areas in Fish and Game Code Section 1505.

Carryover Storage

The purpose of developing minimum carryover storage is to avoid release of uppermost heat bearing reservoir waters to the spawning areas in the river. Presently, Shasta and Trinity reservoirs have minimum pools equal to the "dead storage" of the reservoir (which cannot be physically removed). This small pool of storage is approximately one-tenth of the storage capacity of Shasta and Trinity reservoirs.

During drought when reservoirs were operated at low levels there have been documented impacts to the river fishery due to elevated temperatures. The 1977 year class of winter-run chinook is an example of what can result from temperature impacts on the spawning area (Figure 4). Managing the fishery resources now confined to river reaches below reservoirs with low carryover storage has resulted in a number of dilemmas both in and among rivers in the Sacramento system (Figure 5).

It is not possible to maintain a carryover storage in all project reservoirs during the driest year of record that is large enough to protect all the fisheries in all the rivers. Attempting to maintain a carryover storage under the driest of inflows severely impacts rivers by dedicating inflow to storage. The DFG has adopted a recommendation for minimum carryover storage based on the driest decile or the 90 percent probability of exceedance that more water will flow into the reservoir in a given year.

The biological rationale for selecting the driest decile is that during consecutive drought years, some but not all, returning runs salmon and steelhead will be subjected to severe impacts. It is very important to maintain fishery protection during a drought to avoid severely damaging the entire reproductive core of the population as described in Figure 6. The fishery has some ability to tolerate damage during a drought cycle on an intermittent, but not continuous, basis.

The water quality planning rationale for selecting the driest decile for temperature protection is consistent with a similar provision in the Clean Water Act. The waste load allocation process for streams with impaired water quality (Section 303d of the Clean Water Act) is based on receiving water flows that are typical of a drought and are exceeded 90 percent of the time. Developing a carryover storage requirement that is physically attainable and controls the water quality at some reasonable frequency may be considered a controllable factor.

The methodology used in this report for preliminary carryover storage needs is an empirical, exploratory type of analysis, based on historic operations, hydrology, and observed and simulated temperatures that represent operations over the past five years. Hydrologists have begun scoping a more detailed and precise determination of carryover storage based on operation of a physical model.

The carryover storage need is directed at protecting a critical river reach from elevated temperatures. The critical reach is overlapped between where the population of the most temperature sensitive life stages occur and where the temperature criteria for the organism's survival can be effectively controlled by the dam during the driest decile. The length of the critical reach will vary according to the variations in wet season runoff.

Egg and embryo life stages are the most sensitive to elevated temperatures. The temperature criteria for incubation is a daily average of 56 degrees fahrenheit. This value is consistent with the basin plan, Water Right Order 90-5 and EPA temperature criteria protocol (EPA 1977).

<u>Method for Shasta Reservoir</u>. The occurrence of temperature sensitive life stages in the upper Sacramento River is year-round among the races (Figure 2). The runs whose incubation occurs when there is a risk of elevated water temperatures include winter-run, spring-run, and fall-run chinook. Other species or races are not considered in this analysis. The required temperature control period for incubation begins in late April when spawning starts and ends as late as November when the heat stored in the reservoir waters is gone.

The geographic limit for effective temperature control to 56 degrees in the upper Sacramento River during the warm water period is near Red Bluff (USBR 1991). The temperature requirements for the salmon and steelhead that occur throughout the remaining 240 river miles below Red Bluff cannot be effectively controlled by operation of the Shasta-Trinity Project. Attempting such long range temperature control with reservoirs is ineffective at reducing temperatures; especially considering the volume of cold water reserves that are exhausted and made unavailable for the critical reach during both the current and following years (Biosystems 1992). Temperature control below the critical reach should focus on implementing temperature objectives by controlling the discharge of heat from any present or future point sources or nonpoint sources, such as large agricultural drains.

The estimation of Shasta Reservoir carryover requirements (Figure 7) for the defined critical reach began with a review of actual temperature during recent drought years having low level outlet operation, and simulated temperatures assuming low level outlet operation and current water demands (USBR 1991, 1992). From this review, years were selected that just approximated 56 degrees. Then for the selected years the simulated or actual Shasta Reservoir storage on April 30 was identified. There was some variation in these results (up to 300,000 acre feet). Using the median of the selected April 30 storage, an estimate was made of the previous October 1 carryover requirements for the driest decile, accounting for all releases from storage during the preceding months.

The selected river flow of 3,500 cubic feet per second (cfs) is typical of a flow during the recent dry years. No assumptions were made for larger releases from storage for water transfer to downstream facilities, such as San Luis Reservoir, therefore all such transfers add to the carryover storage estimate.

The estimated carryover storage required to control temperatures to bend under the driest decile exceeded 3.4 million acre feet (maf). This carryover storage was judged to be unattainable because it exceeds the presently forecasted carryover storage for the entire Central Valley Project. Attempting to attain such a storage now would have impacts to all beneficial uses including fisheries.

The exploratory analysis continued by reducing the critical reach during the critical time for the priority species. The winter-run chinook was reduced to a main spawning area where 90 percent of the spawning occurred on average. Based on spawner nest distribution surveys conducted by the DFG over the last 5 years, an average of 90 percent of the winter-run nests occur over the 35 river miles between Keswick and Jellys Ferry bridge. The carryover storage estimated to have a 90 percent probability of protecting this main critical reach is 1.9 maf. This amount of carryover storage was judged to be attainable during the driest decile, but lower carryover storage would occur during drier years.

The estimated carryover storage needs greatly increase if the following operations assumed in the analysis fail to occur: (1) continued use of low level coldwater outlets at Shasta and Trinity Dams; (2) continued high water surface elevations in all afterbays, including Keswick, Lewiston, and Whiskeytown reservoirs; (3) continued seasonal removal of the partial barrier at Red Bluff Diversion Dam to allow spawners access to the temperature control reach; and (4) timing of the Trinity River Diversion to optimize temperature control.

Limitations of this type of empirical analysis include application to years having similar weather and streamflow characteristics. Other influencing factors considered but not included were reduced releases from Shasta Reservoir storage due to inflows from Clear Creek and Spring Creek, and increased releases from Shasta Reservoir storage due to evaporation, deep seepage and releases for flood control all of which were not considered significant under driest decile conditions.

