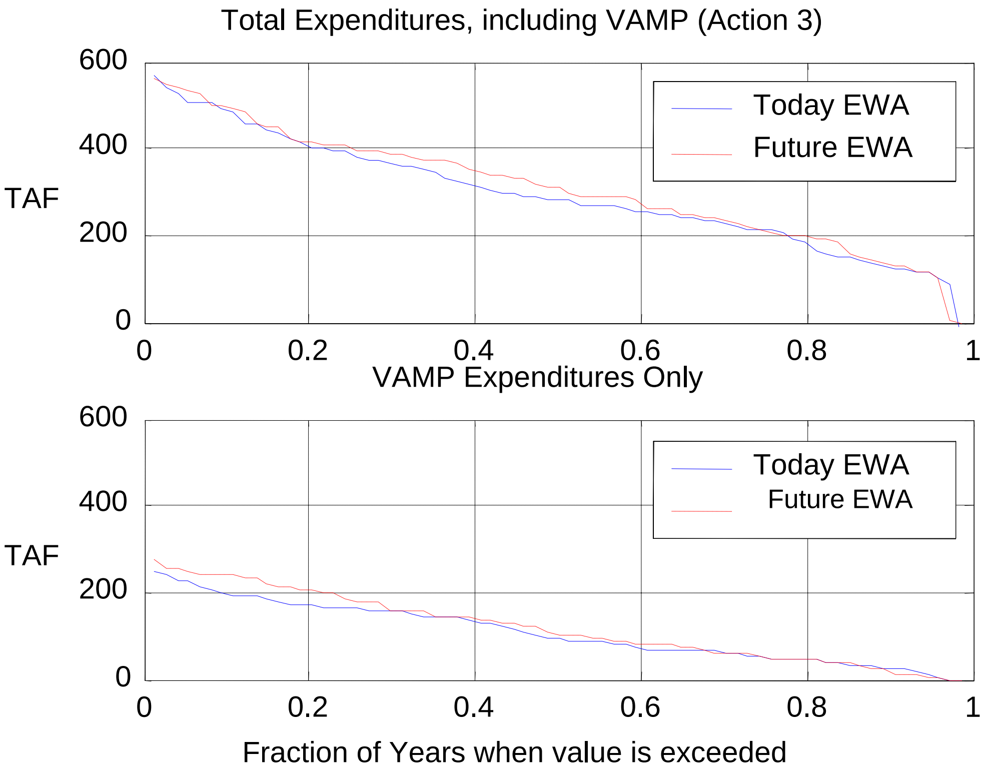


Figure 8-7 – **Annual EWA Expenditures simulated by CALSIM II, measured in terms of export reductions from exports under the EWA Regulatory Baseline (i.e. Step 4 of** Figure 8-1**) relative to exports with EWA operations (i.e. Step 5 of** Figure 8-1**).**

Table 8-10 – **Annual EWA Expenditures simulated by CALSIM II, averaged by Hydrologic Year-Type, defined according to the Sacramento River 40-30-30 Index.**

Hydrologic Year-Type	Today EWA (TAF)	Future EWA (TAF)
Critical	135	139
Dry	235	237
Below Normal	331	352
Above Normal	360	407
Wet	373	385

The measure of deliveries debt payback is the key indicator on whether the simulated EWA operations adhere to the No Harm to Deliveries principle set forth in the CALFED ROD. In CALSIM II modeling, SOD delivery debt is assessed in the month after which it occurs. Upon assessment, that debt is to be repaid in full through dedication of EWA asset available SOD (either as a SOD purchase planned for that month, a wheeled NOD asset planned for that month, or an EWA San Luis storage withdrawl that month). Instances when SOD delivery debt could not be repaid in full can be noted through post-simulation analysis of CALSIM II results. Occurrence of delivery debt not being immediately repaid only occurred for CVP debt in 1943 of the Future EWA study **(**Table 8-11**)**.

Levels of unpaid debt are very minor and within CALSIM II margins or error. Moreover, these amounts of unpaid delivery debt could presumably be managed by EWA assets not represented in CALSIM II (i.e. source-shifting, exchanges). The fact that instances of unpaid delivery debt occurred in the Future EWA run suggests that simulated EWA actions and assets are somewhat near balanced.

Table 8-11 – Instances of not adhering to the EWA "No Harm Principle" (i.e. not repaying delivery debt in full upon assessment), simulated by CALSIM II.

Delivery Debt Account	Today EWA	Future EWA
CVP South-of-Delta	None	3 instances: Jan 1943 (-2,000 af), Feb 1943 (-2,000 af), Mar 1943 (-2,000 af)
SWP South-of-Delta	None	None

A key feature of simulated and real EWA operations that enables increased flexibility of mitigating the impacts of EWA actions is the allowance for carryover debt. In CALSIM II modeling, due to the model structure depicted on Figure 8-1, the annual interruption of the simulated EWA operational baseline necessitates special measures for accounting for carryover debt relative to debt caused by this year's actions (i.e. "new debt" in CALSIM II semantics). The result of these measures are separate debt accounts for carryover and new debt. Unpaid new debt ultimately gets rolled over into the carryover debt account, which can represent one or more years of unpaid debt.

The roll-over of new debt into the carryover debt account occurs in November of Step 5 (Figure 8-7). Results on carryover debt conditions at CVP/SWP San Luis are shown on Figure 8-8 for 73 Octobers and Novembers of Step 5. These carryover debt conditions are at a maximum in November after which they are managed to a minimum in October through dedication of physical EWA assets available SOD or spilling of carryover debt at SWP San Luis. Focusing on the October results, simulated operations under Today EWA and Future EWA suggest similar findings: both suggest that at least 50,000 af of carryover debt will persist for more than one year in 20% of the 73 simulation years, and at least 100,000 af will persist for more than one year in 10% of the 73 years. Extreme amounts of carryover debt persisting for more than one year are higher in Future EWA than with Today EWA.

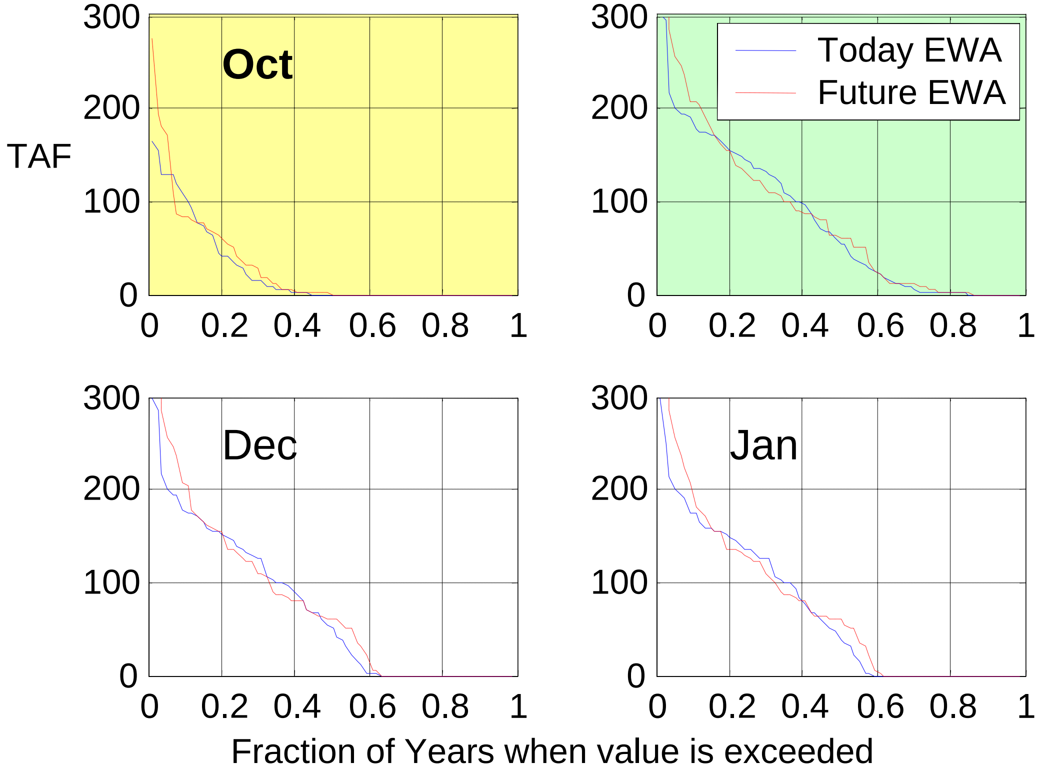


Figure 8-8– Combined carryover debt at CVP and SWP San Luis, simulated in CALSIM II, at the end (Oct) and start (Nov) of the carryover debt assessment year.

The comparative ranges of acquired EWA assets under Today EWA and Future EWA are summarized on Figure 8-9. Focusing first on water purchases only, results are comparable for Today EWA and Future EWA. However there are some years when total purchases under Future EWA are greater than those under Today EWA. It seems that the presence of 8500 Banks in Future EWA somewhat mitigates the limitations of Delta constraints on summer wheeling that sometimes occurred in Today EWA operations. Even though EWA has dedicated 500cfs conveyance capacity at Banks during July-September, this capacity is still vulnerable to interruption due to export reductions caused by other Delta constraints (e.g., Minimum Required Delta Outflow, Export-Inflow limit, Delta salinity objectives).

Focusing on total acquired EWA assets (i.e. water purchases, B2 gains, use of JPOD capacity, wheeling backed-up water), the results for Today EWA and Future EWA are virtually identical except in extreme low-asset years when asset availability is slightly better with Future EWA. On the subject of backed-up water, occurrence can only be induced by Spring EWA actions, but wheeling of the asset from NOD storage to SOD use can occur any time o the year. Results indicate that conveyance of backed-up water occurs in 60% of years. Annual conveyed volumes were less in the Today EWA study relative to the Future EWA study (~10,000 af). Generally, backed-up water conveyance exceeds 30,000, 50,000, and 100,000 af in 40%, 20%, and 10% of the years, respectively.

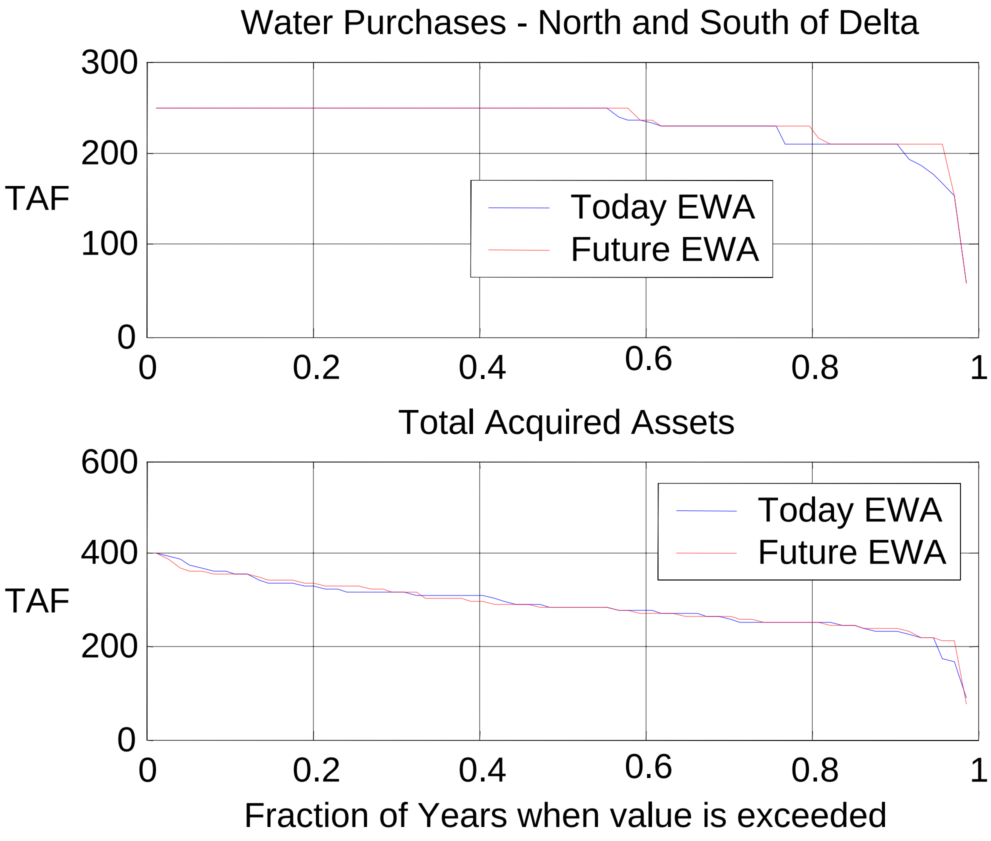


Figure 8-9 – Annual EWA assets simulated in CALSIM II. "Total Acquired Assets" includes Water Purchases and operational assets (i.e. EWA acquisition of 50% of SWP gains from B2 releases, EWA conveyance of Delta Surplus flows using 50% of JPOD capacity or summer dedicated capacity, EWA conveyance of backed-up water caused by Spring EWA actions on exports).

A unique tool for managing carryover debt situated at SWP San Luis is debt spilling, described earlier. In CALSIM II, carryover debt conditions need to be present and severe enough in order to trigger the use of this tool, based on the spill-conditions that were outlined earlier. Also note that there is a symmatics difference between what's called "spill" in CALSIM II and what's called "spill" by EWAT. CALSIM II only designates erasing of carryover debt at SWP San Luis, or reservoir filling in NOD reservoirs as "spilling" debt; it doesn't designate "pumping-to-erase" new debt at San Luis as "spill", even though this is a term sometimes used by EWAT. That distinction noted, the occurrence of carryover debt spilling at SWP San Luis is depicted on Figure 8-10. The frequency of this carryover debt spilling in the Today EWA results is 25 of 73 years with a maximum annual spill of 171,000 af; the frequency in the Future EWA results is 23 of 73 years with a maximum annual spill of 226,000 af.

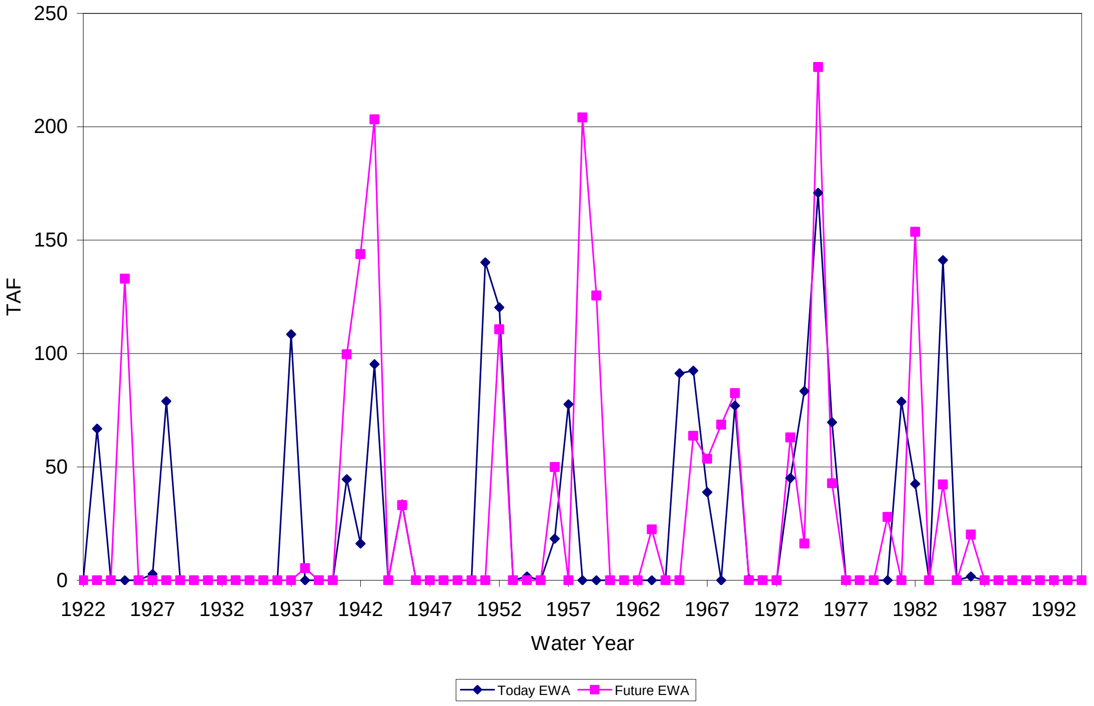


Figure 8-10 – Annual carryover-debt spilling at SWP San Luis, simulated in CALSIM II.

Action-specific expenditures for Winter Export Reductions are expected to be 50,000 af for each month in which their implemented, according to modeling assumptions. Generally this is the case, based on simulated export reductions measured between Step 4 and Step 5 in both the Today EWA and Future EWA studies (Figure 8-11). The action is always taken in December and Januarys, and it is also taken in February if the Sacramento River 40-30-30 Index defines the year to be Above Normal or Wet. Simulation results show that export reductions are always as expected for January and February and nearly always as expected for December (approximately 95% of the years).

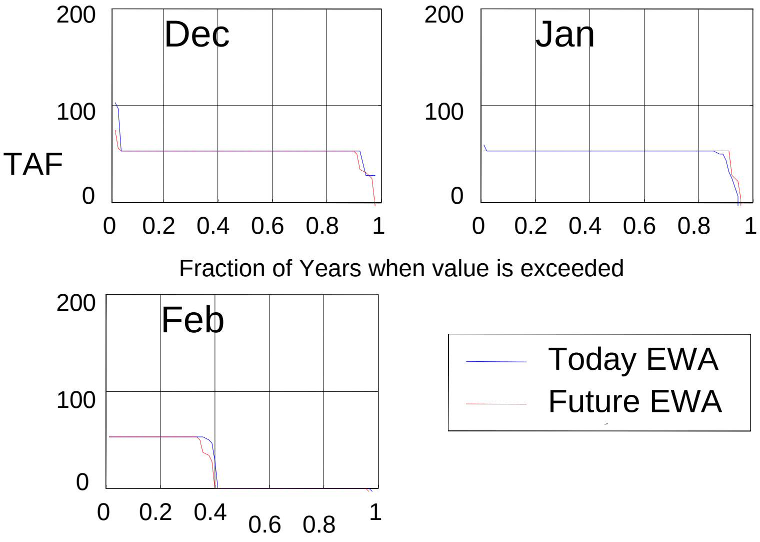


Figure 8-11– Simulated export reductions associated with taking EWA Action 2 (i.e. Winter Export Reductions).

Expectations for Spring actions' expenditures are more difficult to make prior to simulation compared to expenditures for Winter Actions. This is because Spring actions (i.e. EWA Actions 3, 5, and 6) are not linked to spending goals, and are instead linked to target export restriction levels related to VAMP. Results show that action-specific export costs for Spring actions are slightly higher in the Future EWA study relative to the Today EWA study (Figure 8-12 through Figure 8-14). Moreover, the frequency implementing June export reductions (i.e. EWA Action 6, Figure 8-14) is slightly less in Future EWA relative to Today EWA. It appears that in Future EWA, more debt is developed leading up to June in some years, relative to operations under Today EWA, causing the June action to not be triggered since it is conditional on debt conditions. The fact that more debt can develop by June under Future EWA relative to Today EWA seems to be linked to operation of 8500 Banks and the higher average-annual deliveries being made to SWP SOD water users in Future EWA compared to Today EWA (**Table 8-7**).

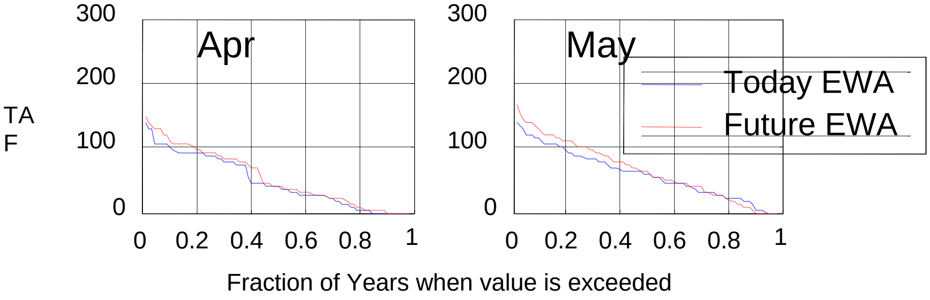


Figure 8-12 – **Simulated export reductions associated with taking EWA Action 3 (i.e. VAMP related restrictions).**

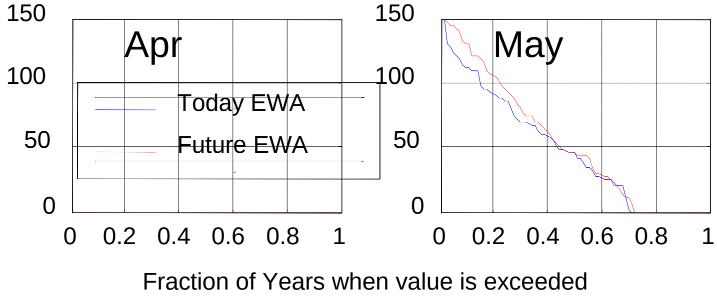


Figure 8-13 – **Simulated export reductions associated with taking EWA Action 5 (i.e. extension of VAMP related restrictions into May 16 – May 31 (i.e. the May Shoulder)).**

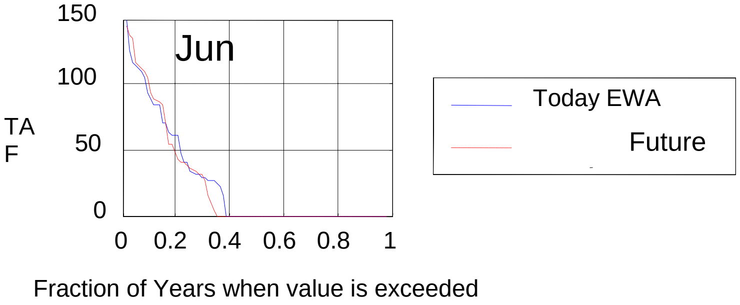


Figure 8-14 – Simulated export reductions associated with taking EWA Action 6 (i.e. representation of June "ramping" from May Shoulder restriction to June Export-to-Inflow restriction).

Post-Processed EWA Results

The results in this section are from the EWA spredsheet model developed by the DWR Transfers Section. The model accounts for assets that CALSIM II does not represent (i.e. E/I Relaxation, Exchanges, Source-Shifting; see Figure 8-15 for assets modeled). Like CALSIM II, the model can be used to describe annual EWA operations. However, the model provides much more assumptions on asset source, availability and includes a financial cost module for analyzing asset acquisition strategies. It is structured to accept output from CALSIM II runs and other computations to allow testing and analysis of how the EWA would fare if the 73-year hydrologic record were to be repeated. The DWR Transfers Section uses this model to test the ability of various tools and management options to meet annual targets for fish actions. Like CALSIM II, this model assumes that actions are implemented as Delta pumping curtailments. However, this model employs much simpler assumptions on action costs, assuming that they vary only with year-type. The annual average action costs by water year type can bee seen in Table 8-12.

Figure 8-16 shows the timeseries of annual debt status for the 73 year analysis. Simulated EWA operations lead to accumulating assets during the long-term drought periods and accumulating debt during wet periods. Maximum debt accumulation happens in 1970 and is a little over 400 TAF. Figure 8-17shows annual pumping expenditures. Figure 8-18 show the annual costs in dollars for the EWA program. For more detailed results and assumption about the model see the EWA Model for OCAP appendix.

Table 8-12. Annual EWA Expenditures Targets by Water Year Type

40-30-30 Index	Annual Cost
Wet	430
Above Normal	490
Below Normal	400
Dry	300
Critical	250

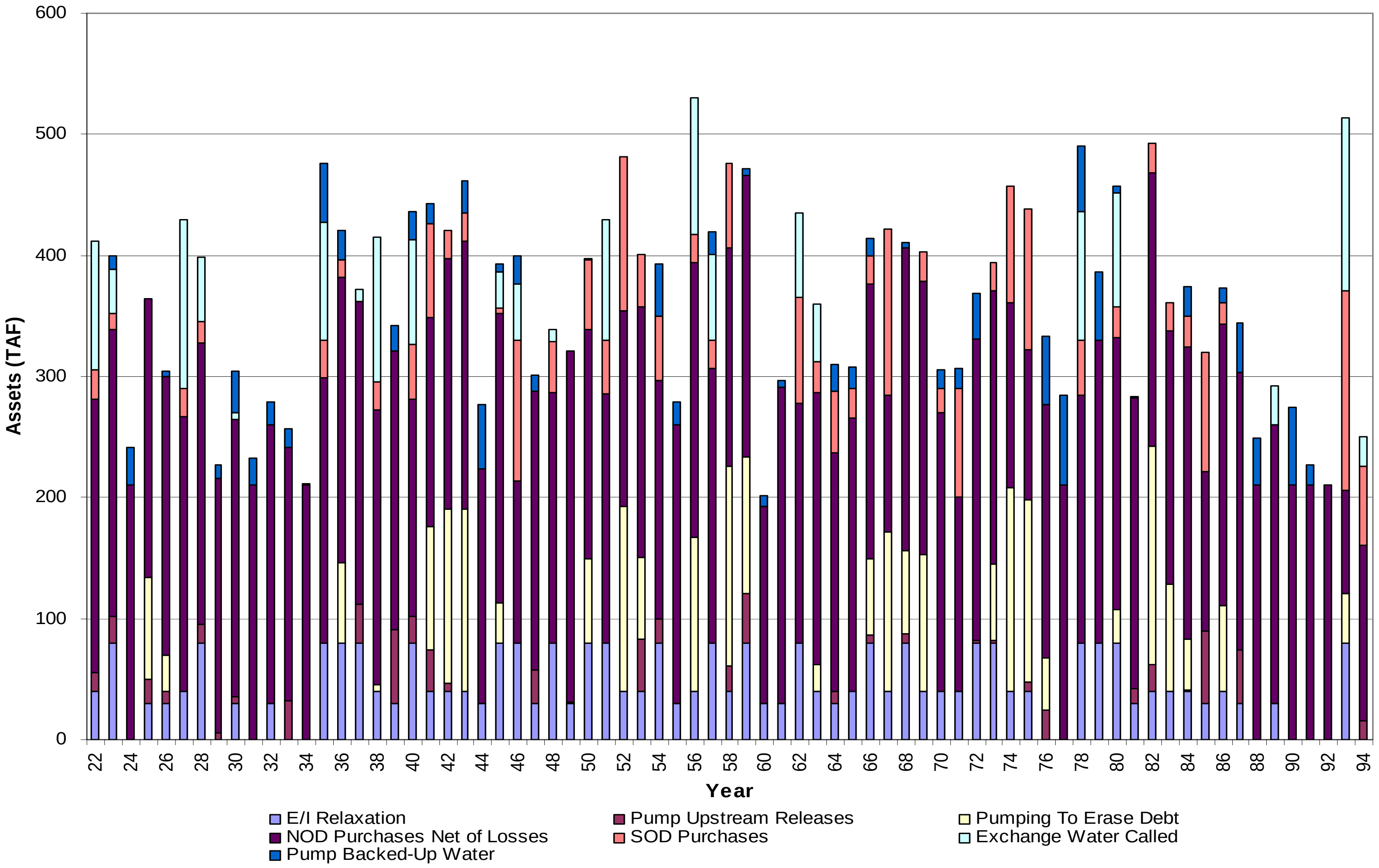


Figure 8-15 EWA Assets by Water Year

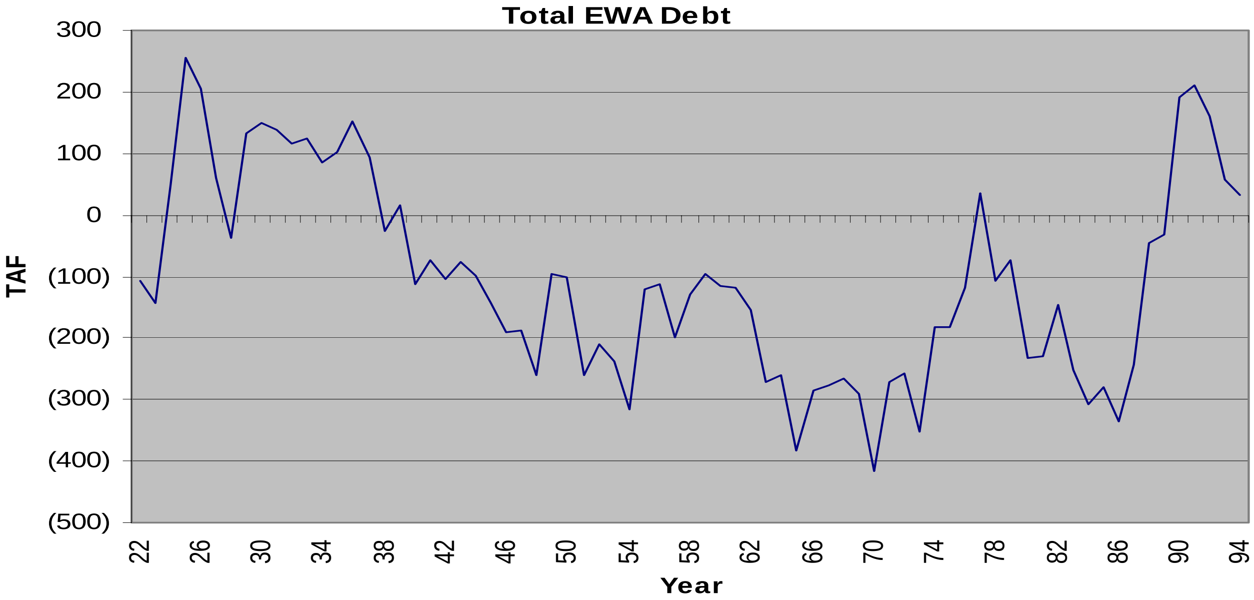


Figure 8-16 Total EWA Debt Balance by Water Year

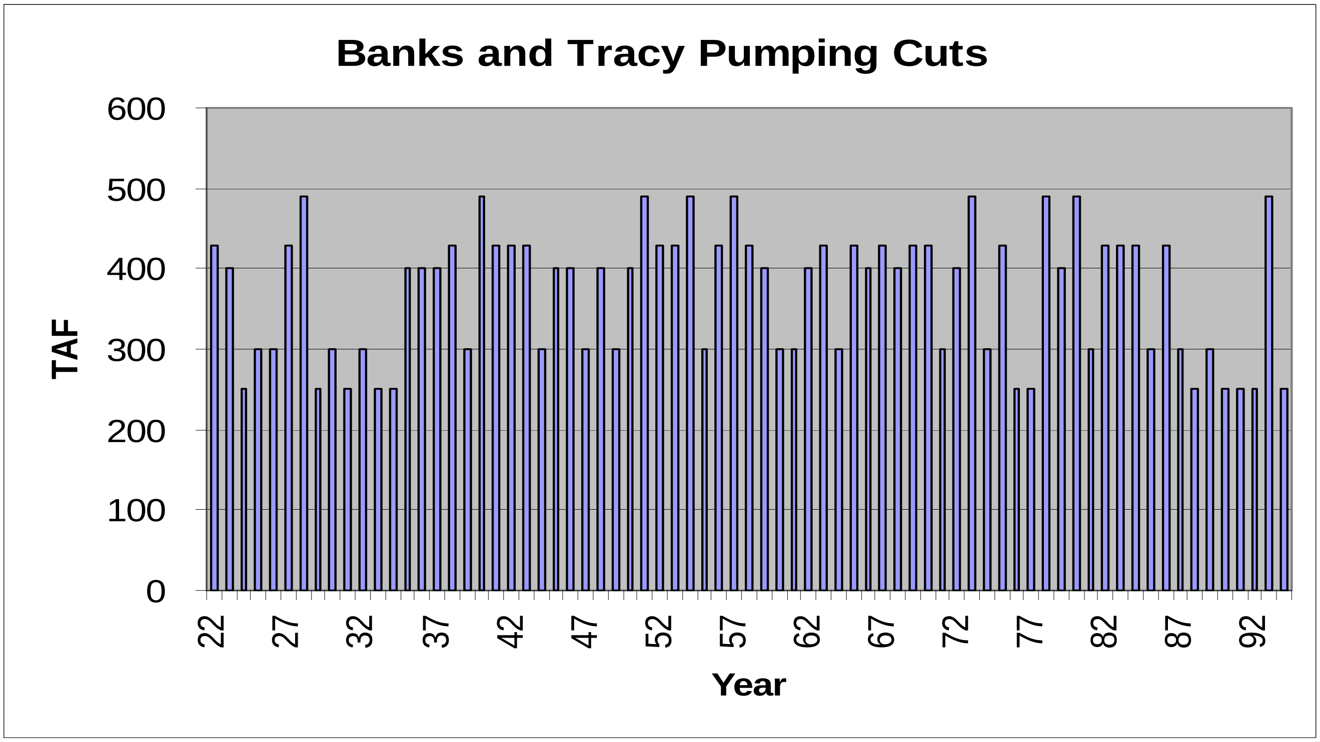


Figure 8-17 Banks and Tracy Cuts

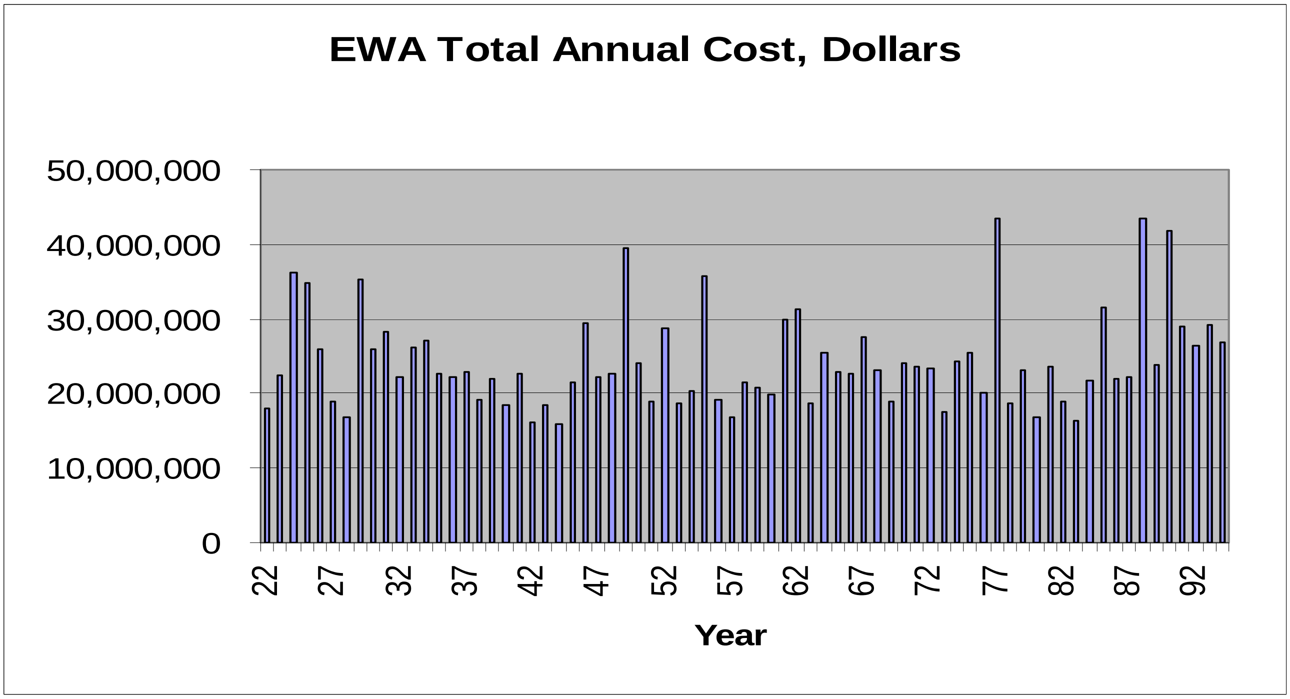


Figure 8-18 Total annual cost of EWA by water year

Conclusions

The main reduction in Shasta Storage is due to the decrease in imports from the Trinity through Spring and Clear Creek Tunnels which is caused from increased flow targets for the Trinity River. Trinity Reservoir storage decreases are due to increased flows targets to the Trinity River.

Decreases in Folsom Lake storage levels are due to increased demands associated with changes in the Level of Development along the American River. Level of Development would include buildout of the water rights and water service contracts. The operation of the American River, specifically operations for the modified D-893 minimum instream flows and the demands for the Future simulations, reflect operations specific to OCAP modeling and may be different than the agreement between Reclamation and the Water Forum. The 47 TAF of mitigation water that is released in this version of Water Forum modeling may not occur in the Future and is showing greater water in the Delta for Exports than may happen in actual operations.

Impact differences between the five studies on the Feather River system are minimal and shift releases to either earlier or later in the year. The change in timing of releases has more to do with the EWA reduction than with increases in demands south of the delta. Oroville does have reduced carryover storage in the Wet through Below Normal years due to a more aggressive allocation curve and increased demands south of the Delta but is less aggressive in the drier years due to reduced carryover storage.

The Stanislaus River shows no major impacts between the five studies because Interim Operations Plan elements are implemented in each of the studies. Assumptions associated with the Future condition studies do not seem to affect operational conditions as simulated under Today conditions.

The increase in export capacity with the intertie at Tracy and the ability to pump up to 8500 cfs at Banks allows for more excess outflow from the delta to be pumped. The upstream reservoirs show marginal extra releases for exports as a result of the increased capacity at the pumps.

October to January costs of operations for CVPIA Section 3406 (b)(2) increase in the future and limit the ability of (b)(2) to cover export restrictions. The over- and under-spending of allocated (b)(2) water shows the following:

- The inability of CALSIM II to completely capture the adaptive management process that occurs on at least a weekly basis in the B2IT Meetings.
- Over-spending demonstrates a need for CALSIM II to have improved forecasting of annual (b)(2) costs.
- Under-spending shows that the current implementation needs a forecasting tool to allow for additional actions to be taken in Wet to Below Normal water years.
- This representation shows just one set of actions that can be taken under CVPIA, and are not the actual operations. The CALSIM II representation of (b)(2) is meant to be used as a planning tool for grossly evaluating (b)(2) costs under various operating scenarios.

The simulated operations of EWA actions and assets in both the Today EWA and Future EWA studies seem to be somewhat in balance. It is noted that simulated EWA operations are based on assumptions that do not perfectly map to the considerations affecting real EWAT operations:

- CALSIM II must simulate EWA operations on a monthly time step with relatively inflexible rules that must apply for a wide variety of simulation years (according to hydrology and operational conditions); EWAT makes operational decisions on a day-to-day basis through a flexible, adaptive management procedure.
- CALSIM II employs an annual position analysis paradigm to track multiple operational baselines (Figure 8-7**)**, which necessitates split accounting for new and carryover debt; EWAT's procedures for tracking multiple operational baselines doesn't get interrupted annually like that of CALSIM II, and therefore they can describe debt without the split accounting.
- CALSIM II represents action possibilities (especially during Winter and June) as a monthly representation of many different action possibilities; EWAT retains the flexibility of selecting among many combinations of multi-day actions during Winter and/or June.
- To reiterate, the CALSIM II representation of EWA operations is a simplified representation that reflects an adaptive management program and does not limit the operational flexibility held by EWAT. The CALSIM II representation is meant to capture a reasonable representation of EWAT's current and foreseeable operations.

Chapter 9 Project Impacts for CVP and SWP Controlled Streams

CVP and SWP project operations affect flow and water temperature in river reaches downstream of project reservoirs. The following effects discussion refers to the monthly reservoir release exceedance charts and monthly water temperature exceedance charts found in CALSIM Modeling Appendix and Temperature Modeling Appendix respectively. Recommended temperature ranges and flows for the species are compared to the exceedance charts. Variation in temperatures and flows within months and days are not available from modeling results but will be similar to what occurs currently. The modeling displays more of a net change by month and shows the general direction of change useful for comparing the five scenarios. Monthly exceedance charts are shown for the following locations among others and compare the five modeling runs outlined in chapter 8:

Trinity River Coho Salmon

Modeling

Table 9-1 shows the average annual differences between the five studies for total annual flow and End of September Trinity Storage. Reductions in imports through Clear Creek Tunnel are directly proportional increases in Trinity River minimum required in stream flows. Figure 9-1 shows the Chronology of Trinity Storage from Oct 1921 – Sep 1993. Figure 9-2 shows the end of September exceedance chart for Trinity.

Table 9-2 shows that the increased flows in Study 4 and Study 5 mainly impact the Above Normal and Below Normal years and not the Wetter hydrologic years or the Dry and Critical years when compared to Study 2 and Study 3. Study 1 with the minimum flow requirement at 340,000 af/year the carryover storage remains steadily higher than the other four studies. Other figures presented in this section are the percentile of Trinity Releases Figure 9-3, and the monthly averages for Lewiston Releases by Long-term average and by 40-30-30 Index water year type can be seen in Figure 9-4 to Figure 9-9. Figure 9-10 shows the monthly percentile from imports from the Trinity through Clear Creek Tunnel. The graphs of averages and percentiles show how the flow increases in the Trinity and adheres to the minimum flow standard on average. The monthly percentiles for imports from Clear Creek tunnel are reduced as the minimum flow requirement increases from Study 1 to Study 2 and 3 to Study 4 and 5.

Table 9-1. Long-term Average Annual Impacts to the Trinity River System

Differences (TAF)	Study 2 - Study 1	Study 3 - Study 1	Study 5 - Study 1	Study 4 - Study 2	Study 5 - Study 3
Average Trinity EOS	-76	-83	-128	-56	-46
Average Annual Lewiston Release	86	83	230	143	146
Average Annual Clear Creek Tunnel Flow	-82	-80	-222	-138	-142

Table 9-2. 1928 - 1934 Average Annual Impacts to the Trinity River System

Differences (TAF)	Study 2 - Study 1	Study 3 - Study 1	Study 5 - Study 1	Study 4 - Study 2	Study 5 - Study 3
Average Trinity EOS	-49	-69	-108	-48	-38
Average Annual Lewiston Release	85	85	128	42	44
Average Annual Clear Creek Tunnel Flow	-85	-85	-139	-51	-55