Placing priority on the critical reach for winter-run chinook salmon impacts spring-run chinook salmon, primarily due to diminished temperature control in September when spring-run incubation is peaking. Reduced temperature control is evidenced in recent observed temperatures, simulated temperatures (USBR 1991), and even historical records before there were any temperature control efforts. Typically by September, Shasta Reservoir coldwater reserves are depleted, the majority of the Trinity Diversions have been used up, weather is still warm and flows are still moderately high.

Remedies needed to prevent both the winter-run and spring-run chinook populations from reaching even lower levels and increasing the urgency of the situation include: (1) installation of the temperature control structure at Shasta Dam which has much larger fishery benefits than predicted in the model (DFG correspondence 1991) (USBR 1991); (2) installation of a temperature control curtain in Whiskeytown Reservoir that will cool the powerhouse release to the Sacramento River and conserve cold water in Shasta and Trinity for September; (3) produce winter-run and spring-run chinook salmon at Coleman Hatchery; and (4) restore the genetically distinct natural populations of Sacramento River system spring-run chinook salmon which currently exist in depleted numbers on tributaries.

Placing priority on the critical reach for winter-run has not strongly influenced the survival of fall-run. The fall-run that spawn early (before mid-October) are the main group at risk and these salmon constitute approximately 15 percent of the population. After October 15 temperature controls such as low level outlet releases and/or Trinity River diversions are more effective due to lower Sacramento River flows and cooler air temperatures. Temperature control for the fall-run could be significantly improved by the remedies described for the other races.

Trinity Reservoir Carryover Storage. Historically, the operations at Trinity Dam frequently achieve temperature control in the reach used for spring-run and fall-run spawning and incubation (North Coast Regional Water Quality Control Board 1989).

An empirical method was used to select the carryover storage associated with the year where operations left just enough cold water reserves to attain basin plan objectives in the Trinity River. The 1991 water year was selected to estimate the carryover storage. Based on the conditions and operations in 1991 the carryover storage target is estimated to be approximately 600,000 acre feet. The required operations include opening of the low level outlet at Trinity Dam. Temperature control curtains are currently being installed in Lewiston Reservoir that may change the temperature relationships.

The refill probability of Trinity Reservoir is very low because the releases from storage can be very high in relation to the yield from the watershed. In order to assure that the releases from storage allow a 90 percent probability of attaining the minimum carryover storage, further analysis is required. The Trinity River release is 340,000 acre feet. Several alternative volumes need to be examined for the Trinity River Diversion within the historical range between several hundred thousand to over one maf.

The remedy for the warming of the Trinity River Diversion (TRD) in Whiskeytown Reservoir can also improve the attainability of a carryover storage at Trinity Reservoir. Although the TRD enters Whiskeytown Reservoir at temperatures below 50 degrees, the USBR powerhouse outlet from Whiskeytown Reservoir draws mid-depth waters that are warmer. A structural remedy has been identified to solve the midlevel withdrawal problem on the power conduit (USBR 1990).

In the absence of this structural remedy, the rate of TRD can be maximized to raise the elevation of the cold water up to the power conduit withdrawal area. This practice is very inefficient and water consumptive and may contribute to difficulties in attaining the carryover storage. However, there are so many conjunctive uses of the TRD it is never clear which use is controlling the rate of diversion.

Instream Flow Requirements for Upper Sacramento River

A series of instream flow management alternatives are presented that balance the need to achieve carryover storage for temperature protection with needs to supply suitable instream habitat that is stable (Figure 7). Formulating biologically sound flow requirements must be based on more than available habitat. Other factors include temperature control, sediment content in the substrate, and flow fluctuation and stability.

In a year with carryover storage below 2.8 maf, the recommended interim instream flow requirement for both Keswick and Red Bluff dams is 3,500 cfs in the period October 1 to April 30, and 4,000 cfs for the remainder of the year. When carryover storage is over 2.8 maf representing probable protection of the entire critical reach the interim instream flow requirement is increased to 4,500 cfs to provide more habitat and reduce stranding risks.

The range of flows identified as providing suitable habitat is 3,000 and 6,000 cfs according to some incomplete studies. Under dry conditions the October to April fishery flow of 3,500 cfs may be considered a conjunctive use of the releases made for other project purposes while the dry season fishery flow is a small fraction of the releases for other purposes. Under wet conditions or higher carryover storage, the October to April fishery flow of 4,500 cfs is generally in the range of the releases for other project purposes such as transfers of storage from Shasta to other facilities (i.e. San Luis Reservoir). Targeting flows that are typical of the releases for other project purposes increases the attainability of flow stability criteria.

There is a need for interim criteria for providing stable streamflows especially during the October through April period when the stage of the river is less than bank full. During the irrigation season the river is over bank full. Fishery surveys on the Sacramento River show there are abundant numbers of redds and recently emerged fry situated in shallow near-shore areas and side channels where there is a high risk of mortality during flow reductions.

Dewatering and sustained flow reductions are primarily a problem in the upper 30 miles of the Sacramento River during the wet season. The reduction of the Keswick release is triggered by storm events that can supply downstream water demands otherwise provided by release from storage; meanwhile there are not any large accretions in this upper most reach of the Sacramento River. Flow reductions then occur until the storm system passes and the cycle repeats itself. Some years over 50 percent of the spawning occurs in this upper high risk area; especially large numbers spawn in the high risk area during drought years when the chance of a flow reduction is greater (Figure 9).

Significant mortality of eggs and fry has been documented in the upper Sacramento River when flow reductions of approximately 20 percent occur at flows in the vicinity of 3,500 cfs. In controlled experiments conducted with chinook salmon, significant increases of egg mortality occurred in streamflow reductions to the point that the water inundated the nests but did not flow. The impact was greater when increased fine sediment was present (Reiser and White 1990). Eggs have been destroyed by freezing after a flow reduction on the upper Sacramento River and in other streams.

Interim flow stability criteria is recommended according to the streamflow because this determines the wetted perimeter changes and side channel flows. During the period October 1 to April 30, flows of 3,500 cfs to 4,500 cfs should not fluctuate more than 300 cfs. Flows of 4,500 cfs to 6,000 cfs should not be fluctuated more than 500 cfs. Flows over 6,000 cfs and steadily increasing flows have no limit. During flow reductions the current ramping rate requirement of 15% over twelve hours would be in effect. These recommendations are based on aerial surveys, boat surveys, and underwater surveys during periods of flow change at river locations having channel configurations known to be most susceptible to stranding of redds and fry. Such susceptible areas include side channels with shallow inverts and broad flat gradient near-shore areas.

The recommendations for flow stability requirements need to be refined using a type of wetted perimeter method developed for salmon spawning streams. The data collected to date for the incomplete instream flow study can be used in this procedure.

An additional instream flow need is for outmigration and distribution of juvenile fish downstream as discussed in the 1987 exhibit. Due to the drought, experimental releases for outmigration have not been available for 4 years. Should carryover storage exceed 1.9 maf in Shasta Reservoir it is recommended that test outmigration flows resume in the range of 40,000 acre feet. Should carryover storage in Shasta Reservoir exceed 2.8 maf then the amount of water applied to outmigration flow experiments should double to 80,000 acre feet.

<u>Instream Flow Requirements for Tributaries to the Upper Sacramento River</u>

Tributaries selected for changes in instream flow were streams having diversions over 100 cfs and support populations of spring-run chinook that need to be restored. All the selected streams have unmet instream water needs due to diversion. As discussed previously the need to restore spring-run chinook salmon is urgent. The streamflow needs for the selected streams are included on Table 2.

Mill Creek and Deer Creek lack sufficient flows in the spring to pass adult spring-run salmon to the spawning areas and lack sufficient streamflow in the fall to pass juvenile salmon downstream to the river and allow spawning for fall-run. Recommendations are based on surveys of critical riffles for passage during known flows. Surveys have been concentrated on Mill Creek but results are applied to Deer Creek on the basis of similar channel configuration.

It is recommended that the Bureau participate in the spring-run chinook salmon recovery effort on Mill and Deer creeks. The operations on the main stem Sacramento River are failing to maintain spring-run so it may be prudent to assist in remedying the population decline on the tributaries. Bureau involvement with the spring-run on Deer and Mill creeks is somewhat consistent with the original Shasta Salmon Salvage Plan (USFWS 1987).

Detailed instream flow studies have been completed on Clear Creek and Battle Creek and interim recommendations will be provided after further coordination with other regulatory agencies and project operators.

<u>Attainment of Water Quality Objectives for Toxicity and Dissolved Metals</u>

The acid mine drainage originating from the Iron Mountain Mine is the largest discharge of metals in the State affecting the greatest downstream area. The discharge from this EPA Superfund site is a complex mixture of numerous metals. The contaminants in the discharge at high enough mass and great enough toxicity to be of primary concern for fish are copper, zinc, and cadmium.

The EPA characterized and evaluated the risks posed to the salmon and steelhead populations in the Sacramento River in an environmental assessment document (EPA 1992). The conclusion of the document are in Table 3.

During the past four years of the drought, emergency actions ordered by EPA have provided a significant increment of toxicity control and conservation of storage in Shasta Reservoir. These actions included lime neutralization on a part of the discharge and diversion of clean waters out of the Spring Creek basin to increase waste storage capacity in Spring Creek Reservoir.

Uncontrolled spills of metal wastes from Spring Creek Debris Dam have occurred during the last five years but at reduced volume and potency than they would have without emergency treatment and diversion. Dilution water was released from Shasta

Reservoir. Recent spills (1992) consumed approximately 100,000 acre feet of storage. The dilution releases avoided catastrophic fish kills but resulted in the loss of water during the drought. The water taken from storage by the toxic mine waste reduced the temperature control capability in the upper Sacramento River and impacted other beneficial uses of water.

The DFG concurs with EPA's interim remedy for the Bolder Creek component of the site (the second of three components on the site). The EPA proposed plan is to install a large lime neutralization plant as soon as possible. There are substitute technologies, such as plugging and flooding the mine with 500 acre feet of water and an unknown mixture of lime. However, there is still uncertainty about the performance of this alternative technology so EPA has reserved it as potential replacement technology at a later undisclosed evaluation time. The DFG recommends that experimental technologies not replace the proven technologies until they have predictable performance and contingencies. The proven technology should not be replaced until after the drought ends and pollution controls are completed on the other major sources at the site.

There are so many residual sources of acid and metal at the site the remaining components of the site have sufficient residual contamination to require some continued dilution. The enlargement of the Spring Creek Debris Dam is a previously approved alternative that should be examined for implementation. Increased waste storage would increase the probability that dilution water needs would not interfere with the conservation of water storage in the Central Valley Project.

One of the major sources of metals at the site requiring attention are the chemical sediments in the bottom of Keswick Reservoir. The metal bearing sediments are several feet thick and form as the wastes become less acid and precipitation occurs. This metal sludge was mobilized into the Sacramento River on May 25, 1988, by a lowering of Keswick Reservoir that exposed the sludge followed by an operation of the Spring Creek Powerhouse that scoured some of the sludge before it was quickly shut-off (Central Valley Regional Water Quality Control Board correspondence 1988). The DFG recommends that minimum Keswick Reservoir elevation be required that prevents the exposure and scouring of the chemical sediments.

References:

California Department of Fish and Game. 1989. Fish Species of Special Concern of California. 222 pp.

California Department of Fish and Game. 1989. Sacramento River Winter-Run Chinook Salmon Classified as "Endangered." Sacramento: California Department of Fish and Game. Special News Release, May 16, 1989.

California Department of Fish and Game. 1990. Central Valley Salmon and Steelhead Restoration and Enhancement Plan. 115 pp.

California Department of Fish and Game. 1992 (Revised). Status report - California Salmon. Report to the California Department of Fish and Game Commission. 34 pp.

California Department of Water Resources. 1989. Upper Sacramento River Fisheries Riparian Habitat Management Plan. 158 pp.

Central Valley Regional Water Quality Control Board. 1988. Letter Regarding Sediment Discharge from Keswick Reservoir-25 May 1988. 2 pp.

Hallock, R. J. 1987. Sacramento River System Salmon and Steelhead Problems and Enhancement Opportunities, a Report to the California Advisory Committee on Salmon and Steelhead Trout. 92 pp.

Hallock, R. J. and H. J. Rectenwald. 1990. Environmental Factors Contributing to the Decline of the Winter-Run Chinook Salmon on the Upper Sacramento River. 1990 Northeast Pacific Chinook & Coho Salmon Workshop Proceedings. Am. Fish. Soc. 1990.

National Marine Fisheries Service. 1989. Sacramento River Basin Winter-Run Salmon to be Designated as Threatened Species Under Federal law. Terminal Island, California: NOAA Fisheries Southwest Region. Press Release. May 26, 1989.

National Oceanic and Atmospheric Administration. 1989. Preliminary Natural Resource Survey, Iron Mountain Mine: Findings of Fact.