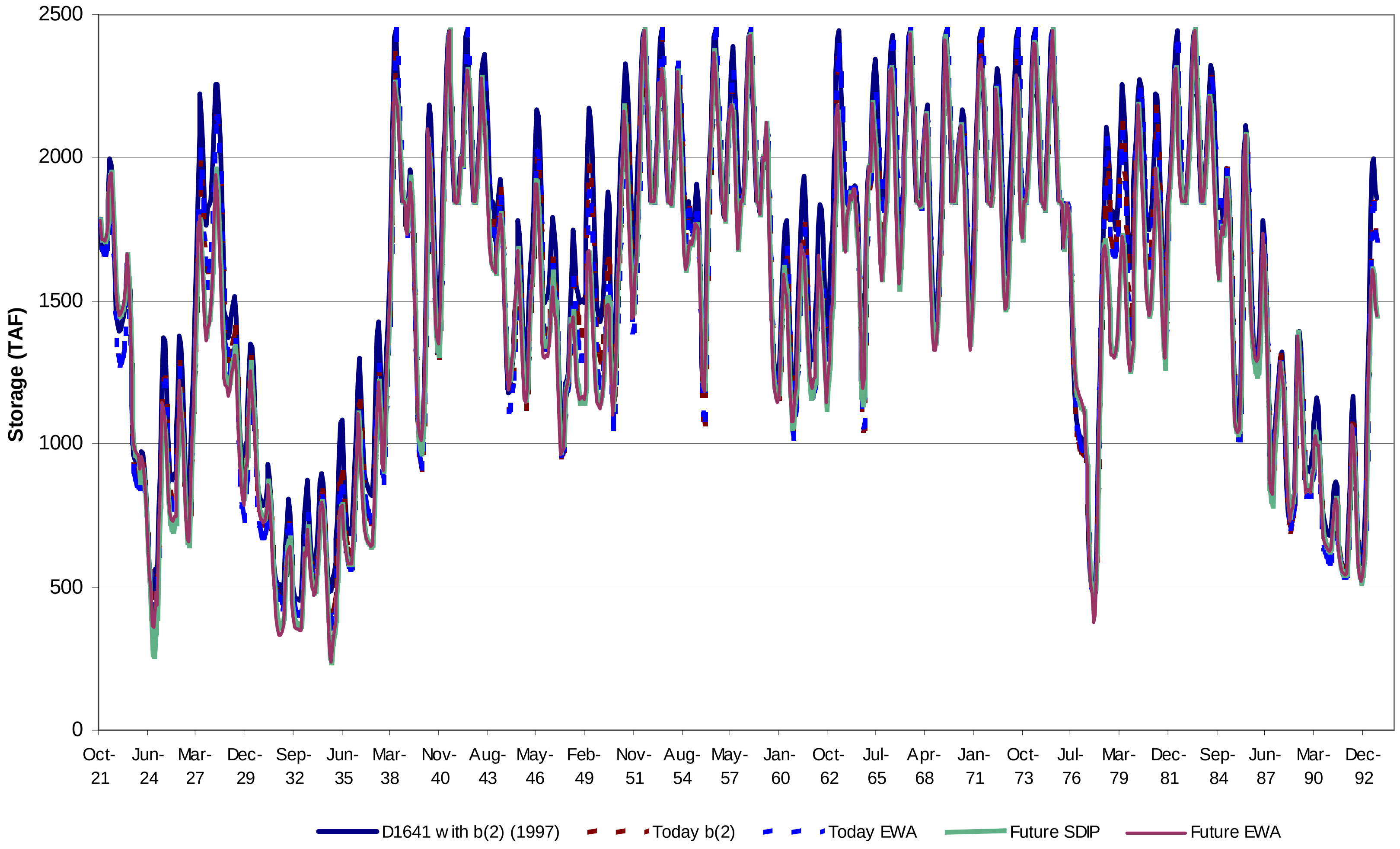


Figure 9-1 Chronology of Trinity Storage Water Year 1922 - 1993

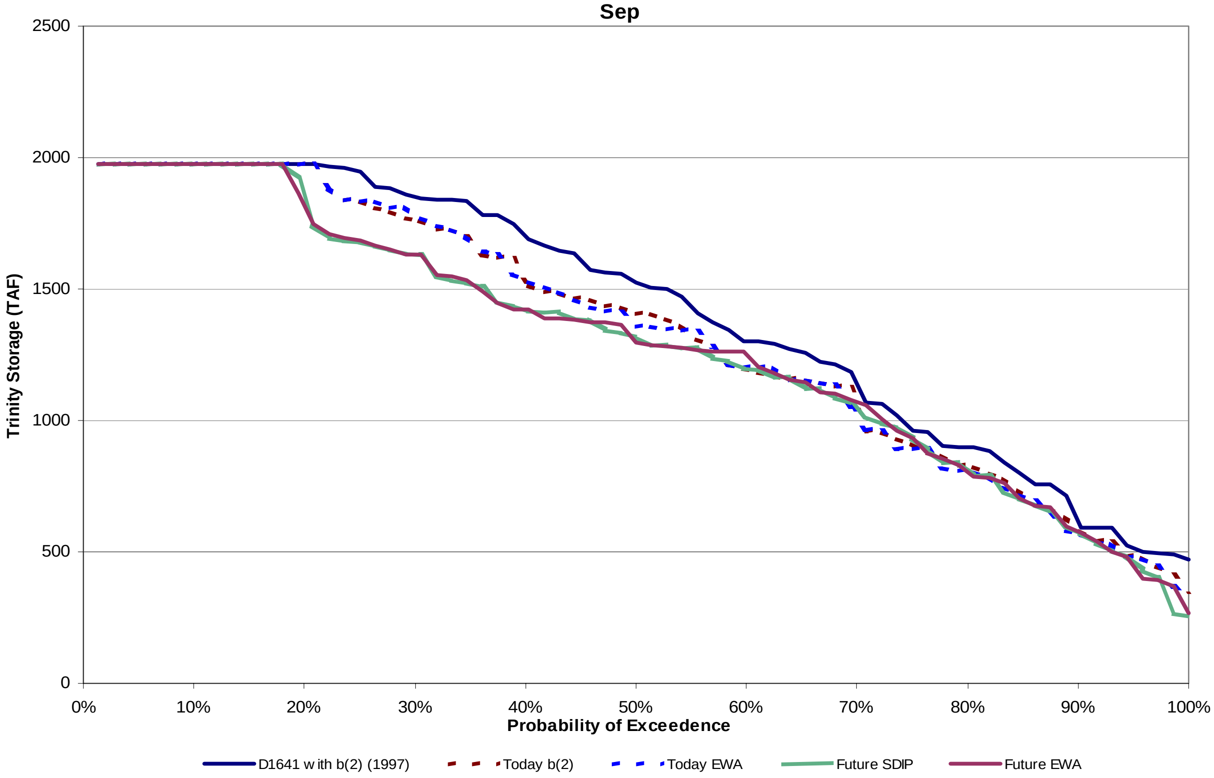


Figure 9-2 Trinity Reservoir End of September Exceedance

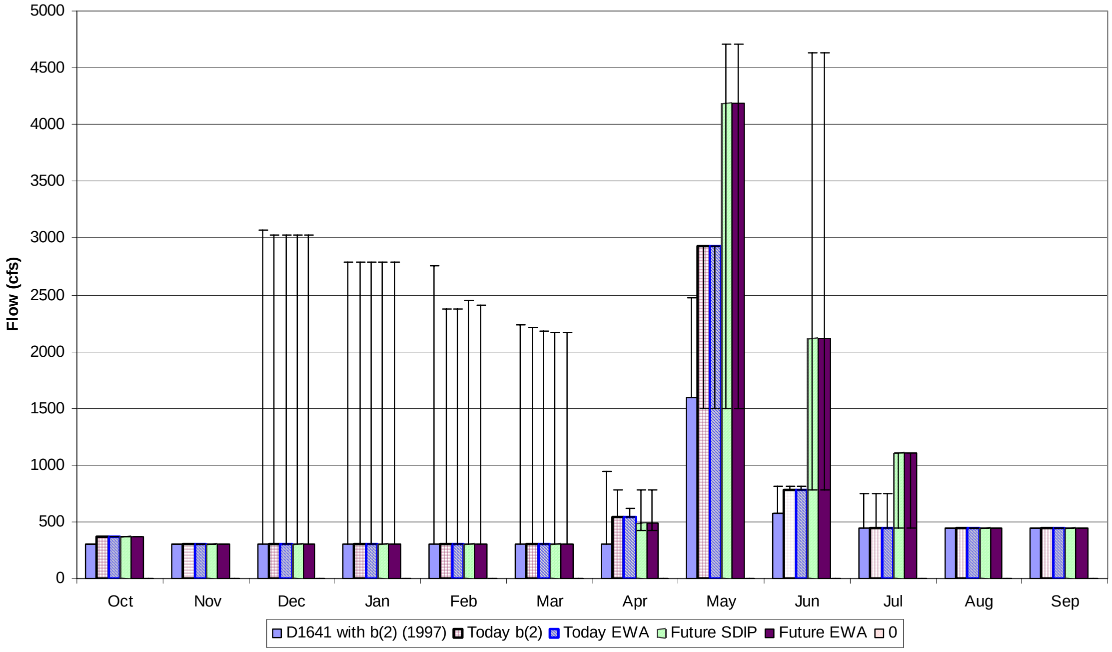


Figure 9-3 Lewiston 50th Percentile Monthly Releases with the 5th and 95th as the bars

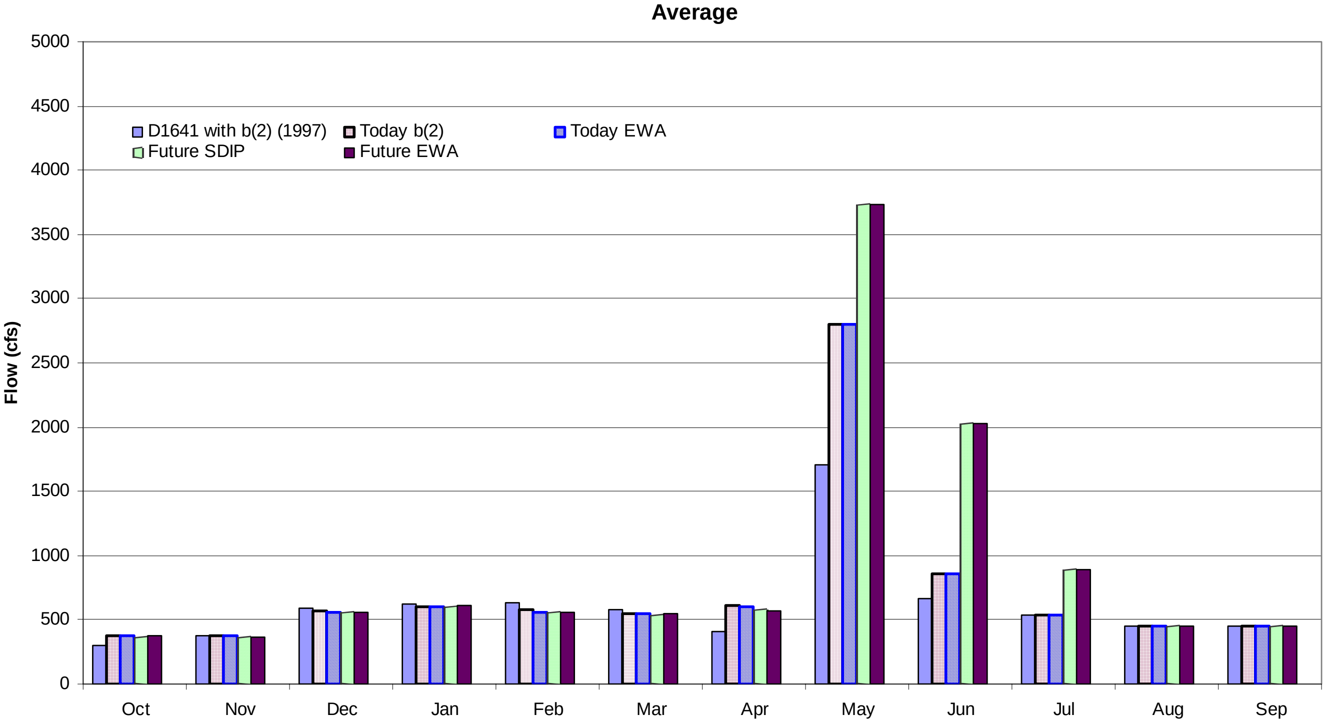


Figure 9-4 Average Monthly Releases to the Trinity from Lewiston

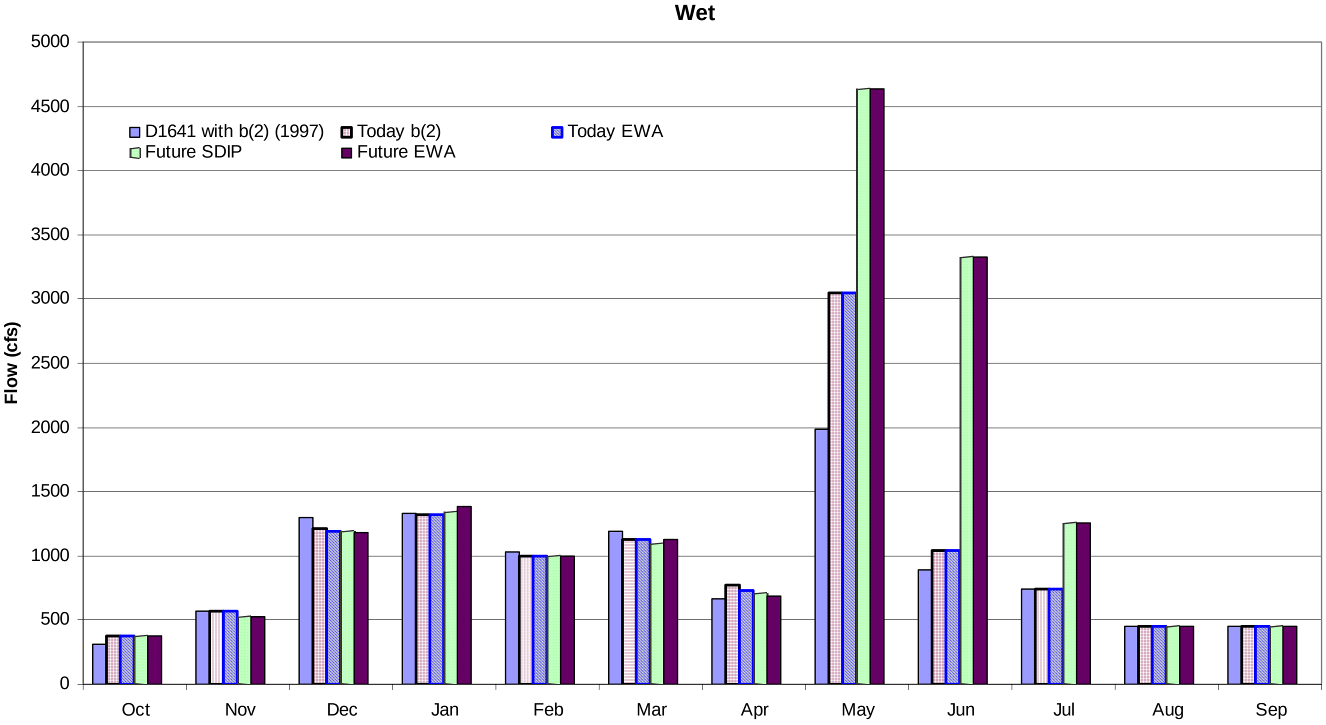


Figure 9-5 Average wet year (40-30-30 Classification) monthly releases to the Trinity

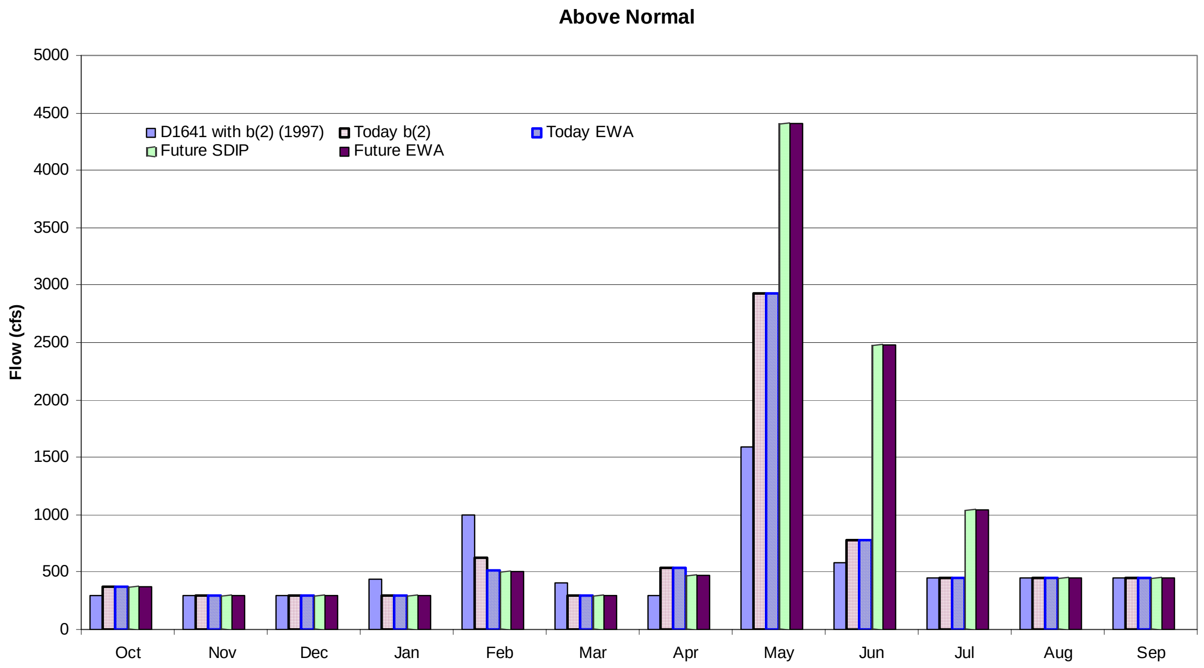


Figure 9-6 Average above normal year (40-30-30 Classification) monthly releases to the Trinity

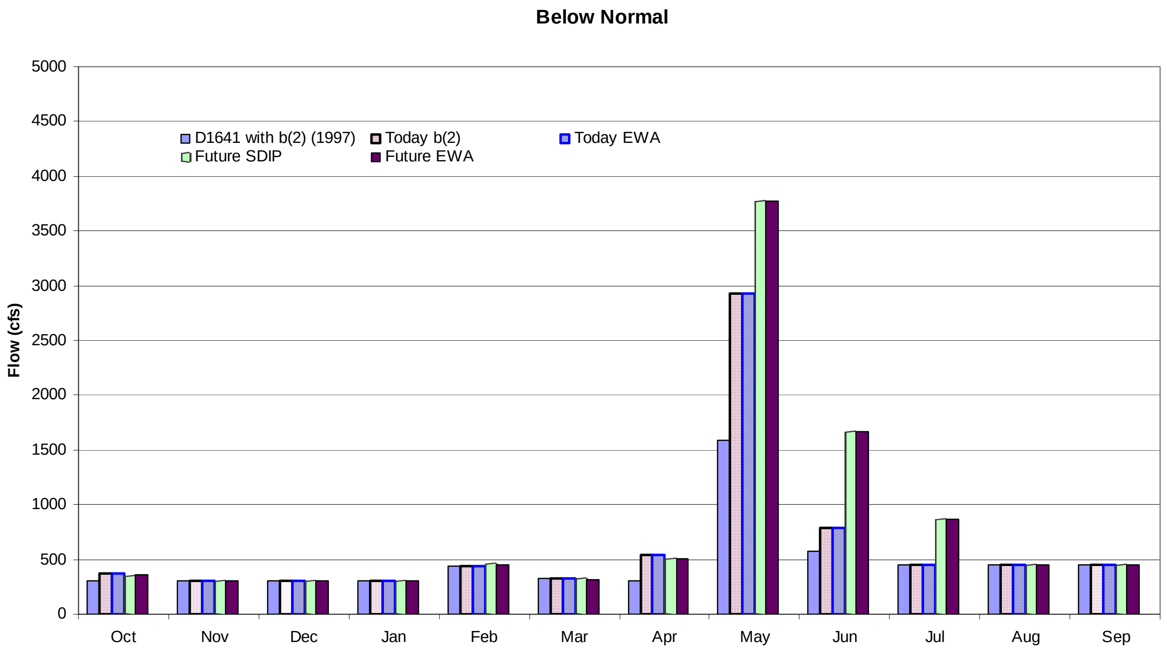


Figure 9-7 Average below normal year (40-30-30 Classification) monthly releases to the Trinity

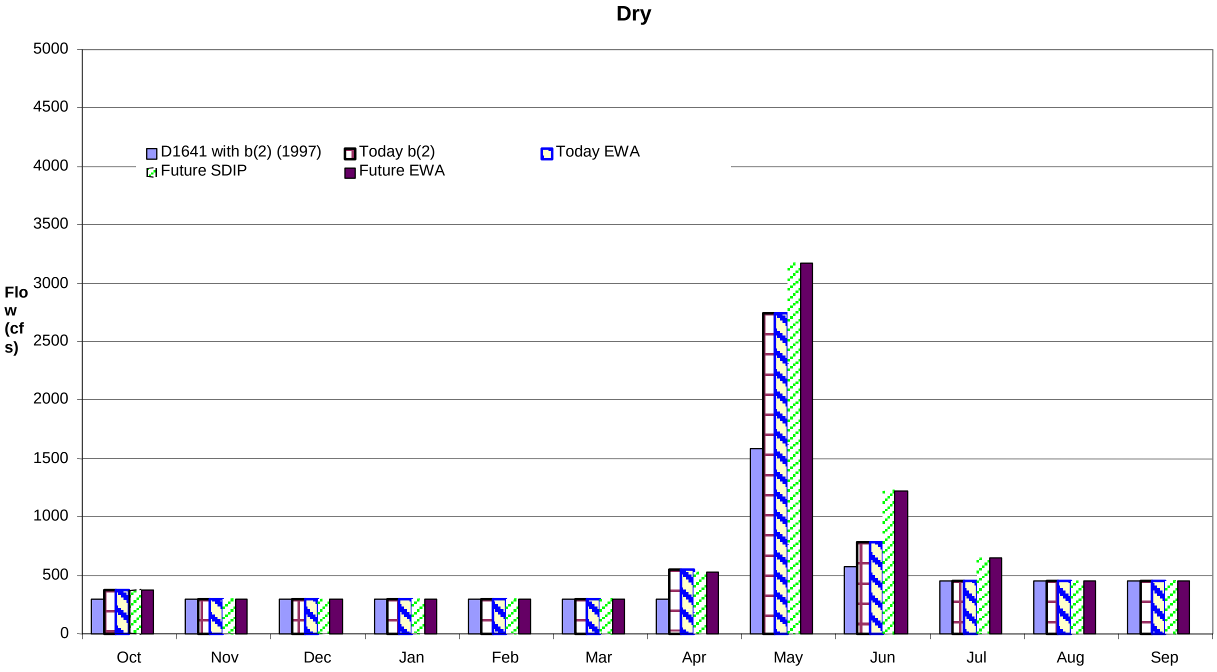


Figure 9-8 Average dry year (40-30-30 Classification) monthly releases to the Trinity

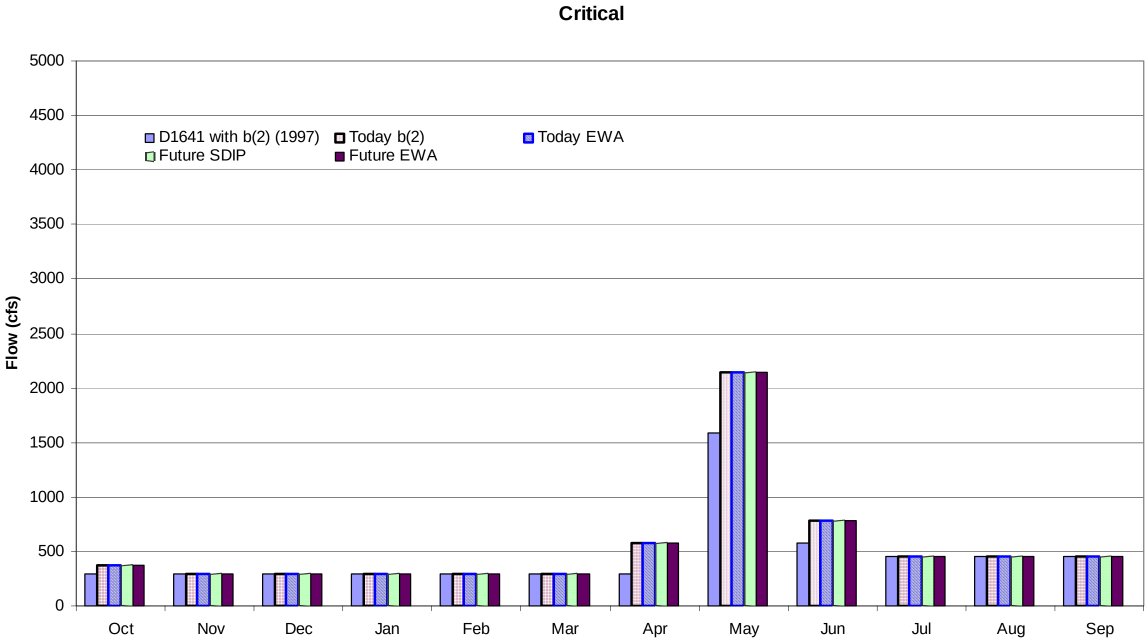


Figure 9-9 Average critical year (40-30-30 Classification) monthly releases to the Trinity

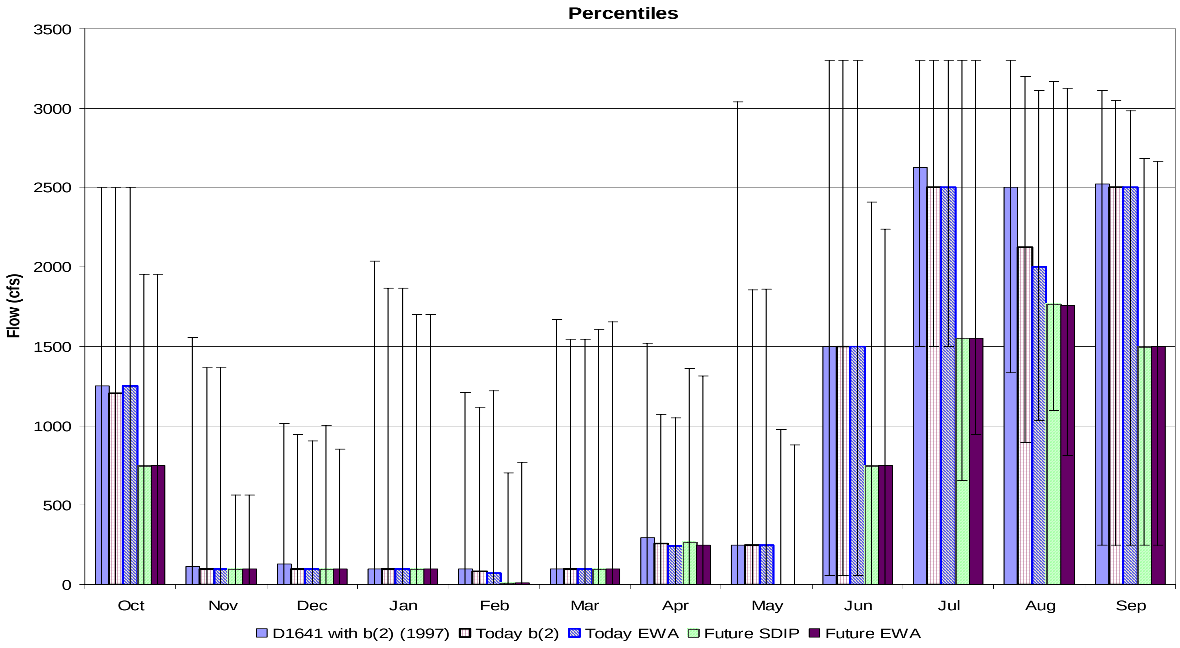


Figure 9-10 Clear Creek Tunnel 50th Percentile Monthly Releases with the 5th and 95th as the bars

Effects to Coho salmon in Trinity River

Adult Migration, Spawning, and Incubation

Flows in the Trinity River would be on more of a prescriptive schedule than in the Central Valley Rivers (Table 9–3).