North Coast Regional Water Quality Control Board. 1989. Water Quality Problems in the Trinity River, Issues Summary. Staff Report May 24, 1989.

Reiser, Dudley W. and Robert G. White. 1990. Effects of Streamflow Reduction on Chinook Salmon Egg Incubation and Fry Quality. Rivers 1(2):110-118.

Slater, D. W. 1963. Winter-Run Chinook Salmon in the Sacramento River, California with notes on water temperature requirements at spawning. US Fish and Wildlife Service. Special Scientific Report-Fisheries. No. 461. 9 pp.

US Environmental Protection Agency. 1977. Temperature Criteria for Freshwater Fish: Protocol and Procedures. 130 pp.

US Environmental Protection Agency. 1992. ARCSWEST. Remedial Activities at Selected Uncontrolled Hazardous Waste Sites in the Zone of Regions IX and X. Public Comment Feasibility Study Boulder Creek Operable Unit, Iron Mountain Mine, Redding, California. Volume I-Text.

US Environmental Protection Agency. 1992. ARCSWEST. Remedial Activities at Selected Uncontrolled Hazardous Waste Sites in the Zone of Regions IX and X. Public Comment Environmental Endangerment Assessment, Iron Mountain Mine, Redding, California. May 1992.

US Environmental Protection Agency. 1986. Public Comment Feasibility Study Addendum (Addendum to the Public Comment FS Iron Mountain Mine, Redding, California) Iron Mountain Mine, Redding, California. Prepared by CH2M Hill. July.

US Environmental Protection Agency. 1992. Water Temperature Control in the Sacramento-San Joaquin Bay/Delta: Toward a Reasonable Strategy. Draft Report March 1992.

US Fish and Wildlife Service. 1983. Coleman National Fish Hatchery, Station Development Plan. 61 pp.

US Fish and Wildlife Service. 1987. An Analysis of the Effectiveness of the Mitigation Plan for Shasta and Keswick Dams. 36 pp.

US Fish and Wildlife Service and California Department of Fish and Game. 1987. Water Quality and Water Quantity Needs for Chinook Salmon Production in the Upper Sacramento River. Sacramento: US Fish and Wildlife Service and California Department of Fish and Game. 1987 Hearing Process on the San Francisco Bay/Sacramento-San Joaquin Delta Estuary.

US Bureau of Reclamation. 1991. California Department of Fish and Game Letter Regarding Planning Report/Final Environmental Statement. Shasta Outflow Temperature Control, Shasta County, California. FES 91-13. June 4, 1991.

US Bureau of Reclamation. 1991. Update on the June 1991 Report on Alternative Operations of Shasta/Trinity Divisions for 1991 Sacramento River Temperatures for Winter-Run Chinook Salmon. August 1991.

US Bureau of Reclamation. 1990. Value Engineering Study for Temperature Control in Whiskeytown Reservoir. 35pp.

Table 1
Restoration Goals for Production of Adult Chinook Salmon and Steelhead from the Upper Sacramento River
(figures in thousands of fish)

Stock	Escapement[a]	Stock Catch	Ratio of Catch to Escapement	Total
Fall	300	600	2:1	900
Late fall	25	50	2+:1[b]	75
Winter	70	42	0.6:1	112
Spring	70	105	1.5:1	175
Steelhead				50

[a]Escapement equals number of spawners plus number harvested in river.
[b]Although the catch:escapement ratio for Sacramento River late-fall-run chinook salmon has not been ascertained, it is estimated to be substantially higher than the ratio for fall run.
Source: California Department of Fish and Game, 1990a.

TABLE 2: Recommended Stream Flows on Tributaries to the Upper Sacramento River Directed at Restoration of the Spring-Run Chinook Salmon.

<u>Stream</u>	Interim Flow Recommendations by Month											
	Sept	Oct 1-15	Oct 16-31	Nov	Dec	Jan	Feb	March	Aprl	May	Jun	Jul
Clear	150	150	200	200	200	200	200	200	150	150	150	150
Mill	20	20	20	20	--	--	--	50	50	50	50	--

Clear Creek flows to be measured at McCormick-Saeltzer Dam. Flows based on 1986 Instream Flow Incremental Methodology study.

Table 3. Conclusions of the Iron Mountain Mine(IMM) Endangerment Assessment on Acid Mine Drainage(AMD) to the Sacramento River (EPA 1992).

- The primary species and populations of concern because of IMM AMD contamination are the Sacramento River's four runs of chinook salmon, a run of steelhead trout, and resident rainbow trout, all of which are economically important to the region. Of particular concern is the potential effects of the IMM AMD on the federally threatened and State endangered winter-run chinook salmon. The early life stages of these fish (particularly swim-up fry) are highly susceptible to the toxicity of and suffocation from aqueous and sediment-borne metals and their resulting effects.

- The potential zone of impact of the IMM AMD in the Sacramento River is dynamic and could extend from Keswick Dam to the confluence of Cottonwood Creek (a distance of approximately 30 river miles). During periods of acute toxicity, the zone of impact is dictated by the hydrology of the watershed and the influence of tributary inflows for dilution of IMM AMD to levels "safe" to aquatic life. The exact zone of impact from IMM contamination in the Sacramento River has not been thoroughly defined, but it is a range depending on a wide variety of variables such as the dissolved metals concentrations, durations of exposure of organisms to the dissolved metals, the number and life stages of fish present, the rate of decay of dissolved metals concentrations in Keswick Reservoir and in the Sacramento River, the effects of toxic sediments released into the river, and hydraulic conditions throughout the system.

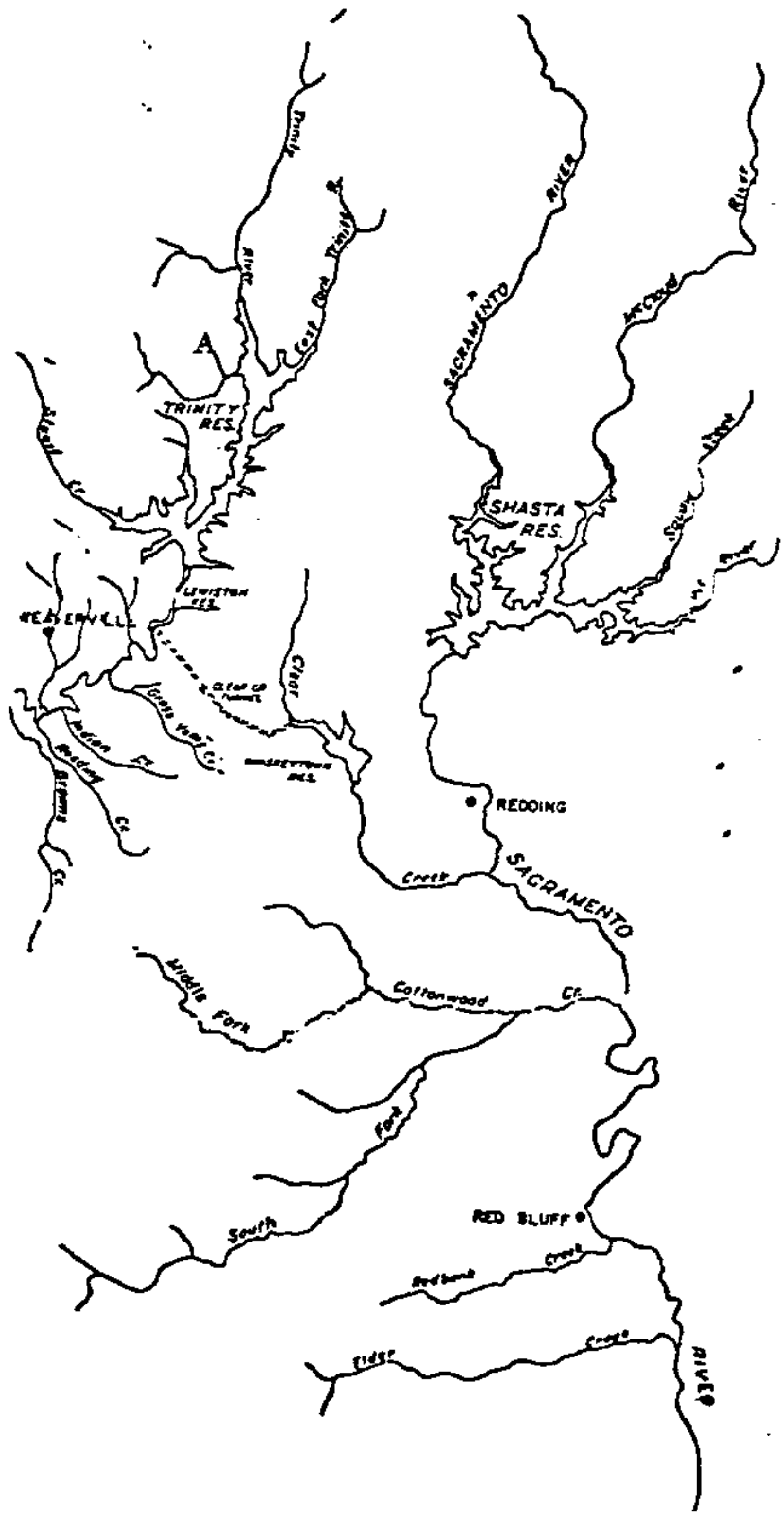
- The potential zone of impact for IMM AMD is within important habitat of the four runs of Sacramento River chinook salmon, a run of steelhead, and resident rainbow trout. This zone is also being studied for inclusion as critical habitat of the winter-run chinook salmon under the Endangered Species Act.

- Sacramento River water in Keswick Reservoir that is impacted by IMM AMD and released downstream of Keswick Dam has occurred and potentially occurs at levels that are occasionally acutely toxic to aquatic life, frequently chronically toxic to aquatic life, and that usually exceed Sacramento River Basin Plan standards (i.e., exceed "safe" levels).

- Acutely toxic levels of IMM AMD entering the Sacramento River have historically occurred during the rainy season (i.e., November through March). Fish kills resulting from the contamination have been reported in each of these months.

- Chronically toxic levels of IMM AMD entering the Sacramento River have resulted in accumulation of fish tissues, as reported in the State's toxic substances monitoring program. These accumulations indicate potential adverse physiological responses particularly in resident trout populations and indicate a need to reduce the overall metals loading into the Sacramento River to reduce stress on these resident populations.