Table 9–3 Trinity River releases (monthly average) at Lewiston Dam under current and future operations. Numbers in parentheses are frequency of occurrence. Ramping is figured into monthly averages. The hydrologic modeling period is less than 100 years so not all months add up to 100 percent due to rounding.

	Current, cfs	Future, cfs	Note
January	300	300	>300 (10%)
February	300	300	>300 (11%)
March	300	300	>300 (8%)
April	540 (83%)	427 (7%), 460 (27%), 493 (20%), 540 (26%)	>600 (17%)
May	1,498 (11%), 2,924 (89%)	1,498 (11%), 2,924 (26%), 4,189 (20%), 4,570 (11%), 4,709 (27%)	

	Current, cfs	Future, cfs	Note
June	783	783 (40%), 2,120 (18%), 2,526 (26%), 4,626 (12%)	
July	450	450 (60%), 1,102 (40%)	
August	450	450	
September	450	450	
October	373	373	
November	300	300	
December	300	300	>300 (10%)

Adult coho typically enter the Klamath River and the mouth of the Trinity starting in September with peak upstream migration occurring in October and November. Flows during this time would be a minimum of 300 cfs in all year types and would not change between the current operations and future operations scenarios. Flows are increased from 300 cfs to 373 cfs in October since 1997. This flow would provide adequate in stream conditions for the upstream migration of coho salmon. Water temperatures early in the upstream migratory period, in September, would often be above preferred ranges near the mouth of the Trinity, but dam operations cannot efficiently control water temperature at the mouth, 110 miles below Lewiston Dam. Releases would always be 450 cfs in September. Temperatures were modeled down to Douglas City. This is the reach where Trinity operations have the greatest temperature effect. Temperatures in September would be below 60° F at Douglas City in September of about 90 percent of years and suitable for holding adult coho. During a few dry years temperatures could exceed 60° F in September, potentially delaying upstream migration and leaving adults in warmer Lower Klamath and Trinity River reaches. Temperatures under future operations are increased by about 1° F in September, with or without EWA. Between October and May mean monthly temperatures at Douglas City would always be maintained at or below 60° F. During November when spawning initiates, average monthly temperatures would be almost always below 50° F at Douglas City. Flows during spawning and incubation would be maintained at 300 cfs, which has been shown to provide suitable conditions for spawning and incubation of coho salmon. Most coho spawning in the main stem occurs between Lewiston Dam and Douglas City with the greatest concentration in the first few miles below the dam.

Fry, Juveniles, and Smolts

The Trinity River supports young coho salmon in the main stem year round. Most rearing occurs upstream of Douglas City. A critical period for juvenile coho rearing in the Trinity may be June through September of dry years when water temperatures are at the high end of what is considered optimal for coho rearing. Under current operations water temperatures would be above a monthly average of 60° F about 20 percent of years in June, 60 percent of years in July, and 25 percent of years in August. Conditions under the future operational scenarios would be improved during this period. Temperatures in June would rise above 60° F about 5 percent of the time and in July they would be above 60° F in 30 percent of years. August temperatures would be relatively unchanged. The temperature benefits under future operations are the result of higher releases provided in April through July. Temperatures are reduced by about 2° F on average under future operations in May, June, and July, with and without EWA.

The spring high flows under the future condition are provided to mimic the natural hydrograph during the snowmelt period. These flows should increase survival of out-migrating coho smolts. The higher flows are intended to return more natural geomorphic processes to the Trinity River (USDI 2000). These higher flows should benefit coho salmon through the long-term habitat values provided. The higher flows are designed to discourage riparian vegetation establishment down to the edge of the lower flow channel margins and to scour the bed to maintain spawning and rearing habitat (USDI 2000). Off channel habitats out of the main river flow are important for sustaining juvenile coho salmon through the winter months when water is cooler and may potentially be created by the higher flows. Flows under current operations should be adequate to sustain the in-river spawning coho salmon population at the current level. Flows in the future condition are intended to increase salmon and steelheads populations.

The net effect of future CVP operations on Coho salmon in the Trinity River should be a benefit to the population through the habitat values provided. The effect of current operations should be no change attributable to water operations.

Trinity River Chinook Salmon EFH

The increased flows in the spring for the restoration program would aid out-migrating Chinook so smolt survival should increase. The habitat benefits provided through more natural geomorphic processes should benefit Chinook salmon.

Temperatures in the Trinity during the fall Chinook spawning period will be slightly increased in the future because more water would be released early in the season. The result will be slightly higher egg mortality, mostly in critically dry years (Figure 9–11).

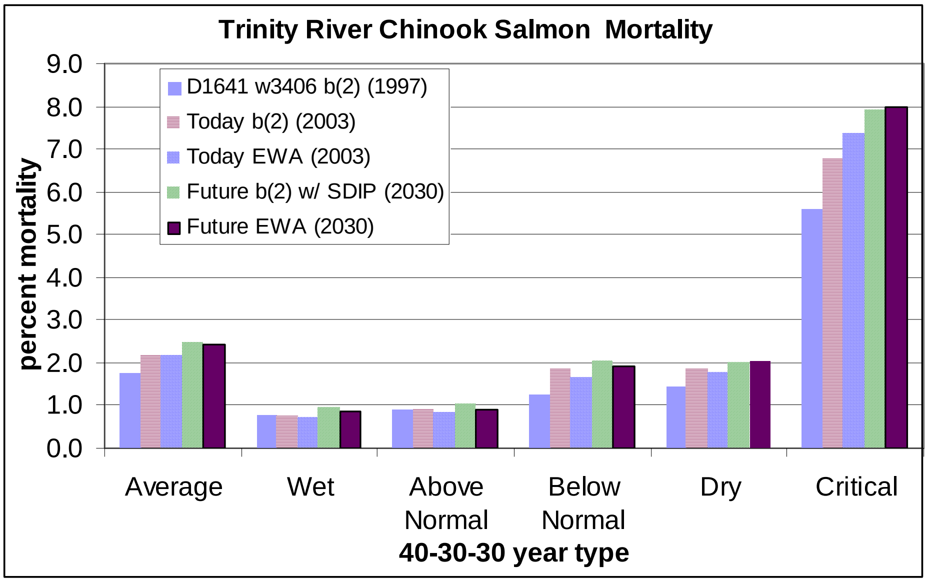


Figure 9–11 Percent mortality of Chinook salmon from egg to fry in the Trinity River based on water temperature by water year type.

Clear Creek

Modeling

Whiskeytown Reservoir tries to maintain 235,000 af End of September storage. Figure 9-12 shows that the End of September Storage for Whiskeytown dropped from 235,000 af to 180,000 af from once in Study 1 (1932) to three times in Study 2 and Study 3 (1924, 1932 and 1934) and increases to 4 times in Study 4 and Study 5 (1924, 1931, 1932 and 1934). The drawdown of storage are also illustrated in the Storage spreadsheet for the 5 study comparison in the CALSIM II Modeling Appendix. The increased frequency of drawdowns during the 1928 – 1934 drought are due to trying to maintain the same minimum flows down Clear Creek while importing as much from Clear Creek Tunnel and and causing increased dedication of inflow for releases, see Table 9-4 and Table 9-5.

Table 9-4. Long-term Average Annual Differences in Flows for Clear Creek Tunnel, Clear Creek Release and Spring Creek Tunnel

Differences (TAF)	Study 2 - Study 1	Study 3 - Study 1	Study 5 - Study 1	Study 4 - Study 2	Study 5 - Study 3
Annual Clear Creek Tunnel	-82	-80	-222	-138	-142
Annual Clear Creek Release	-2	-3	-2	-1	0
Annual Spring Creek Tunnel	-81	-78	-220	-138	-142

Table 9-5. Average Annual Differences in Flows for Clear Creek Tunnel, Clear Creek Release and Spring Creek Tunnel for the 1928 to 1934 drought period

Differences (TAF)	Study 2 - Study 1	Study 3 - Study 1	Study 5 - Study 1	Study 4 - Study 2	Study 5 - Study 3
Annual Clear Creek Tunnel	-85	-85	-139	-51	-55
Annual Clear Creek Release	-2	-5	-5	-4	0
Annual Spring Creek Tunnel	-83	-79	-132	-46	-53

Figure 9-13 shows that Clear Creek is mainly being driven by the 3406 (b)(2) releases with the 50th and 95th percentiles for each month in all 5 studies being identical. Figure 9-14 to Figure 9-19 illustrate the monthly averages by long-term average and by 40-30-30 Water Year Classification.

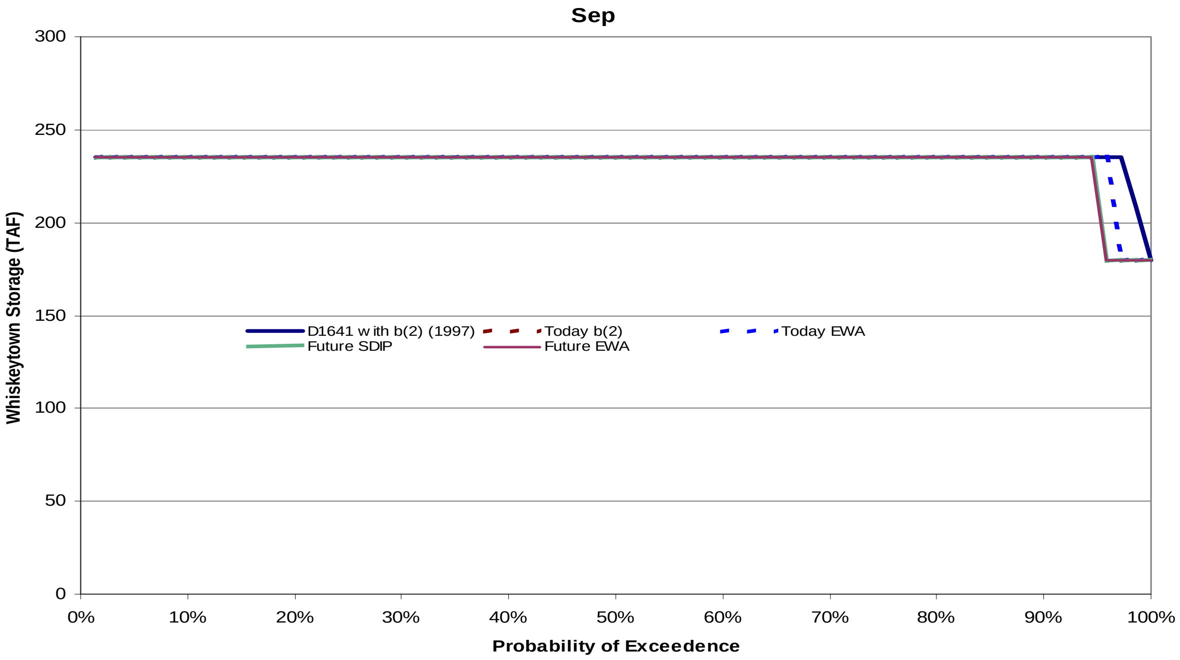


Figure 9-12. Whiskeytown Reservoir End of September Exceedance

Figure 9-13 Clear Creek Releases 50th Percentile Monthly Releases with the 5th and 95th as the bars

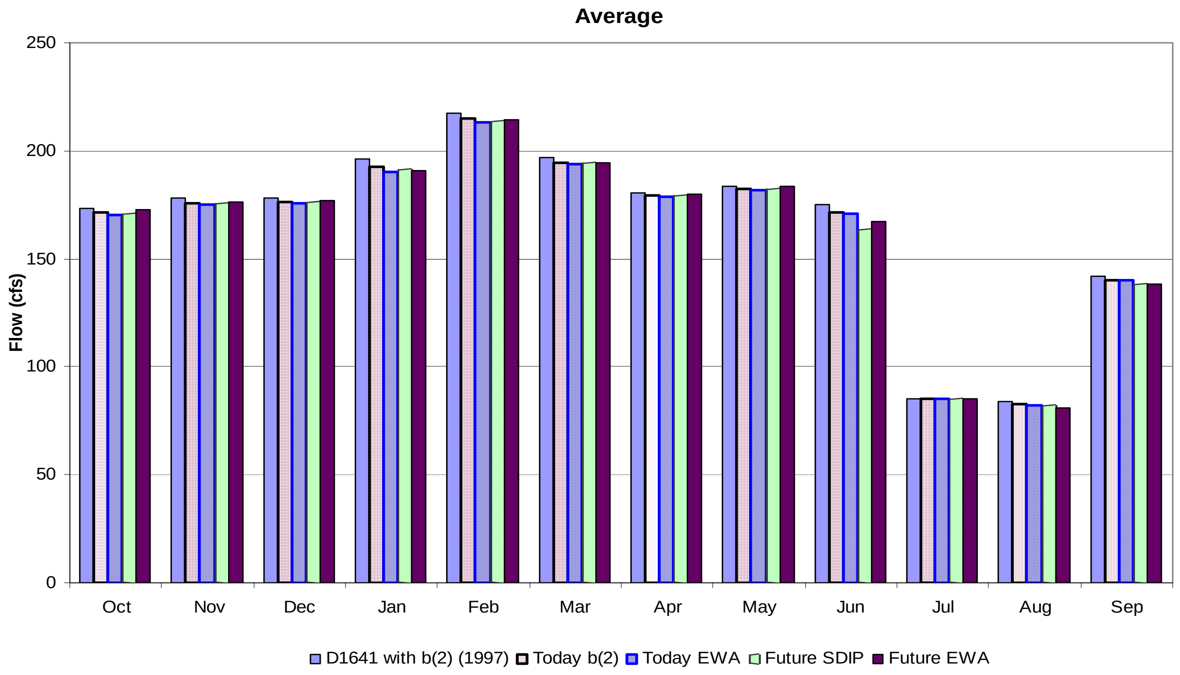


Figure 9-14 Long-term Average Monthly Releases to Clear Creek

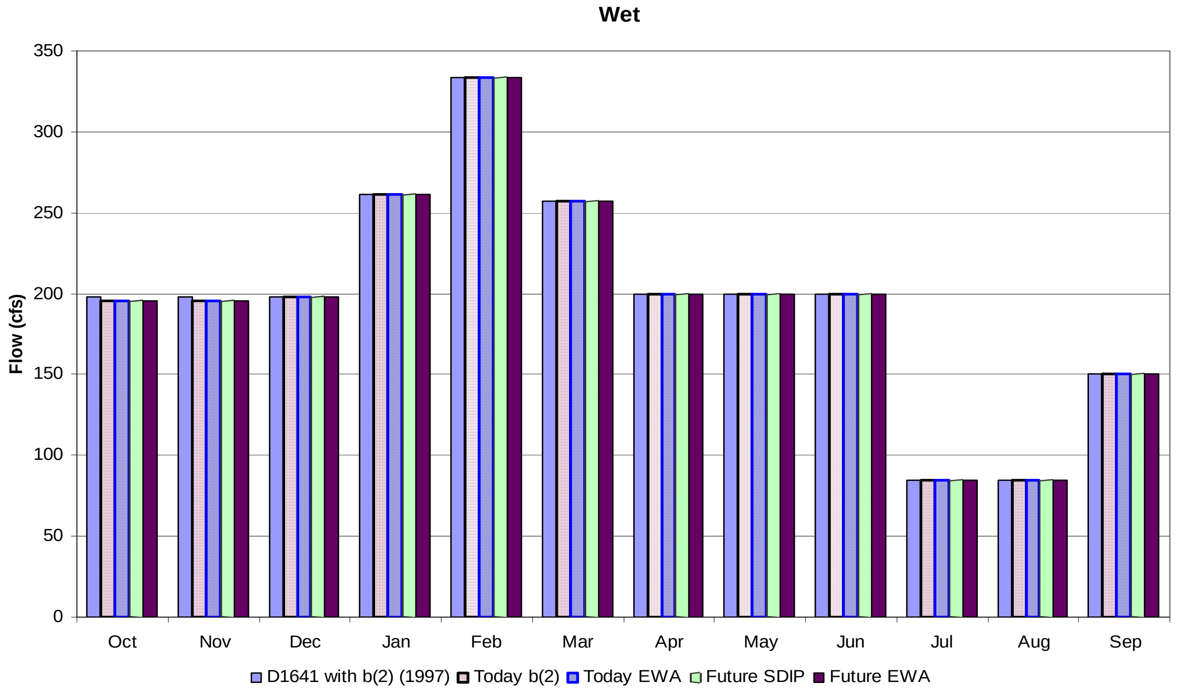


Figure 9-15 Average wet year (40-30-30 Classification) monthly releases to Clear Creek

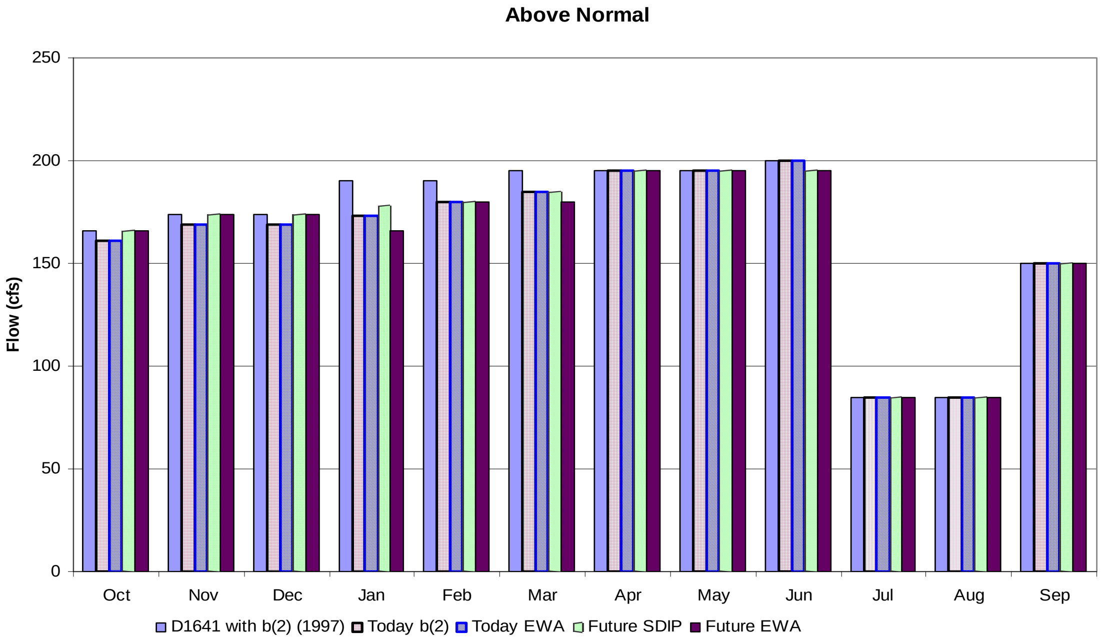


Figure 9-16 Average above normal year (40-30-30 Classification) monthly releases to Clear Creek

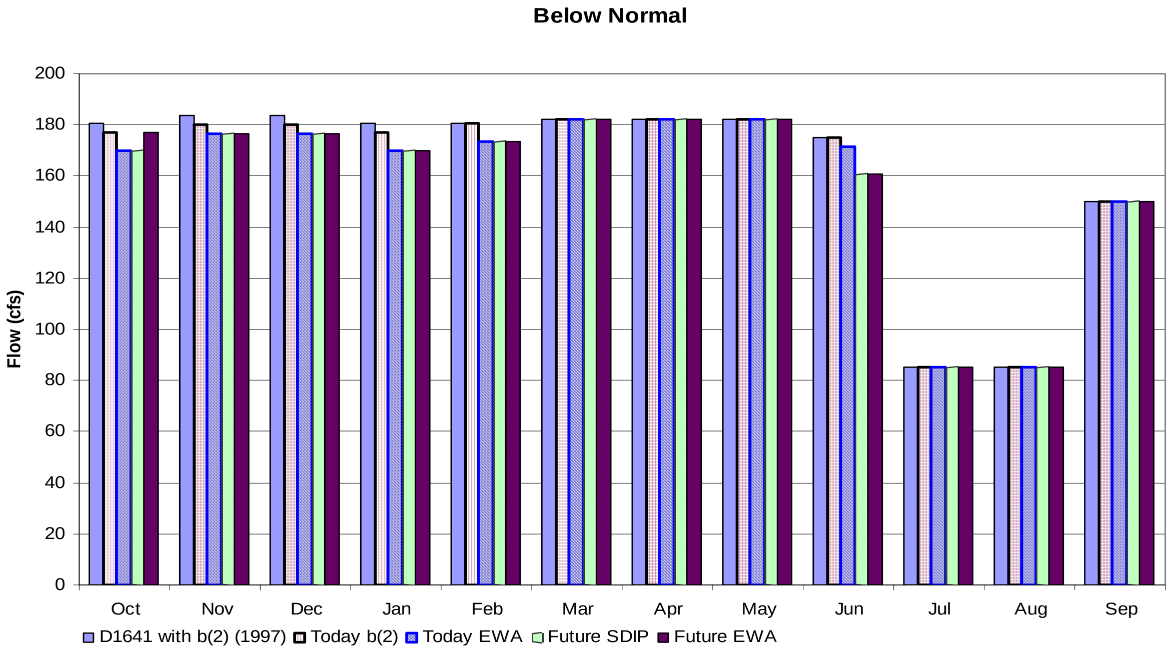


Figure 9-17 Average below normal year (40-30-30 Classification) monthly releases to Clear Creek