Figure 1
LOCATION MAP



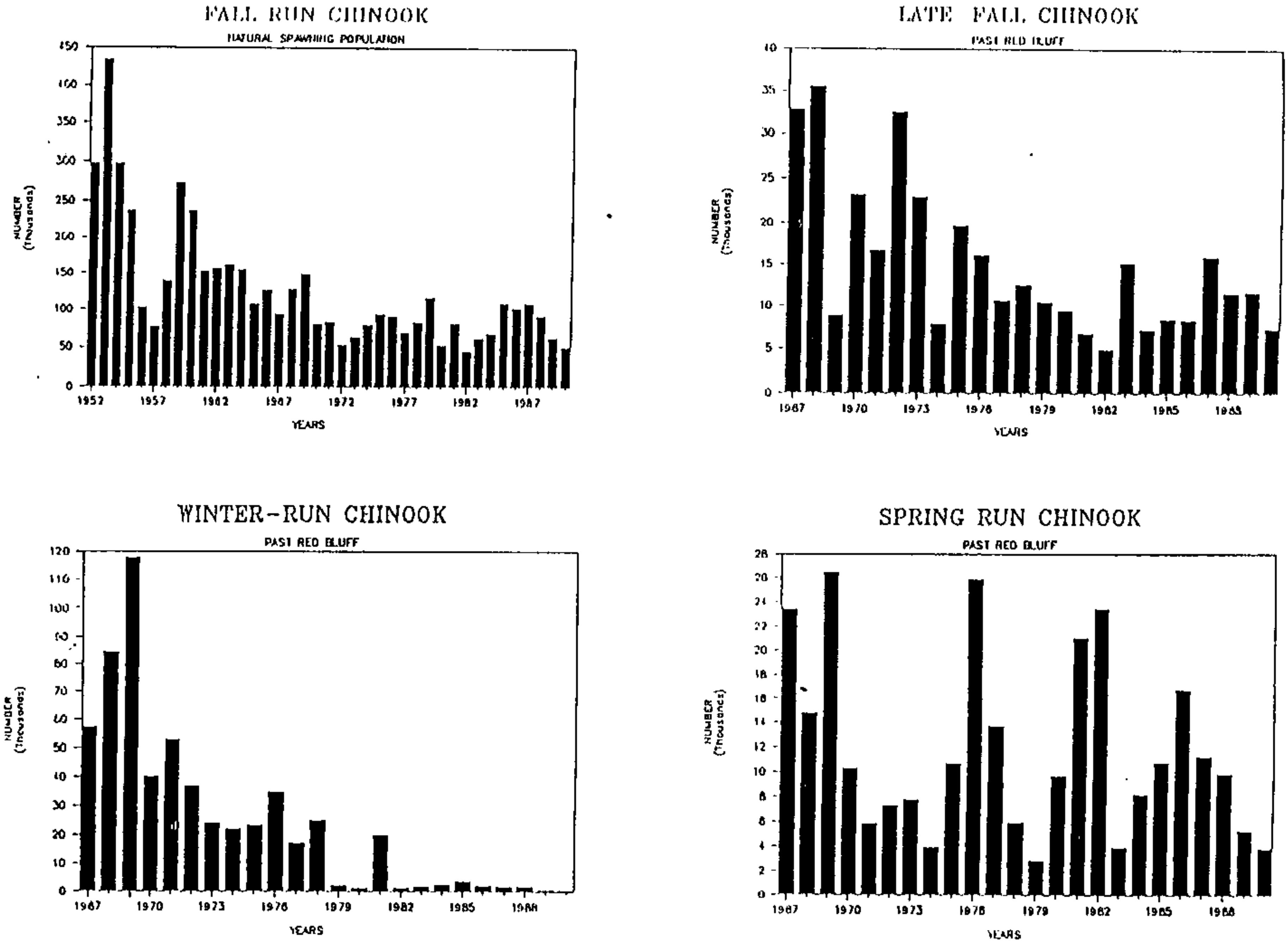


Figure 3. Naturally Spawning Chinook Salmon Estimates or Counts for the Various Races. (Estimates for Fall Run are total above the mouth of the Feather River less Battle Creek. Counts for the other races are above Red Bluff Diversion Dam.)

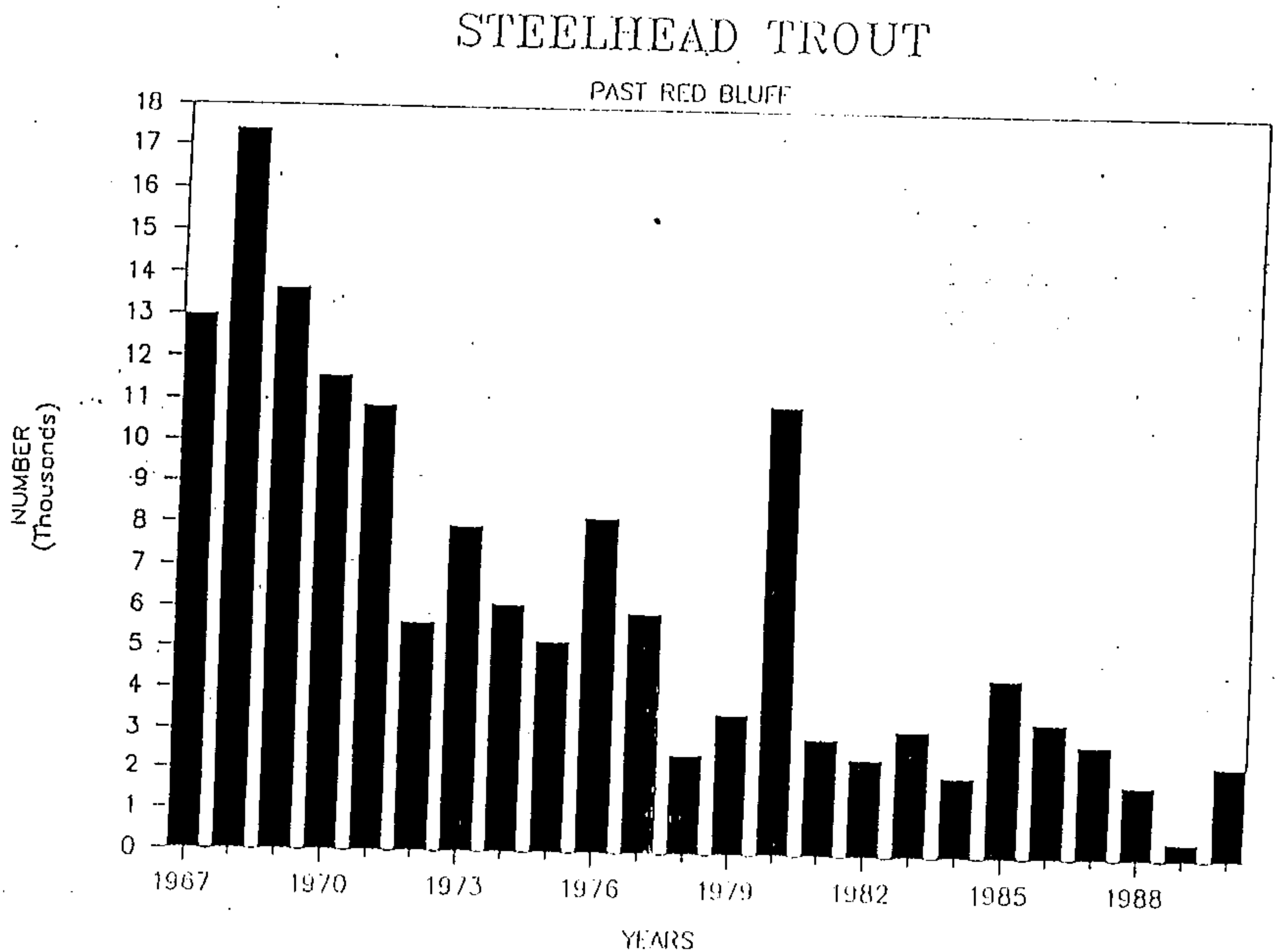


Figure 4. Steelhead Trout Counts Passing Red Bluff Diversion Dam.

Figure 5.

UPPER SACRAMENTO RIVER FISH COUNTS AT RED BLUFF DIVERSION DAM

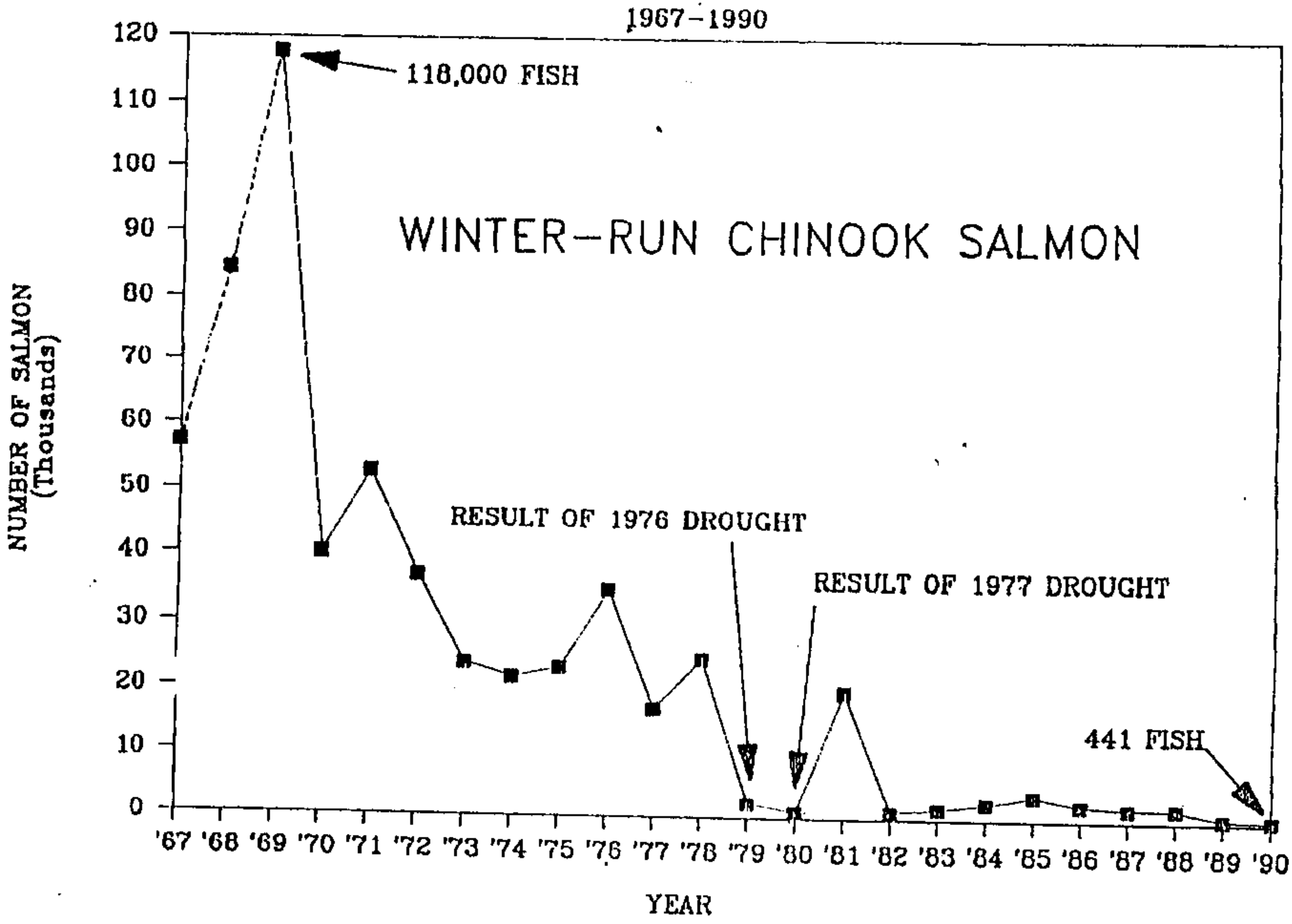


Figure 6.

Management Dilemma for Fisheries During Drought Without Adequate Carryover Storage

- **If too much reservoir release:**
  - Inadequate carryover storage
  - Reduced temperature control at spawning grounds
  - Depletion of storage for meeting delta needs
  - Constrain release patterns on other reservoirs in the system

- **Timing of cold water allocations:**
  - Not enough cold water to support all species/runs in Sacramento River
    - Management for winter run damages spring run
    - Management for spring run damages winter run
    - Fall run is not strongly influenced by management decisions
  - Constrain release patterns on other reservoirs in the system

Figure 7.

Importance of Maintaining Fishery Protection in a Drought

- **Reproductive core of salmon population**
  - Three year life cycle
  - Therefore, reproductive core contained in 3 successive runs
  - High population losses in 3 successive years can severely damage the reproductive core

- **Recovery from severe damage to core is very slow**
  - With few remaining breeders, recovery takes generations
  - There are about 3 generations per decade

- **Droughts are characterized by successive dry years**
  - Successive dry years create high risk of damage to the reproductive core

- **Need capability to protect previously damaged year class upon return to spawning grounds**
  - Requires some protective capability during drought

Figure 8.