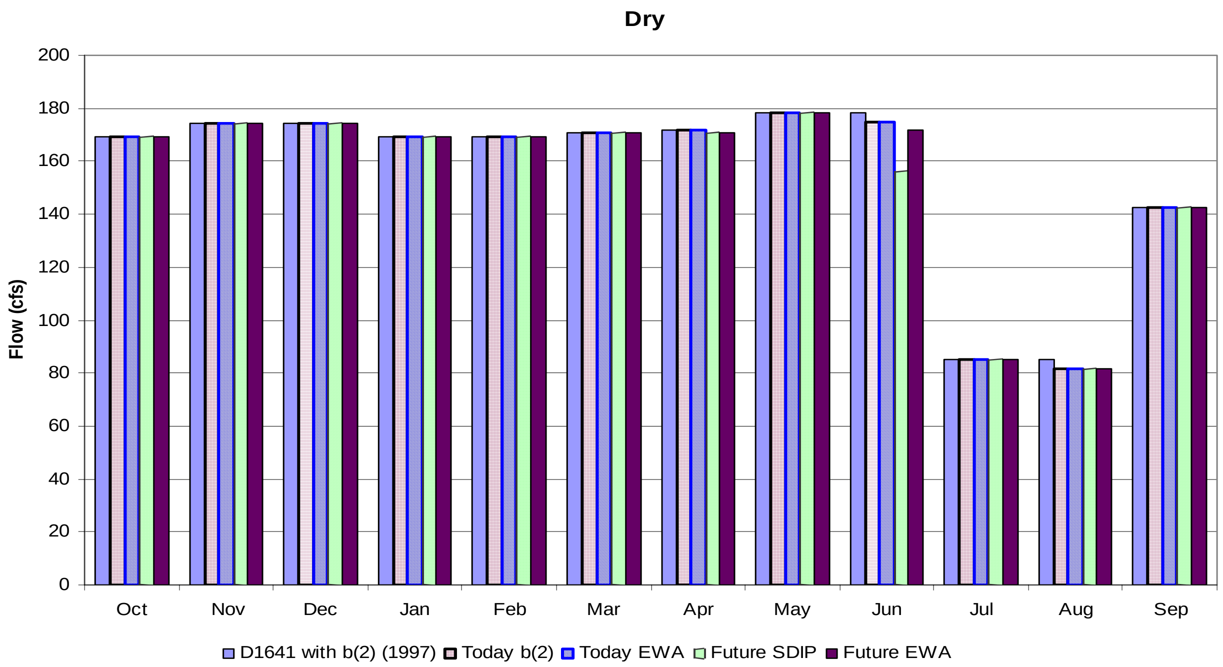


Figure 9-18 Average dry year (40-30-30 Classification) monthly releases to Clear Creek

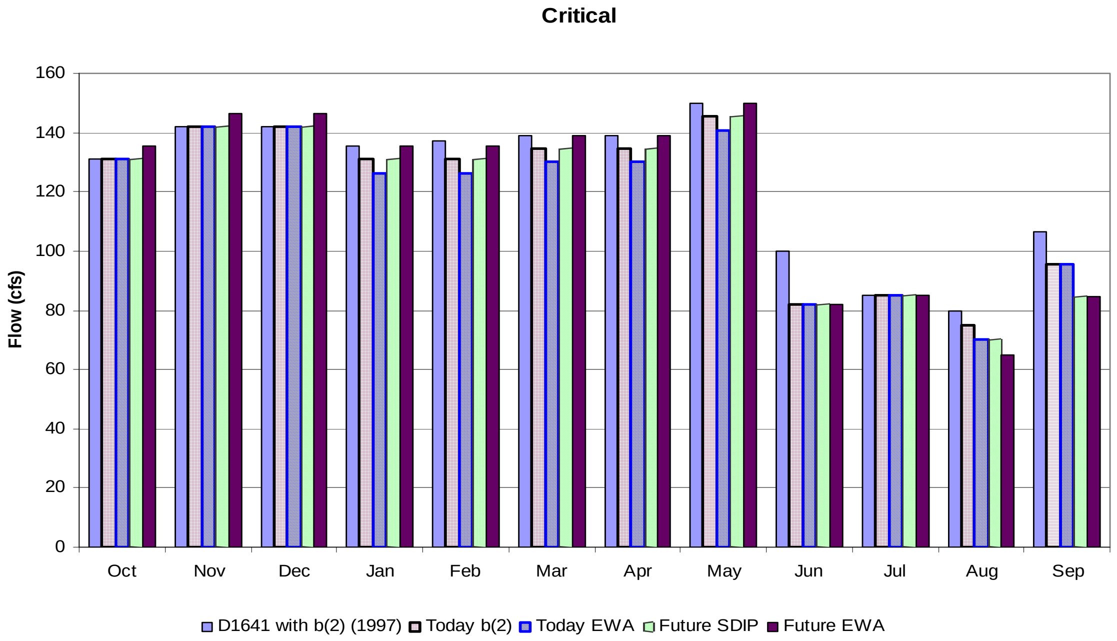


Figure 9-19 Average critical year (40-30-30 Classification) monthly releases to Clear Creek

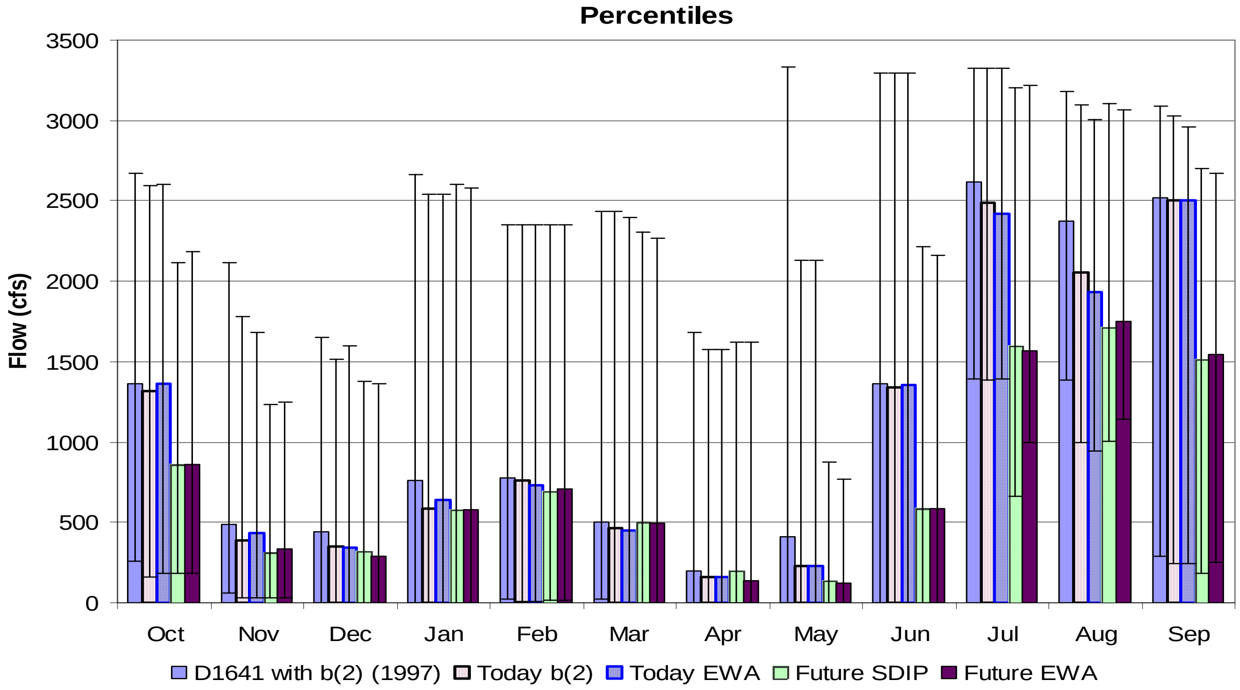


Figure 9-20 Spring Creek Tunnel 50th Percentile Monthly Releases with the 5th and 95th as the bars

Adult Migration, Spawning, and Incubation

The removal of the McCormick-Saeltzer Diversion Dam in 2000 at river mile 6.5 gave salmon and steelheads easier access to the base of Whiskeytown Dam 18 miles upstream from the Sacramento River. A natural bedrock chute just below the old Saeltzer dam site may be a low flow partial barrier to Chinook. Most steelheads adults are expected to migrate upstream in Clear Creek during December through March to spawn with spawning potentially stretching into April. Water temperatures during this period are projected to be within the preferred range for steelheads spawning and incubation between Whiskeytown Dam and Igo. Flow releases from Whiskeytown Dam into Clear Creek during upstream migration are expected to be 200 cfs in about 70 percent of the years during steelheads upstream migration in all scenarios. During the drier years releases are expected to be lower, as low as 30 cfs in the driest years in all scenarios. Optimal spawning flows were estimated to be 87 cfs upstream of the old Saeltzer dam site and 250 cfs below the old dam site (Denton 1986). Nearly all steelheads/rainbow spawning documented in redd surveys occurs close to Whiskeytown Dam (Jess Newton, personal communication, April 2003). During most years flows should be suitable for spawning in upstream areas but during dry years flows for attraction, holding, and upstream migration could be less than optimal. Tributary inflows downstream of Whiskeytown Dam provide some variation in the lower river hydrograph for increased attraction and migratory flows during rainfall events.

Spring–run Chinook salmon enter Clear Creek from April through September and spawn during August and September. Flow releases would be 200 cfs over 70 percent of the time in April, May, and June. Flows in July would always be 85 cfs and in August almost always 85 cfs except during the driest years when they could drop to 30 cfs. September flows would be 150 cfs except during the driest 10 percent of years when they would be 30 cfs. These flows should provide adequate habitat for Chinook salmon upstream of the former Saeltzer Dam site. During the driest years the 30 cfs flows would not accommodate a large number of spawners so depending on run size more competition for spawning sites may occur. Spring–run may benefit from a spawning attraction release during the late spring period to assist in upstream migration and passage through the bedrock chute area. This may be provided by CVPIA section (b)(2) water. Flows during dry years could be as low as 30 cfs. These flows would likely be too low for spring–run to migrate upstream. Chinook would not likely make it past the bedrock chute area at this flow. The area of Clear Creek upstream of the Clear Creek road bridge to Whiskeytown Dam is considered to be spring–run habitat (Jim DeStaso, personal communication). Denton (1986) estimated optimal flows for salmon in this reach would be 62 cfs for spawning and 75 cfs for rearing based on the IFIM study, provided suitable incubation and rearing temperatures were provided. Spring–run begin spawning in Clear Creek in September. The flows of 30 cfs in dry years would be below the optimum flow for Chinook spawning. Unless the spring–run population increases above present levels, spawning habitat availability should not be limiting, as long as the fish are able to migrate to the habitat at the lower flow levels. Water temperatures at Igo sometimes exceed optimal spawning and incubation temperatures of <56° F. Most spring–run would likely spawn upstream closer to Whiskeytown Dam where optimal spawning and incubation temperatures can be provided year round. NOAA Fisheries (2003) states that the Denton (1986) flow recommendations are not applicable and that there are no applicable studies completed that can be used to describe the effect of operations on rearing, emigration, and spawning. Therefore use of the Denton (1986) recommendations may be somewhat subjective but in the absence of other on-the-ground recommendations we used Denton (1986).

High flow events during the incubation period have the potential to scour redds and injure pre-emergent fry. High flow events in excess of 1,000 cfs often occur during heavy rain in the winter and spring (Figure 11−7). High flow events of approximately 3,000 cfs or greater, which occur infrequently, are needed to wash the artificially deposited gravel downstream (Table 9–9). Whiskeytown Reservoir releases remain constant during all but the heaviest runoff periods when the reservoir overflows through the glory hole outlet. High flow events in Clear Creek are now smaller than those that occurred prior to flow regulation in the system. Clear Creek fishery studies found that spawning gravel in Clear Creek could be improved by adding spawning gravel below Whiskeytown Dam and allowing high flows to deposit it in downstream spawning areas. High flow events of approximately 3,000 cfs or greater, which occur infrequently, are needed to wash the artificially deposited gravel downstream(Table 9–9).

Steelheads fry are expected to emerge from redds from approximately mid-February through May. Release temperatures from Whiskeytown Dam are modeled to remain at optimal levels throughout this period. Most fry will likely remain in upstream areas near where they were spawned, at least through the early rearing period until early summer. Spring–run Chinook fry emerge from redds between December and February, depending on water temperature where they are spawned. Water temperatures during this period are optimal for survival of fry.

Fall–run Chinook salmon are expected to enter the river starting in August and continuing through October, with spawning occurring in November and December. Higher than preferred temperatures during August of some years could potentially delay entry of adults into the river because Sacramento River temperatures will be a few degrees cooler. Temperatures during the spawning period should be suitable for incubation of fall–run Chinook salmon.

Fry, Juveniles, and Smolts

The freshwater life stages of steelheads and Chinook salmon could occupy Clear Creek throughout the year. Mean monthly temperatures of Whiskeytown Reservoir releases are modeled to be in the preferred range for growth and development of steelheads (45° F to 60° F) and of Chinook salmon (50° F to 60° F) throughout the year under all hydrologic conditions. Whiskeytown releases would be about 1° F cooler under both future scenarios in July through September and up to 1° F warmer in October and November. Other months would be essentially unchanged. Average monthly temperatures downstream below Igo will rise above 60° F in August in about 5 percent of years in the future vs. 4 percent of years under current operations. The average monthly temperatures are always within the range that the species have been shown to survive and grow well with adequate food supplies (Myrick and Cech 2001). Based on observations of juvenile salmonids and their prey in streams further north, food availability does not appear to be a limiting factor to salmon or steelheads in the upstream rearing areas of any of the affected Central Valley streams.

Optimal rearing and emigration flows have not been estimated for Clear Creek. We expect that the modeled flows will be suitable for the rearing, smoltification, and emigration of steelheads and Chinook salmon during most years. During the driest years flows during summer and fall could be limiting for steelheads rearing and for spring–run Chinook that hold over in Clear Creek through the summer. During dry years, a source of somewhat higher flows for out migration could be provided by brief tributary inflows during rainfall events, but these would be dependent on the weather.

There would be little difference in flows between current and future operations under all scenarios. No change in effect on fish is anticipated. Water temperature below Igo would be about 1° F cooler in August and September and 1° F warmer in October and November under future operations. The result should be slightly improved conditions for spring–run and steelheads during late summer. The warmer October and November temperatures would primarily affect fall–run spawning and spring–run incubation but are within the preferred temperature ranges of the species.

Stranding of fry and juvenile steelheads and Chinook salmon could occur following high flow events if river stages drop rapidly and isolate fish in stream margins that are not connected to the main channel. Whiskeytown Reservoir releases typically remain constant under the majority of flood events. If uncontrolled spills do occur, they are made through the “glory hole” at Whiskeytown Reservoir. The reservoir attenuates flood flows by spreading stage changes over the entire surface area and the glory hole naturally dampens the change in rate of flow along with the changes in reservoir water surface elevation. Rapid decreases in river stage following high flow events are typically the result of unimpaired flows from local and tributary inflows downstream from Whiskeytown Reservoir. Flow changes under proposed operations are less than those that occurred prior to flow regulation.

Sacramento River

Modeling

The largest impact to Shasta reservoir operations is reduction of Trinity Imports from Spring Creek Tunnel in the summer months (Table 9-6). The reduction in imports is more damaging to storage and cold water pool during the long-term droughts as the reservoir is not allowed to fill and the pool diminishes each consecutive year (see for averages during the 1928 – 1934; see Figure 9-21 and Figure 9-22 for traces of the 1928 - 1934 and 1986 - 1992 droughts, respectively).

Table 9-6. Long-term Average Annual and End of September Storage Differences for Shasta Storage, Spring Creek Tunnel Flow, and Keswick Release

Differences (TAF)	Study 2 - Study 1	Study 3 - Study 1	Study 5 - Study 1	Study 4 - Study 2	Study 5 - Study 3
Annual Spring Creek Import	-81	-78	-220	-138	-142
Shasta EOS	-43	-46	-177	-131	-130
Annual Keswick Release	-79	-77	-217	-136	-141

Table 9-7. Average Annual and End of September Storage Differences for Shasta Storage, Spring Creek Tunnel Flow, and Keswick Release for the 1928 to 1934 drought period

Differences (TAF)	Study 2 - Study 1	Study 3 - Study 1	Study 5 - Study 1	Study 4 - Study 2	Study 5 - Study 3
Annual Spring Creek Import	-83	-79	-132	-46	-53
Shasta EOS	-119	-124	-254	-104	-129
Annual Keswick Release	-72	-64	-88	-16	-24

Figure 9-24 shows the End of September exceedance for Shasta storage, the 1.9 Million af requirement in the Winter Run B.O (1993) is more frequently violated as the imports from the Trinity are reduced from Study 1 to Studies 2 and 3 and from Studies 2 and 3 to Studies 4 and 5. Figure 9-25 shows the monthly percentiles flows for releases from Keswick Reservoir. Figure 9-26 to Figure 9-31 show the monthly average flows by long-term average and by 40-30-30 Index water year classification. The percentile and average charts indicate that as the imports from Trinity decrease the monthly flow also decrease. The simulated decreases in monthly flow releases are affected by the interpolation of required flow release versus storage and actual operations might include the same monthly flow and would lead to a further decrease in Shasta storage.

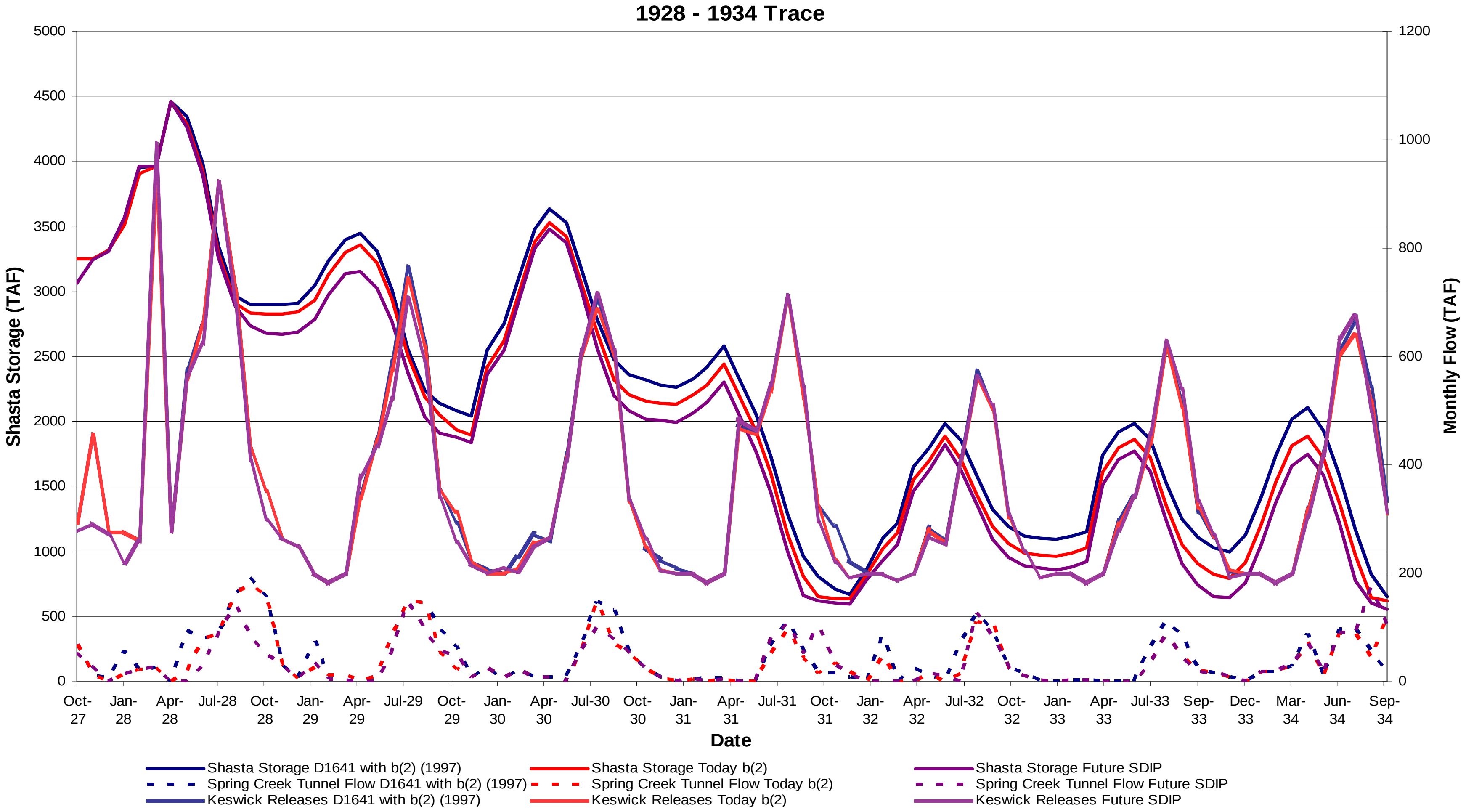


Figure 9-21. Oct-1927 to Sep-1934 Trace of Shasta Storage, Spring Creek Tunnel Flow, and Keswick Release for Studies 1, 2 and 4

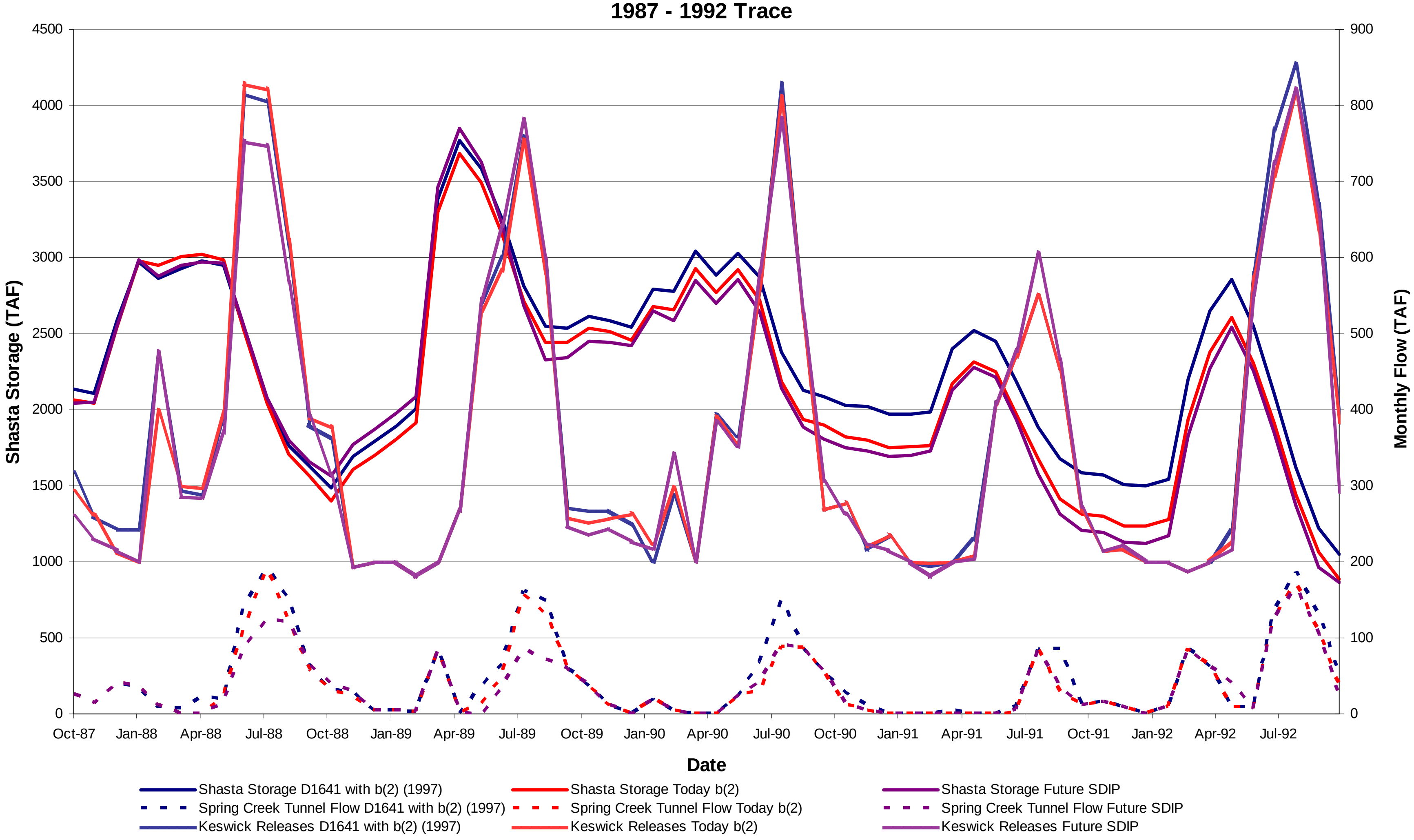


Figure 9-22. Oct-1987 to Sep-1992 Trace of Shasta Storage, Spring Creek Tunnel Flow, and Keswick Release for Studies 1, 2 and 4

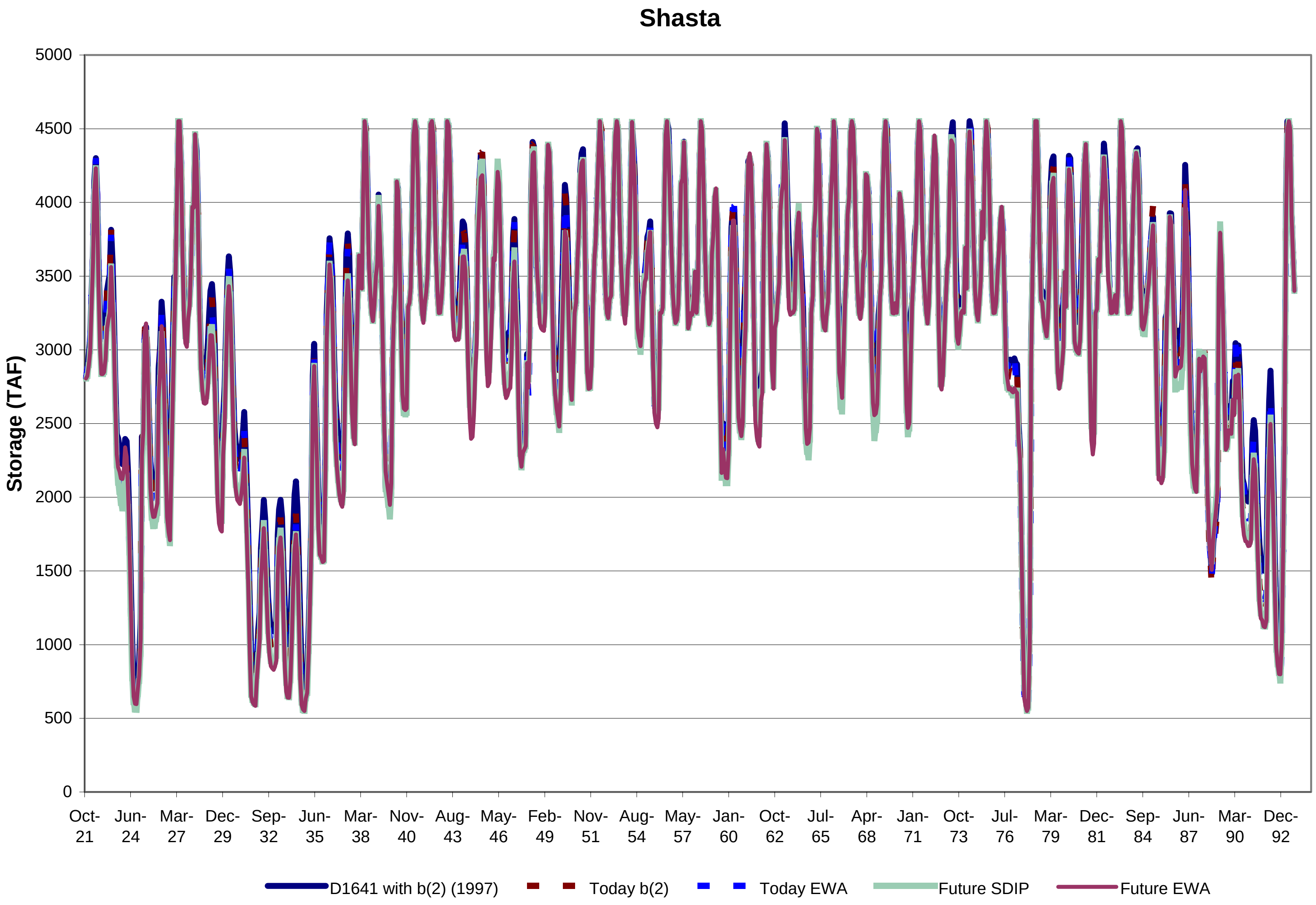


Figure 9-23. Chronology of Shasta Storage Water Year 1922 - 1993

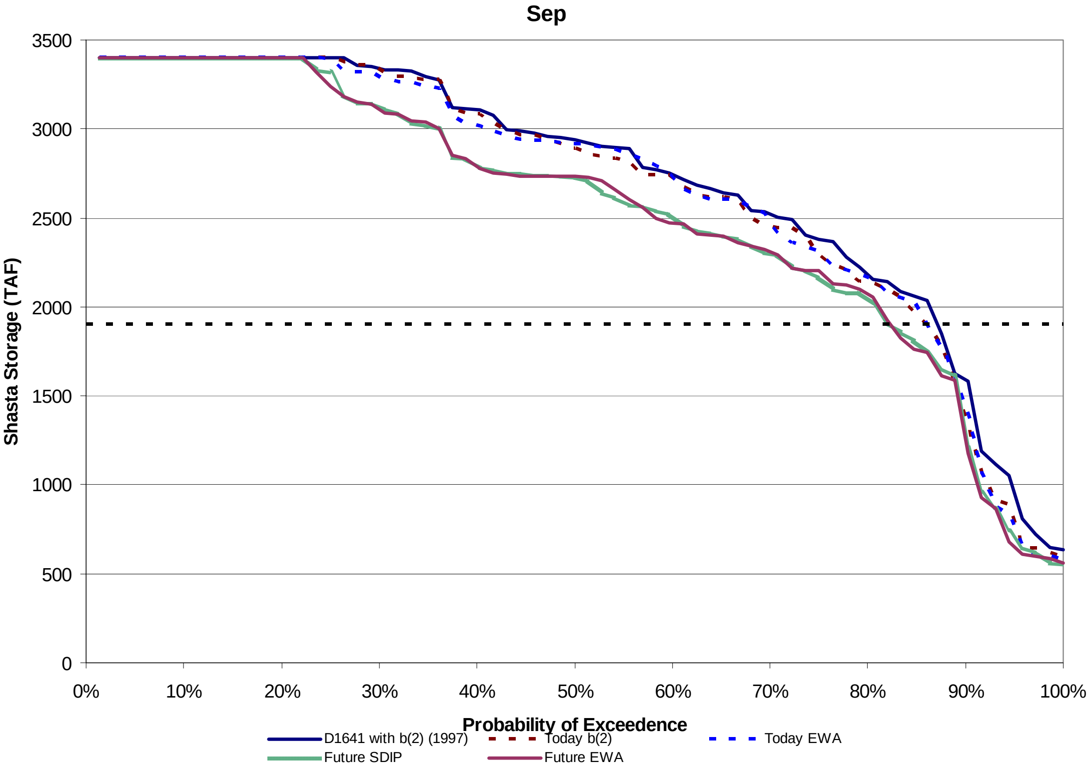


Figure 9-24 Shasta Reservoir End of September Exceedance

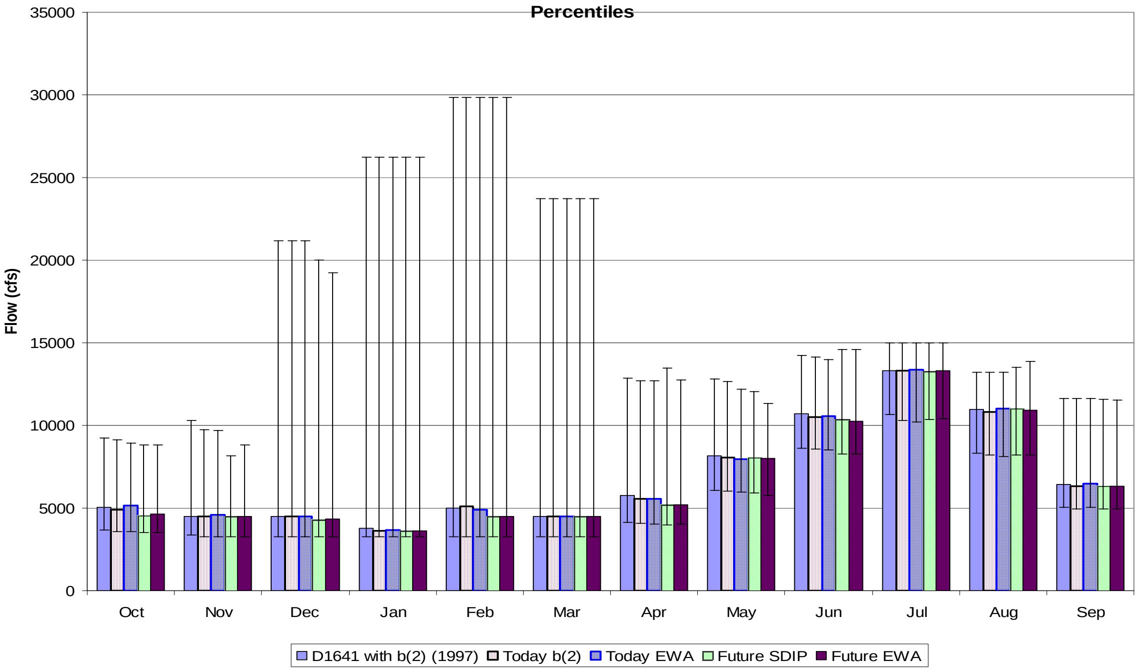


Figure 9-25 Keswick 50th Percentile Monthly Releases with the 5th and 95th as the bars

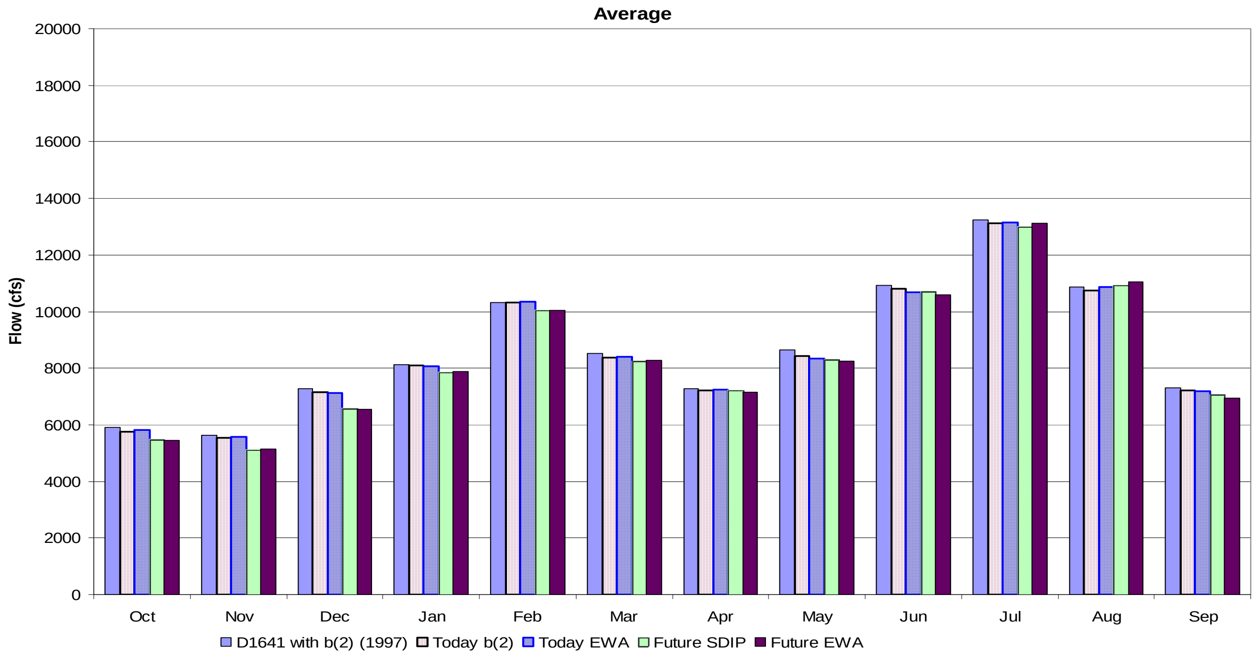


Figure 9-26 Average Monthly Releases from Keswick

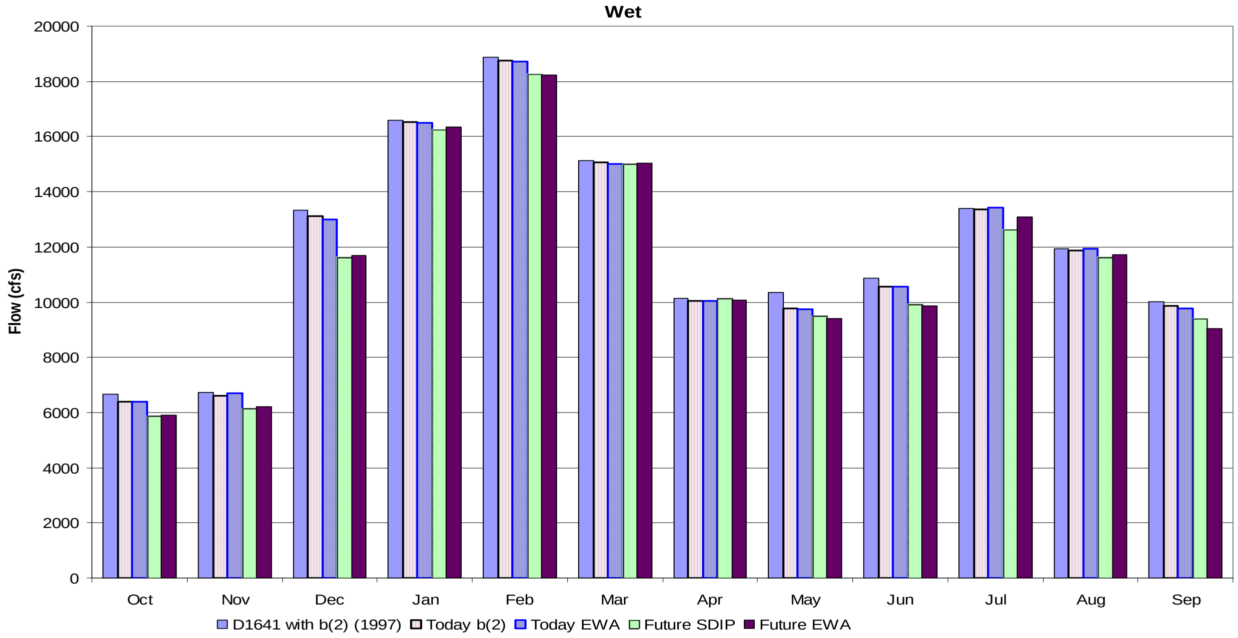


Figure 9-27 Average wet year (40-30-30 Classification) monthly releases from Keswick

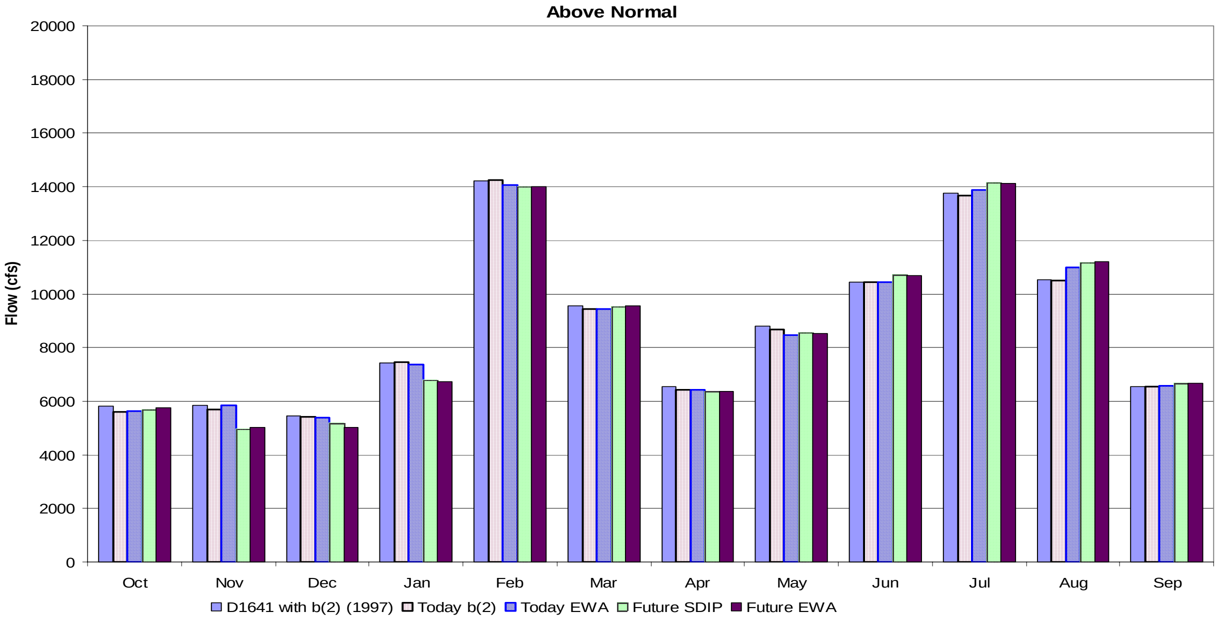


Figure 9-28 Average above normal year (40-30-30 Classification) monthly releases from Keswick

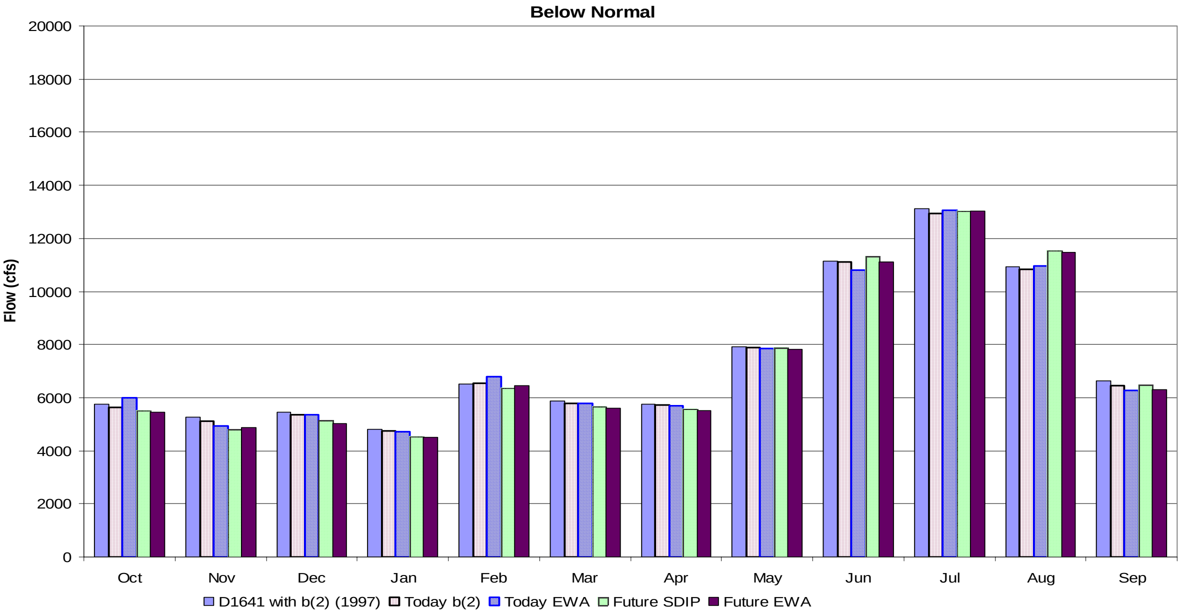


Figure 9-29 Average below normal year (40-30-30 Classification) monthly releases from Keswick

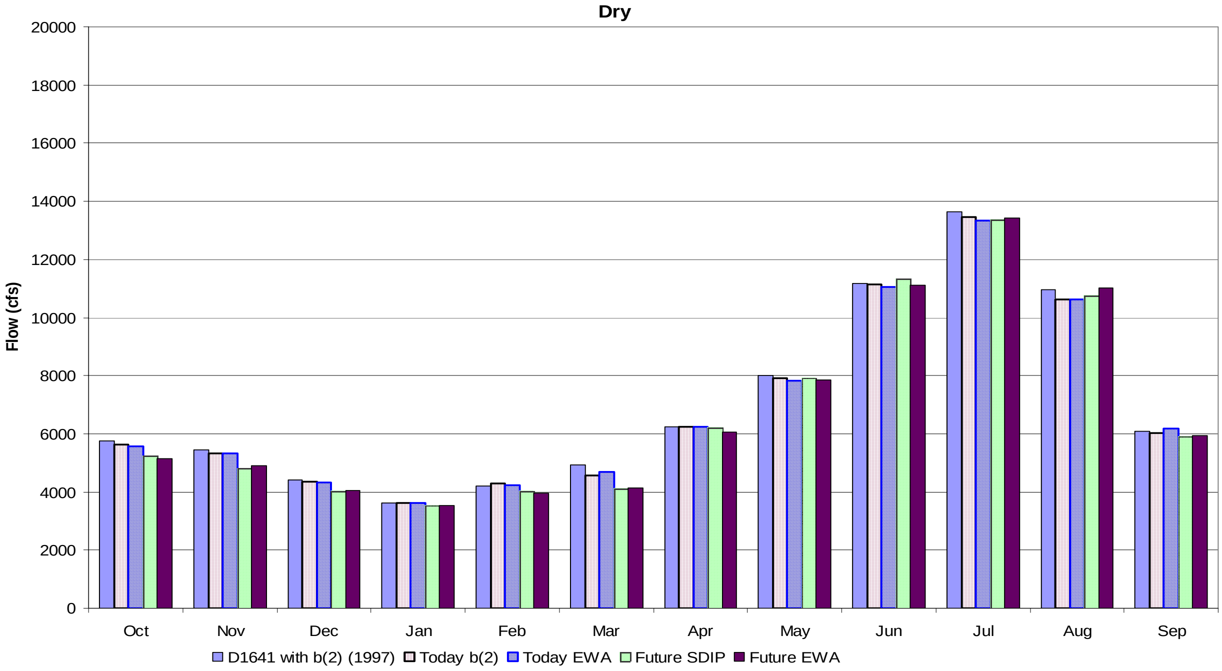


Figure 9-30 Average dry year (40-30-30 Classification) monthly releases from Keswick