Estimation of Shasta Reservoir Carryover Requirements for Driest Decile

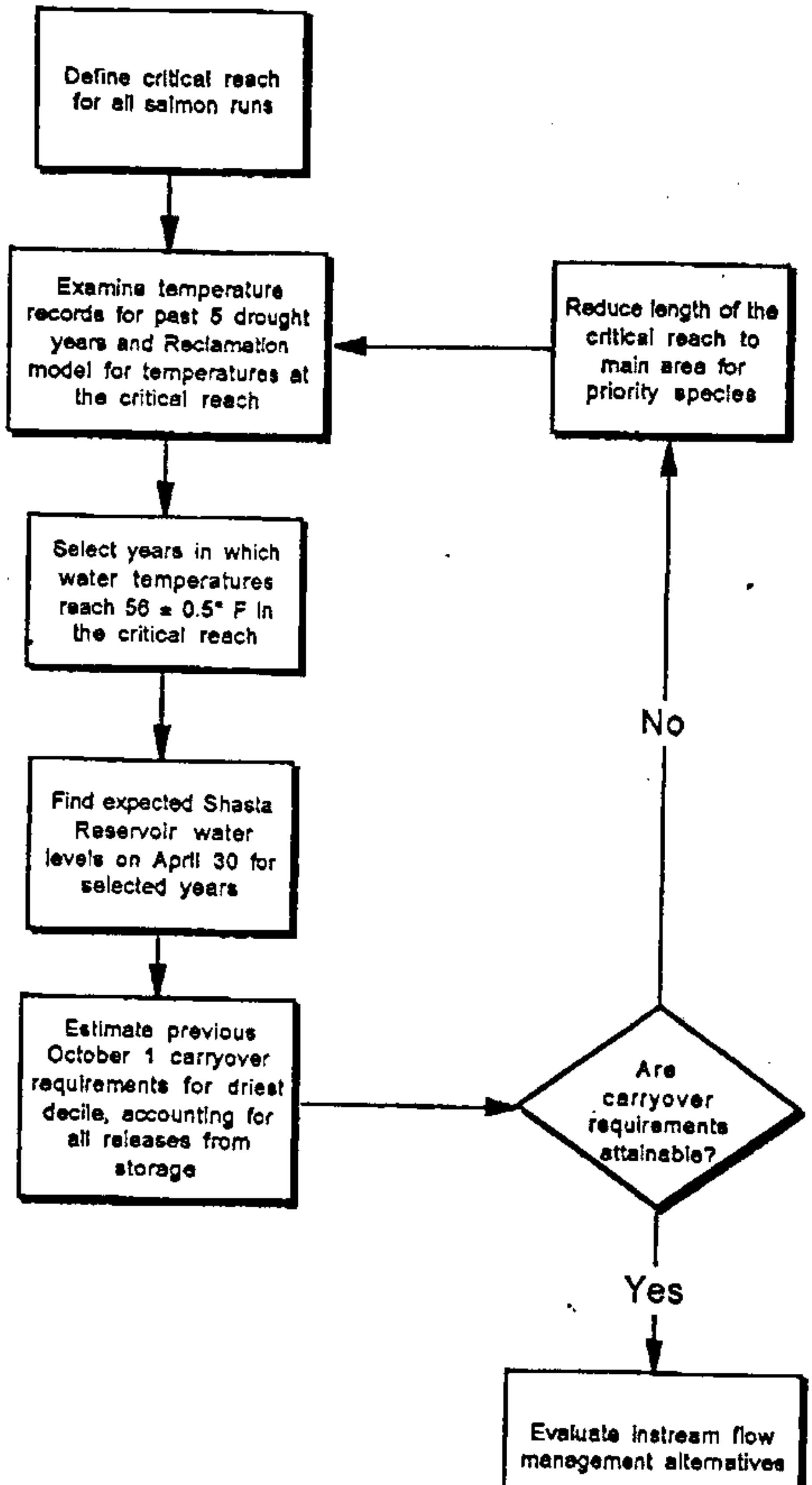
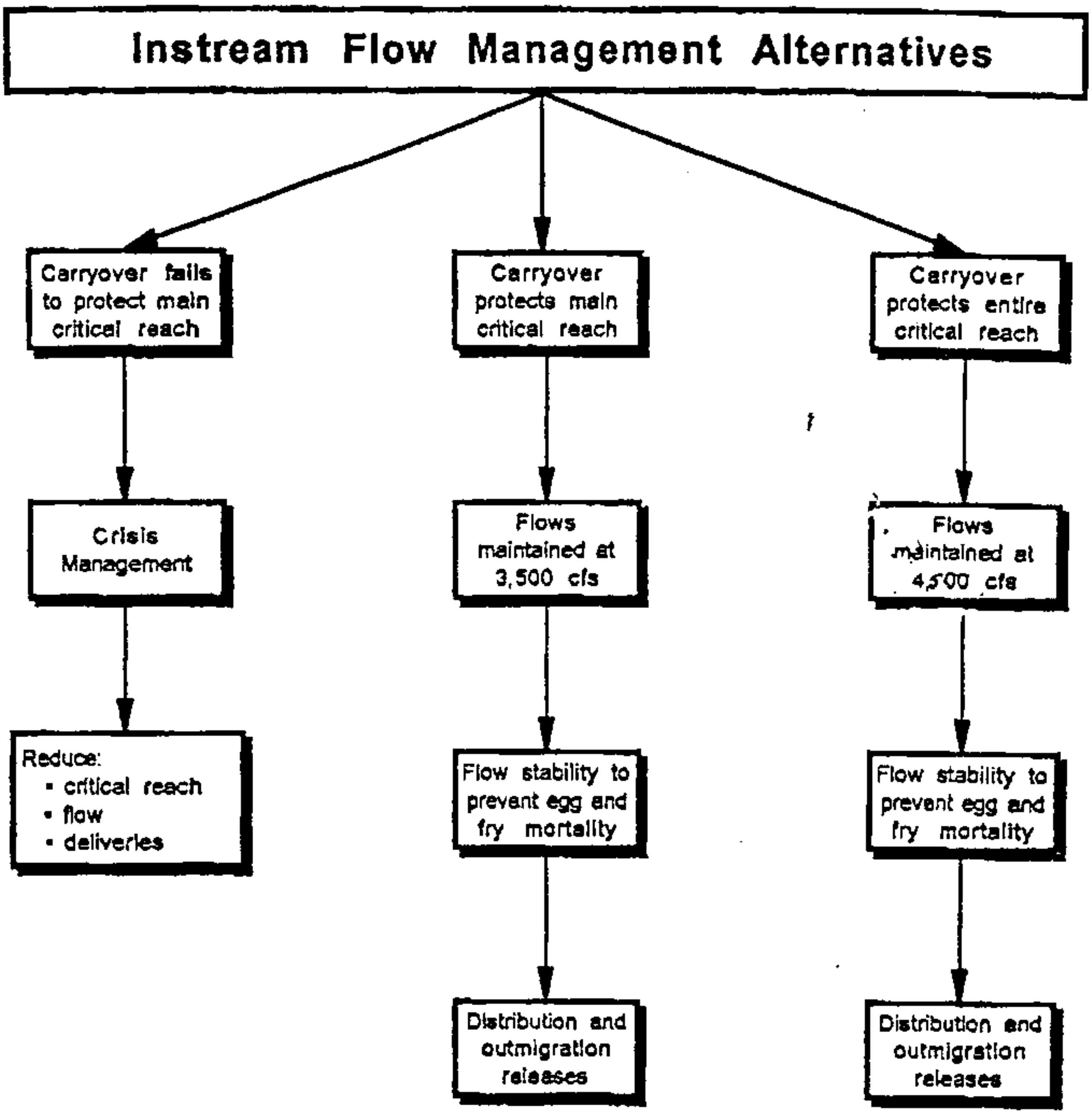


Figure 9.



Instream Flow Management Alternatives
Carryover fails to protect main critical reach
Carryover protects main critical reach
Carryover protects entire critical reach
Crisis Management
Flows maintained at 3,500 cfs
Flows maintained at 4,500 cfs
Reduce:
• critical reach
• flow
• deliveries
Flow stability to prevent egg and fry mortality
Flow stability to prevent egg and fry mortality
Distribution and outmigration releases
Distribution and outmigration releases

Figure 10. **Distribution of spawning salmon in the mainstem Sacramento River 1986 and 1987**