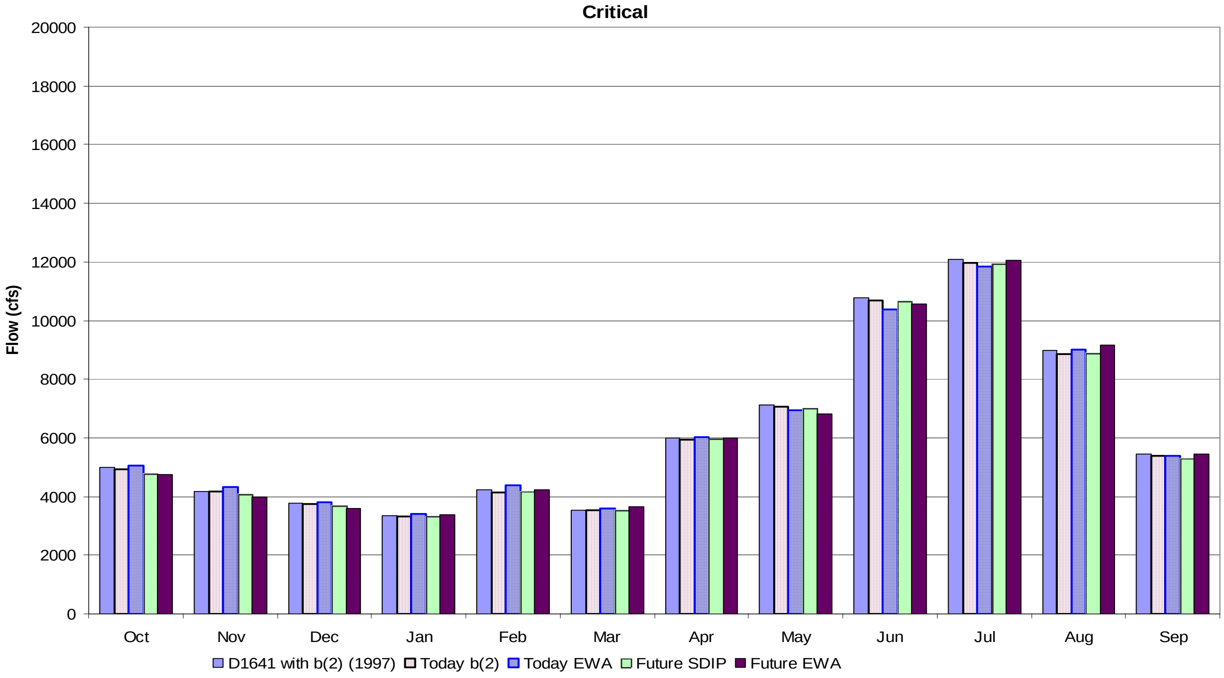


Figure 9-31 Average critical year (40-30-30 Classification) monthly releases from Keswick

Adult Migration, Spawning, and Incubation

Adult steelheads are expected to migrate upstream past Red Bluff primarily from August through December and spawn in the Sacramento River from December through April with peak activity occurring from January through March (McEwan 2001). During the upstream migration time period flows are high during August as water deliveries are being made. Flows get gradually lower as water deliveries tail off and weather cools so less water is needed for temperature control. Flows are expected to affect upstream migrating steelheads only to the extent that they affect water temperatures. The minimum Keswick release is 3,250 cfs. Steelheads spawning wetted usable area peaks at 3,250 cfs in the upper river reaches and peaks at about 13,000 cfs in the lower reach, forty miles further downstream, but with a low variability in availability (FWS 2003). Therefore we surmise that the 3,250 cfs flow level provides adequate physical habitat to meet the needs of all steelheads life stages in the Sacramento River. Flows during the summer greatly exceed this amount to meet temperature requirements for winter–run. The winter–run temperature objectives during the summer and run of the river temperatures the rest of the year result in water temperatures suitable for year-round rearing of steelheads in the upper Sacramento River.

Winter–run–run Chinook migrate upstream during January through June. Spring–run migrate from March into October, although the run is nearly complete by the end of June. Fall–run and late fall–run are migrating through the rest of the year so that Chinook salmon are migrating upstream in the Sacramento River during all months of the year (Figure 12-5). Winter–run spawning peaks in May through July and spring–run spawning peaks in August and September. Redd counts in recent years showed no spawning peak in the Sacramento River during the expected spring–run spawning period until October when the redds were considered fall–run redds (DFG aerial redd count survey data). Keswick average monthly releases between January and October range from a low of 3,250 cfs during dry years in all scenarios in January – April and October to a high of 53,000 during flood control releases in the wettest years in January and February. The largest difference in flow between the current and future operations will be slightly lower releases in July, September, and October in the future. Flows during July exceed what is needed for salmon and steelheads from a physical habitat standpoint so the reduction should not negatively affect fish as long as temperatures are suitable in July. Flows at the low end of the range of projected flows (3,250 cfs) provide enough spawning area for approximately 14,000 winter–run Chinook (FWS 2003), which is roughly double the recent escapement levels. If escapement increases significantly to near recovery goals, the flow versus habitat relationships should be reassessed at the higher escapement levels. The lower flows in September and October would lower the amount of spring–run spawning habitat. Spring–run spawning habitat was not estimated but is not limiting the population because few Chinook spawn in the main stem Sacramento River during the spring–run spawning period, i.e. there is plenty of space with suitable spawning habitat for the ones that are there. During very wet years monthly flows as high as 53,000 cfs could occur during upstream migration for winter–run. During winter–run spawning, flood control peak flows above 50,000 cfs could occur and when combined with tributary inflow could potentially affect redd survival (Table 9–9). Attempts are made to spread flood control releases out whenever possible. When the high peaks occur egg to fry survival could decrease for a brood year due to redd scouring or entombment. Long-term habitat benefits from high flood control flows should include gravel recruitment from streamside sources enhancing spawning gravel, LWD recruitment, and establishment of new cottonwood seedlings. The population effects should be maintained or better egg to smolt survival rates in the future.

Most of the winter–run spawning (98 percent) in recent years with better access to upstream habitat has occurred upstream of Balls Ferry. Water temperatures during winter–run spawning can be maintained below 56° F down to Balls Ferry in about 90 percent of years in May through August and 70 percent of years in September. Temperatures in the future modeling scenarios would be slightly increased 1 – 2° F in the driest 10 percent of years with the greatest increase in September. Temperatures at Bend Bridge in about 65-80 percent of years in May through September would exceed 56° F. They would exceed 56° F about 25 percent of years in April and 40 percent of years in October. The highest water temperatures of the year would occur in August through October during dry years as the cold-water pool is depleted. During the years when 56° F cannot be maintained the cold-water pool storage in Shasta Reservoir would not be sufficient to maintain cool temperatures throughout the summer and decisions would have to be made as to how to allocate the available cool water throughout the warm weather period. Increased flows for the Trinity River restoration program in the future decrease the ability to maintain cool temperatures in the Sacramento. Effects of water temperature on egg incubation are evaluated using the water temperature mortality model. Figure 9–32 shows the average percent mortality of Chinook salmon eggs and pre-emergent fry in the Sacramento River based on water temperature while eggs are in the gravel. The model projects that water temperature related mortality would be slightly higher for all runs in the future than under current operations. The greatest change in mortality would occur in dry and critical year types and is greatest for spring–run. During dry years only about 5 percent of winter–run eggs are projected to suffer mortality but in critically dry years 45 percent would suffer mortality (Figure 9–33). The hydrological period contains eleven critically dry years, which is 15 percent of the years used in modeling. During dry years about a 20 percent of spring–run eggs could suffer mortality with 80 percent of them affected in critical years. A relatively small percentage of the total Central Valley spring–run population spawns in the main stem Sacramento River. Therefore an overall spring–run population effect from reduced egg survival in the Sacramento River is not likely, assuming spring–run in the main stem are not genetically distinct from those in the tributaries.

Table 9–8 shows that Reclamation has reconsulted on winter-run and recommended moving the temperature compliance point nearly every year since the NOAA Fisheries B.O. was issued in 1993.

Table 9–8 Winter-Run B.O. Temperature Violations and Reinitiation Letters

				Reclamation letters		
Water Year	Water Year Starting Shasta Storage (TAF)	End of April Shasta Storage (TAF)	40-30-30 Index	Date	Action	Compliance
1993	1683	4263	AN			
1994	3102	3534	C			
1995	2102	4165	W	7/13/1995	Conserve cold water	Jelly's Ferry
1996	3136	4308	W	5/17/1996	Exceed 56 °F 4/26	Bend Bridge

				Reclamation letters		
				7/12/1996	Exceed 56 °F 5/27	
				7/18/1996	Conserve cold water	Jelly's Ferry
				8/28/1996	Conserve cold water	Ball's Ferry
				9/23/1996	Transition to stable min flow for fall-run salmon by Oct 15	Clear Creek
1997*	3089	3937	W	7/30/1997	Exceed 56 °F at Bend 4 days	
				8/8/1997	Conserve cold water	Jelly's Ferry
1998	2308	4061	W	6/25/1998	Exceed 56 °F at Bend 4 days	
				9/18/1998	Temp exceed 56 since Sep 12	Jelly's Ferry
1999	3441	4256	W	8/19/1999	Exceed 56 °F at Bend 4 days	
2000	3327	4153	AN	6/2/2000	Exceed 56 °F at Bend 3 days	
				7/14/2000	Conserve cold water	Jelly's Ferry
				8/29/2000	Conserve cold water	Ball's Ferry
				10/16/2000	Exceed 56 °F at Balls 3 days	
2001	2985	4020	D	7/17/2001	Exceed 56.5 °F at Jelly's 2 days	
				1/10/2002	Exceed 56 °F at Jelly's 8/28/2001 to 9/1/2001 and 9/152001 to 9/30/2001	
2002	2200	4297	D	6/5/2002	Exceed 56 °F at Jelly's 5/18/2003	

				Reclamation letters		
2003	2558	4537	AN	6/18/2003	Exceed 56 °F at Bend 5/14/2003	
				8/28/2003	Conserve cold water	Ball's Ferry
* 1997 was the first year that the TCD was used						

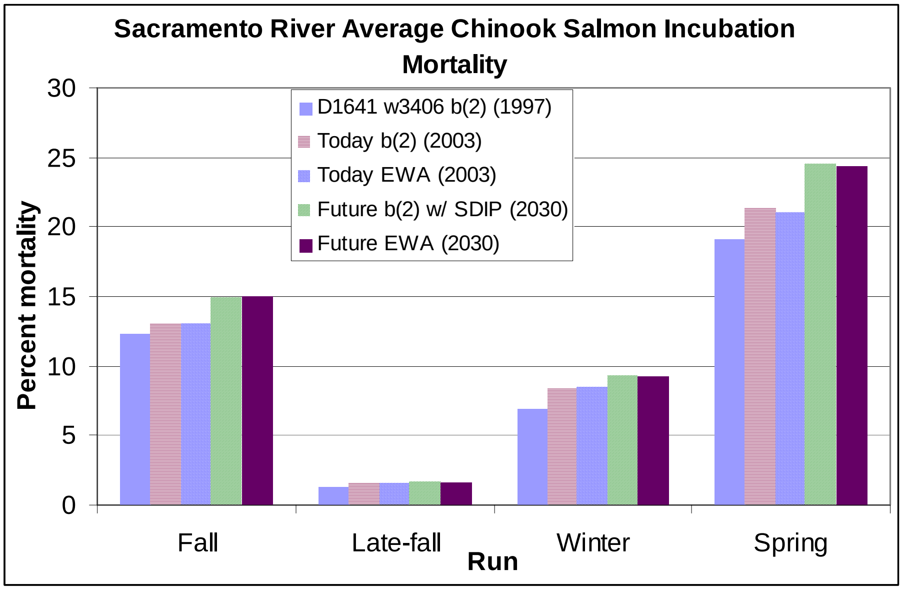
The spawning distribution used in the temperature model for winter–run and spring–run was updated following 2003 redd surveys based on 2001 through 2003 spawning data to reflect the shift in distribution since the ACID fish ladder was installed. Fall and late-fall distribution was not updated because the diversion dam has always been removed during their spawning migrations. Table 9–10 shows the Chinook spawning distribution used in the model.

A second temperature modeling run was conducted targeting 56° F at Bend Bridge (16 miles downstream of Balls Ferry) and Jellys Ferry (1993 winter run BO). This run met 56° F at Balls Ferry most of the time in May and June, about 90 percent of the time in July and August, 45 percent (current) and 30 percent (future) of the time in September, 50 percent (current) and 30 percent (future) in October, and 90 percent of the time in November. Downstream at Bend Bridge 56° F was met about 80 percent of the time in May, 75 percent of the time in June, 65 percent in July, 25 percent of the time in August, 15-20 percent of the time in September, and 20 – 35 percent of the time in October. Temperature at Bend would exceed 65° F about 10 percent of years in August and September. Temperatures at Red Bluff would exceed 65° F about 12 percent of years in August and September. The main difference in the temperature runs is that the cold-water pool runs low sooner in the summer with the Bend Bridge target. More cold-water is used to dilute warmer tributary flows from Battle Creek and Cottonwood Creek early in the temperature control season with the Bend Bridge/Jellys Ferry target. Changes in mortality during the incubation period are shown in Figure 9–32, Figure 9–33, and Figure 9–34. Mortality is higher using the Bend/Jellys temperature target than with the Balls Ferry target on average for all runs in all year types because the cold water is used more efficiently to extend the cold water supply out through the summer. Use of the Shasta temperature control device can be adjusted year to year by the Sacramento Temperature Group based on known storage conditions. Sacramento River at Shasta Dam release temperatures and at Bend Bridge temperatures for 1994 through 2001 are in Figures 6-1 and 6-2 and show the effect of past temperature control operations.

Stranding of some salmon and steelheads redds could occur and is analyzed in chapter 6 for each project river by comparing stage discharge relationships to typical spawning water depths and egg pocket depth. Some fall–run redds have been dewatered in the Sacramento River when flows are lowered after the rice decomposition program is completed and Shasta releases decreased in the fall (NOAA Fisheries 2003). The extent of redds dewatering and population level effects for Chinook has not been evaluated.

Table 9–9 Estimated bed mobility flows for affected Central Valley Rivers.

River and reference	Bed load movement initiated, cfs	Bed mobility flow that may scour some redds, cfs
Sacramento River (Buer 1980 and pers. comm. 2003)	25,000	40,000 – 50,000
Clear Creek (McBain&Trush and Matthews 1999)	2,600 (up to 11 mm particles)	3,000 – 4,000 coarse sediment transport (32 mm)
Feather River		
American River (Ayres Associates 2001)	30,000 – 50,000	50,000
Stanislaus River (Kondolff et al 2001)	280 cfs for gravel placed in river near Goodwin Dam	5,000 – 8,000 to move D_{50}
Trinity River (USDI 2000)	6,000 cfs to move D_{84}	11,000 cfs to scour point bars



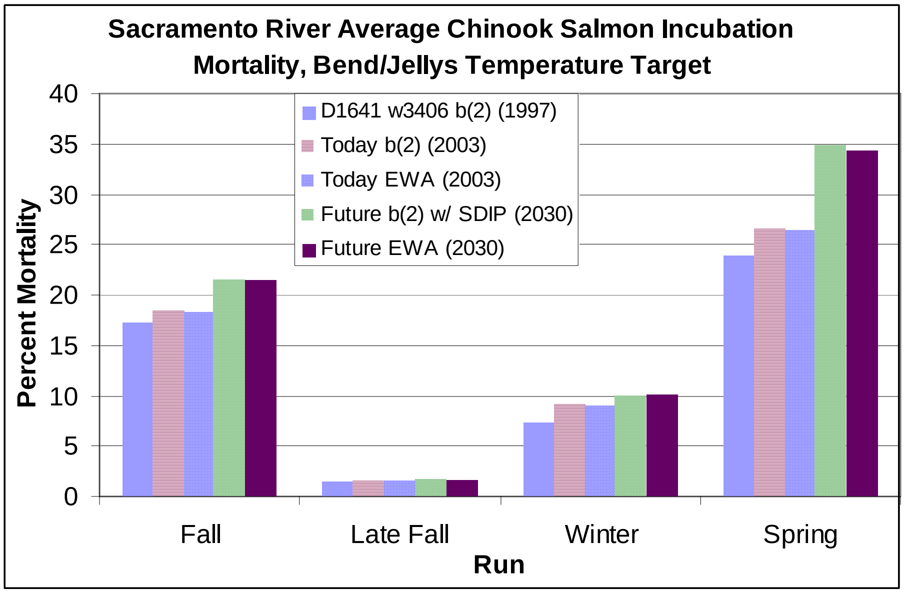
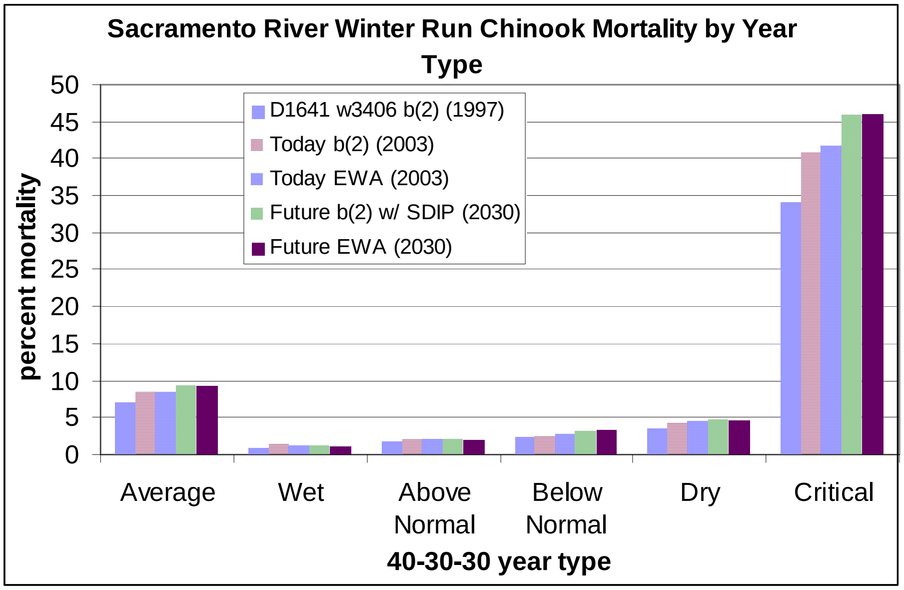


Figure 9–32 Average Chinook salmon mortality in the Sacramento River during the incubation period based on water temperature. Top chart is Balls Ferry temperature target; bottom chart is Bend Bridge/Jelly's Ferry temperature target.



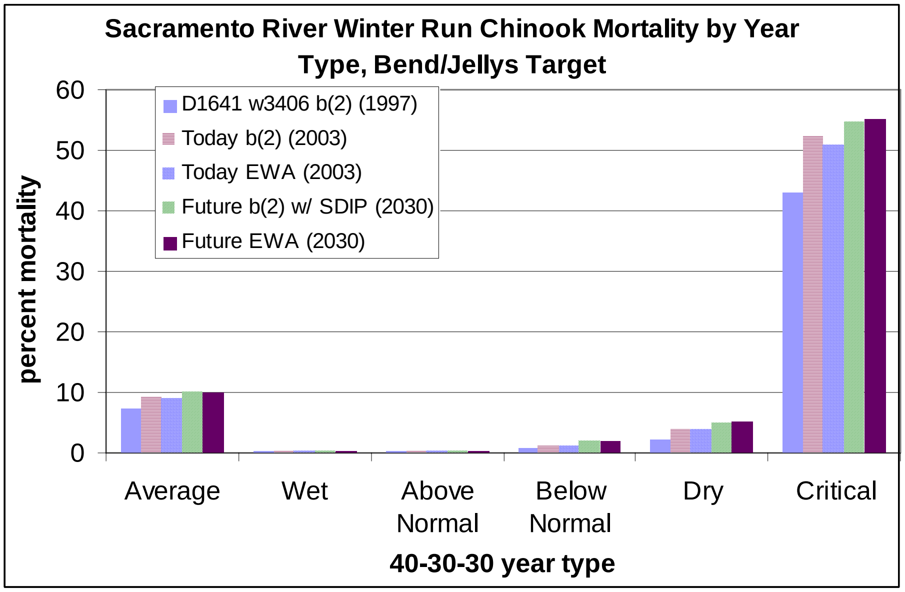
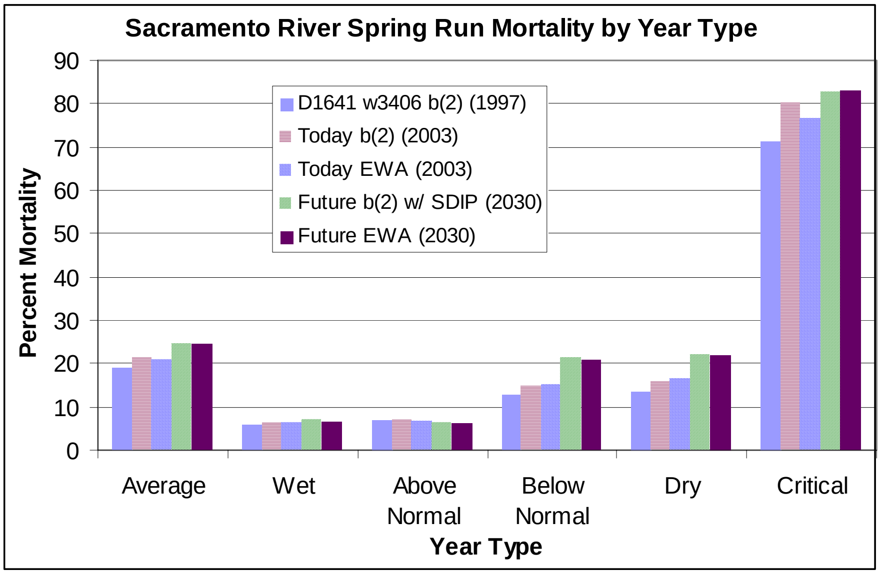


Figure 9–33 Sacramento River winter run Chinook salmon mortality due to water temperature during incubation, by year type. Top chart is Balls Ferry temperature target; bottom chart is Bend Bridge/Jelly's Ferry temperature target.



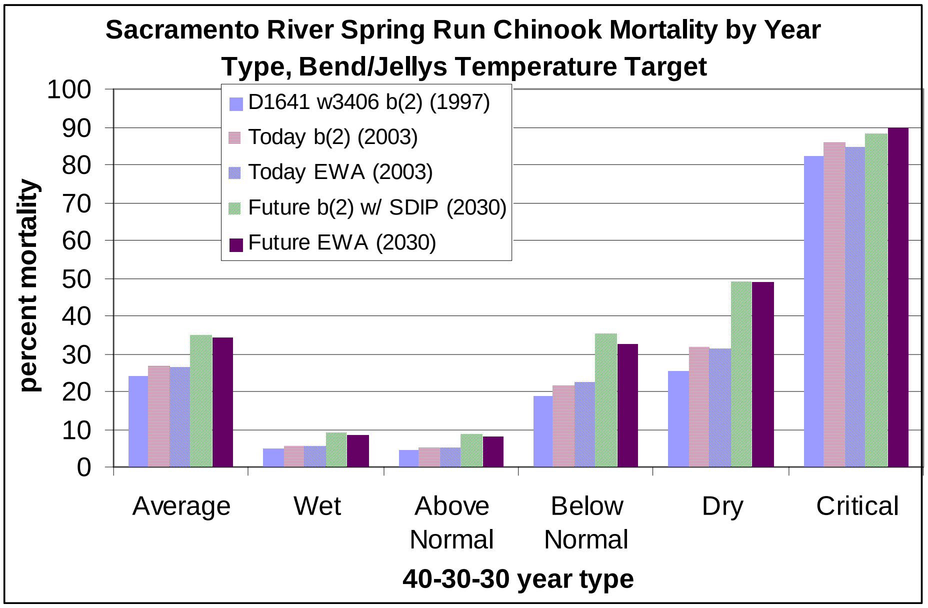


Figure 9–34 Sacramento River spring run Chinook salmon mortality due to water temperature during incubation, by year type. Top chart is Balls Ferry temperature target; bottom chart is Bend Bridge/Jelly's Ferry temperature target.

Table 9–10 Spawning distribution by reach used in the Chinook salmon temperature related egg to fry mortality models.

Sacramento River

Salmon Reach	No.	River Reach	Spawning Distribution (%) (Old winter and spring distribution in parentheses)				
			Fall	Late-Fall	Winter	Spring	Distance
UPPER	1	Keswick Dam – ACID Dam	4.26	25.5	47.1 (2.7)	5.8 (0)	3 miles
	2	ACID Dam – Hwy 44	10.54	21.7	17.3 (54.7)	16.7 (45.6)	2.5 miles
	3	Hwy 44 – Upper Anderson Bridge	13.98	21.1	32.4 (29.2)	21.2 (28.8)	13.5 miles
	4	Upper Anderson Bridge – Balls Ferry	13.05	13.9	2.3 (7.9)	22.4 (7.2)	8 miles
	5	Balls Ferry – Jelly’s Ferry	12.88	4.4	0.3 (1.5)	31.4 (8.0)	9 miles
	6	Jelly’s Ferry – Bend Bridge	6.96	1.7	0.3 (2.1)	1.9 (3.2)	9 miles
	7	Bend Bridge – Red Bluff Div Dam	1.88	1.1	0.0	0.0	15 miles
	Total – Upper Salmon Reach		**63.55**	**89.4**	**99.7 (98.1)**	**99.4 (92.8)**	**60 miles**
MIDDLE	8	Red Bluff Div Dam – Tehama Bridge	22.29	5.6	0.3 (1.6)	0.6 (6.4)	13.7 miles
	9	Tehama Bridge – Woodson Bridge	6.35	2.2	0 (0.3)	0 (0.8)	11 miles

	10	Woodson Bridge – Hamilton City	5.59	1.1	0.0	0.0	19 miles
	Total – Middle Salmon Reach		**34.23**	**8.9**	**0.3 (1.9)**	**0.6 (7.2)**	**43.7 miles**
LOWER	11	Hamilton City – Ord Ferry	1.54	1.1	0.0	0.0	15 miles
	12	Ord Ferry – Princeton	0.68	0.6	0.0	0.0	20 miles
	Total – Lower Salmon Reach		**2.22**	**1.7**	**0.0**	**0.0**	**35 miles**

Feather River

Spawning Reach	No.	River Reach	Spawning Distribution (%)
UPPER	1	Fish Dam – RM 65.0	20
	2	RM 65.0 – RM 62.0	20
	3	RM 62.0 – Upstream of After bay	20
	Total – Upper Salmon Reach		**60**
LOWER	4	Downstream of After bay – RM 55.0	10
	5	RM 55.0 – Gridley	10
	6	Gridley – RM 47.0	10
	7	RM 47.0 – Honcut Creek	10
	8	Honcut Creek – Yuba River	0
	9	Yuba River – Mouth	0
	Total – Lower Salmon Reach		**40**

American River

No.	River Reach	Spawning Distribution (%)
1	Nimbus Dam – Sunrise Blvd	31
2	Sunrise Blvd – A. Hoffman/Cordova	59
3	Ancil Hoffman/Cordova – Arden	5

4	Arden – Watt Ave	3
5	Watt Ave – Filtration Plant	1
6	Filtration Plant – H St	0
7	H St – Paradise	1
8	Paradise – 16th St	0
9	16th St – Mouth	0

Fry, Juveniles, and Smolts

The freshwater life stages of steelheads and Chinook salmon occupy the upper Sacramento River throughout the year. The minimum flow of 3,250 cfs should provide adequate rearing area and water velocities for emigration. Juveniles will benefit from tributary inflows during rainfall events when emigrating downstream from the upper river. Monitoring data along the river and in the delta shows that juveniles emigrate in greatest numbers during freshets that occur during rainfall events. Mean monthly temperatures below Keswick Reservoir and downstream at Bend Bridge are forecast to be in the preferred range for growth and development of steelheads (45° F to 60° F) and Chinook salmon (50° F to 60°F) throughout all of most years. Temperatures in about 10 percent of years could rise above 60° F at Keswick during August through October and rise as high as 67° F in August. Temperatures could exceed 60 in August – October in about 20 percent of years at Bend Bridge. Temperatures in the future are increased by about one degree in August through October. This would lower the amount of suitable rearing area for winter–run Chinook during the first couple months of juvenile rearing but Chinook would still be able to utilize most of the habitat down to at least Bend Bridge in most years until water cools in the fall and the temperature becomes suitable for rearing further down the river. This amount of habitat should be suitable to sustain the present winter–run population through the early rearing stage. Some Chinook fry begin emigration immediately upon emergence while others remain near the spawning area until they begin emigration at a larger size. Martin (et al 2001) concluded that larger proportions of winter Chinook fry rear above RBDD at lower discharge volumes during their emergent period. Temperatures would be marginal at RBDD for juvenile Chinook rearing in about 10 percent of years in August through October. Temperatures at Red Bluff in the future will be increased in September and October.

Steelheads have been found to survive and grow in other Central Valley streams (American and Feather Rivers) at temperatures in this range. Ramping criteria for Keswick Reservoir that are in place July through March minimize stranding effects to steelheads and Chinook salmon when release changes are made and flood control is not an issue. Reclamation uses these same criteria between April and June under normal operating conditions. Greater magnitude fluctuations in flow occur when pulses are produced from rainfall than occur due to reservoir operations.

Flows in the lower Sacramento River are important for rearing and emigrating salmon and steelheads. The species often out-migrate during periods of increased flow. Freeport flows are displayed. These include the sum of flows from the Sacramento, Feather, and American and other tributaries. The monthly modeling does not show the flow peaks used by outmigrating salmonids. The peaks would likely be similar in the future because they result largely from uncontrolled runoff from the tributaries added to the relatively constant reservoir releases. The monthly average Freeport flows show a slight decrease at times in the future but the decreases shown by modeling would not likely be detectable by fish. Because salmon and steelheads move largely in response to the peaks in flow, the lower average flows in the lower Sacramento River at Freeport may or may not significantly affect salmon or steelheads. Flow changes will still occur in response to precipitation and changing Delta water needs and provide needed cues for upstream and downstream migrating salmon and steelheads.

Red Bluff Diversion Dam

Reclamation plans to continue the current May 15-September 15 gates lowered period at RBDD. The gates will be in a closed position during the tail end of the winter–run upstream migration and during much of the upstream migration season for spring–runspring–run. Approximately 15 percent of winter–run and 70 percent of spring–run that attempt to migrate upstream past RBDD may encounter the closed gates (TCCA and Reclamation 2002). This is based on run timing at the fish ladders (ie. after the delay in migration has occurred) when the gates were lowered year round so a delay is built into the run timing estimate. Most of the spring–run that do pass RBDD pass before May 15 and over 90 percent of the spring–run population spawns in tributaries downstream of RBDD. These downstream tributary runs never encounter the gates. When the gates are closed, upstream migrating Chinook salmon have to use the fish ladders to get past RBDD. Vogel et al (1988) found the average time of delay for fish passing through RBDD was three to13 days depending on the run (spring–run was the highest) and individual delays of up to 50 days occur. Recent radio tagging data indicate an average delay of 21 days (TCCA and Reclamation 2002). Although studies have shown that fish do not immediately pass the fish ladders, the extent that delayed passage affects ultimate spawning success is unknown. Average monthly water temperatures at Red Bluff would be maintained at suitable levels for upstream migrating and holding Chinook through July of all years. Fish delayed by RBDD should not suffer high mortality due to high temperatures unless warmer than average air temperatures warm the water significantly above the monthly average temperatures predicted by the model. Average monthly water temperatures during August and September could be greater than 65° F in 10 percent of years and as high as 69° F in years with low cold water pool storage in Shasta. During these years delays at RBDD would be more likely to result in mortality or cause sufficient delay to prevent migration into tributaries. This would effect primarily fall–run fish. The proportion of the spring–run and winter–run populations that encounter closed gates is small so effects of delays at RBDD during these dry years would probably not be as great as the population effect of higher than optimal spawning and incubation temperatures.

The spring–run population upstream of RBDD has failed to recover from what appears to have been a down cycle that should have ended shortly after the by-passes at Shasta Dam for temperature control began (1987) and shortly before the full eight months gates out operation began (1995). During this same period, spring–run downstream of the RBDD have increased about 20 fold, suggesting that some upstream event other than the RBDD operations have caused the decline in the spring–run population (TCCA and Reclamation 2002). This may be an artifact of a change in sampling protocols, but remains an unknown. It is also possible that some spring destined for the upper Sacramento River get delayed at RBDD so head back downstream and enter tributaries to span.

Early migrating steelheads encounter the lowered gates at RBDD. Approximately 84 percent of adult steelheads immigrants pass RBDD during the gates-out period based on average run timing at RBDD. Although the historical counts of juvenile steelheads passing RBDD do not differentiate steelheads from resident rainbow trout, approximately 95 percent of steelheads/rainbow trout juvenile emigrants pass during the gates-out period based on historical emigration patterns at RBDD (DFG 1993, as summarized in FWS 1998). Effects of RBDD operation on steelheads run timing would be unchanged from the current condition. About 16% of steelheads would still be delayed. Steelheads this early in the run are not ready to spawn and steelheads are repeat spawners so the slight delay of a small portion of the steelheads run is not a big effect on steelheads.

Fry, juveniles, and smolts that pass RBDD when the gates are lowered are more susceptible to predation below the gates because pike minnows and striped bass congregate there. The predation situation at RBDD has improved since gate operations were changed so that not as many predator species now stop at RBDD during their upstream migrations (CH2M Hill 2002). The predation situation as it is now would likely continue through future operations.

Fall–run Chinook salmon migrate into the upper Sacramento between August and October with the peak migration occurring during October. RBDD gates are raised during the majority of the fall–run migration but some do get delayed prior to September 15 when the gates get raised. Fall–run Chinook salmon spawn heavily in the main stem of the Sacramento River, primarily upstream of Red Bluff, although a few do spawn just downstream of the RBDD. The highest density spawning area occurs from the city of Anderson upstream to the first riffle downstream of Keswick Dam.

Feather River

Modeling

Figure 9-36 shows the end-of month Oroville Reservoir storages for all five studies. Generally the storages for all five cases are very similar over the 72 years simulated. Oroville storage results in Study 3 are occasionally lower than results from the other simulations a few times. These lower values may be attributed to the EWA actions in the third study. The increased Banks export capacity in Studies 4 and 5 increases the States ability to draw down Oroville Reservoir, however the plot seems to indicate that this is counterbalanced by the SWP's enhanced ability to export additional unstored water during excess conditions.

Figure 9-36 shows that the Oroville storage is reduced in Studies 4 and 5 when the end of September Oroville Reservoir storage is greater than 2.5 MAF. The model seems to be taking advantage of the increased Banks export capacity to move additional water from Oroville in the wetter cases, resulting in lower carryover storage. Figure 9-37 shows that the 8,500 cfs Banks implementation seems to shift releases from winter months to the summer months.   Figure 9-38 through Figure 9-43 indicate that this trend is consistent over all five water year types.   As water availability decreases with water year type lower Oroville Reservoir releases are required during the July - September period.

Table 9-11 compares some of the annual average impacts to Feather River flows between the studies. While the earlier figures show that the various scenarios do affect the monthly distribution of Feather River releases, the average annual impacts appear to be insignificant. Long term average annual Feather River impacts flows are almost identical for the five studies. The 1928-1934 averages do show some very slight differences between the studies but overall the average annual impacts are minimal.

Table 9-11 Long-Term Average Annual Impacts to the Feather River

Differences (cfs)	Study 2 - Study 1	Study 3- Study 1	Study 5- Study 1	Study 4- Study 2	Study 5- Study 3
Long Term Average Feather River Flow below Thermalito	0	0	-2	-1	-2
1928-1934 Average Feather River Flow below Thermalito	-3	5	14	26	9

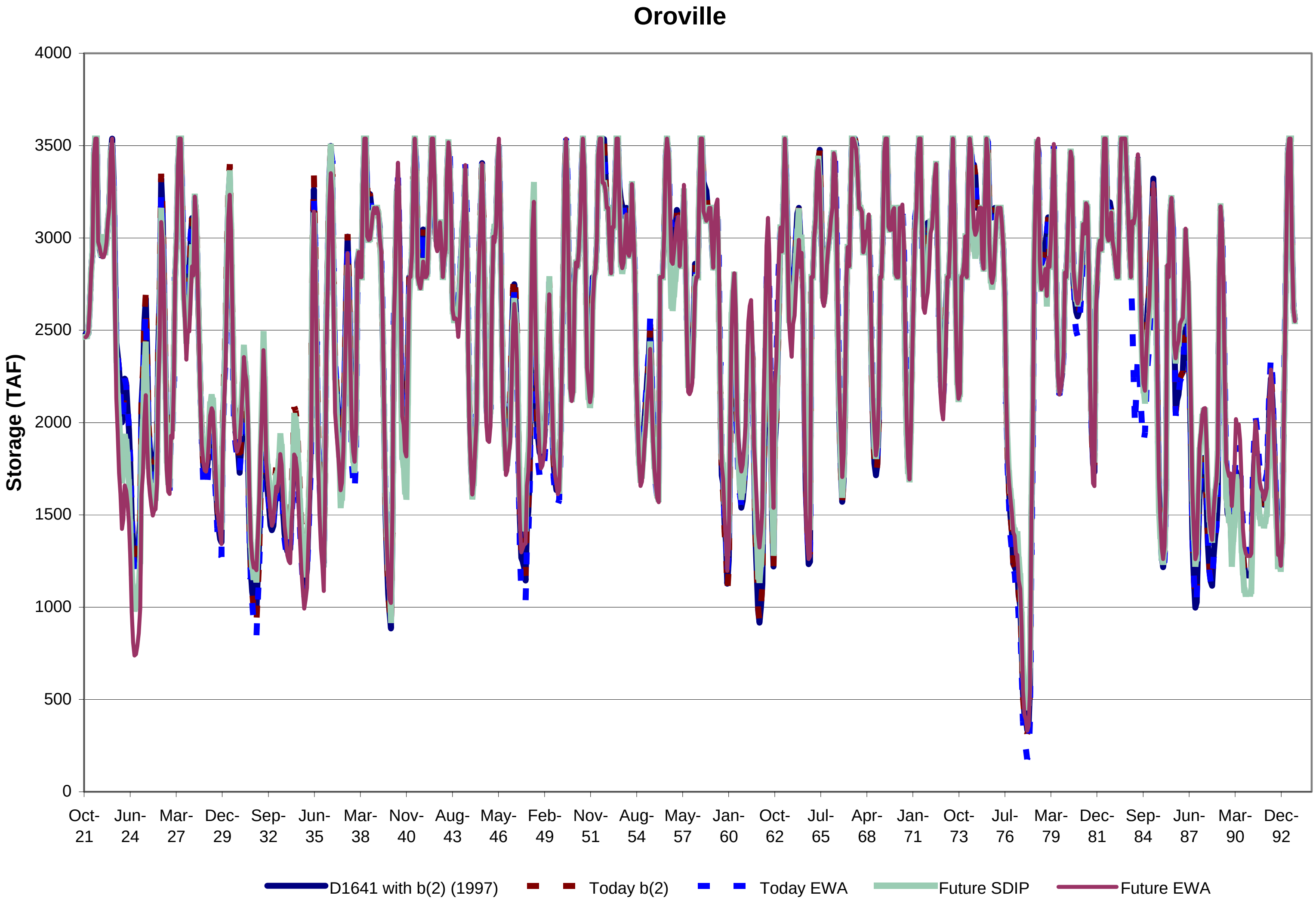


Figure 9-35 Chronology of Oroville Storage Water Year 1922 - 1993

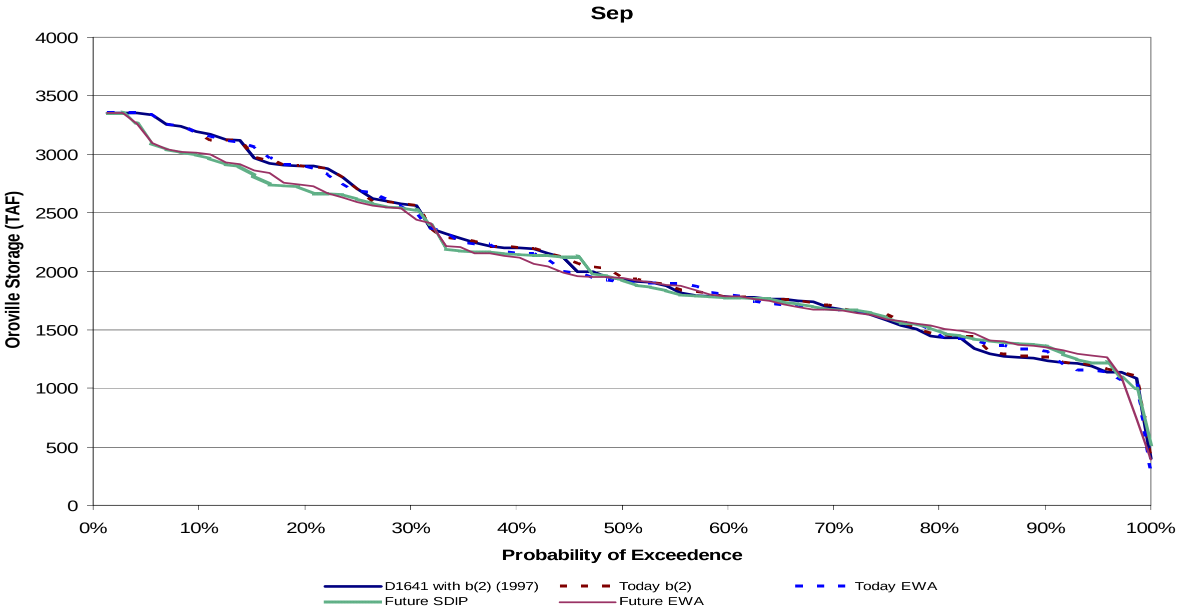


Figure 9-36 Oroville Reservoir End of September Exceedance

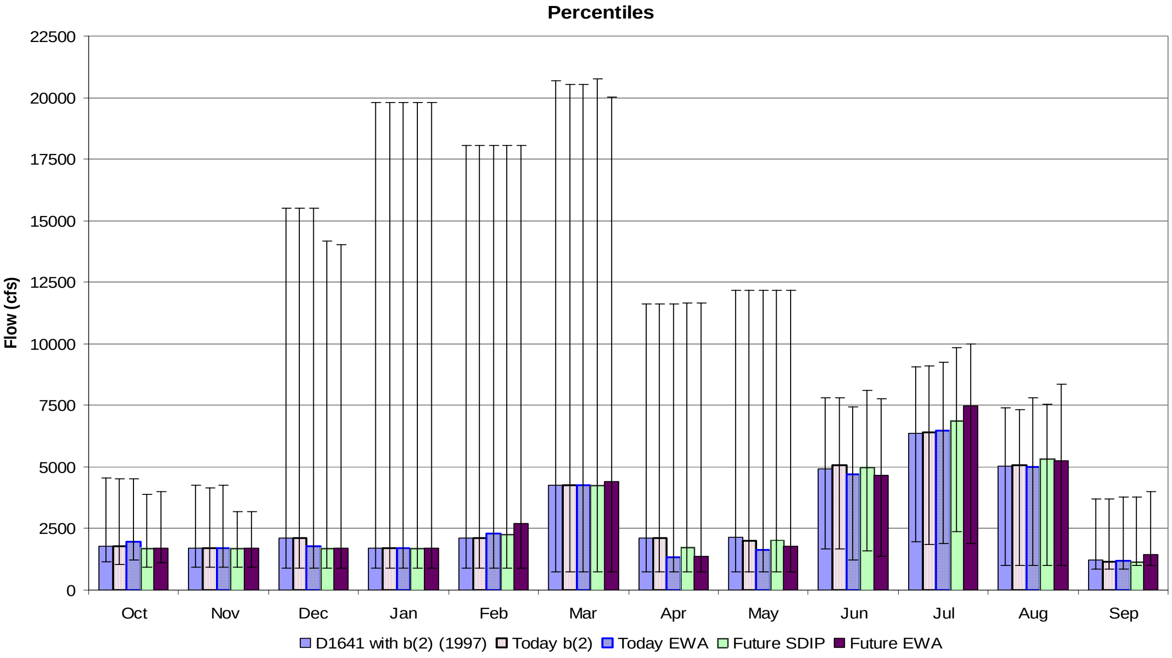


Figure 9-37 Flow Below Thermoltio 50th Percentile Monthly Releases with the 5th and 95th as the bars

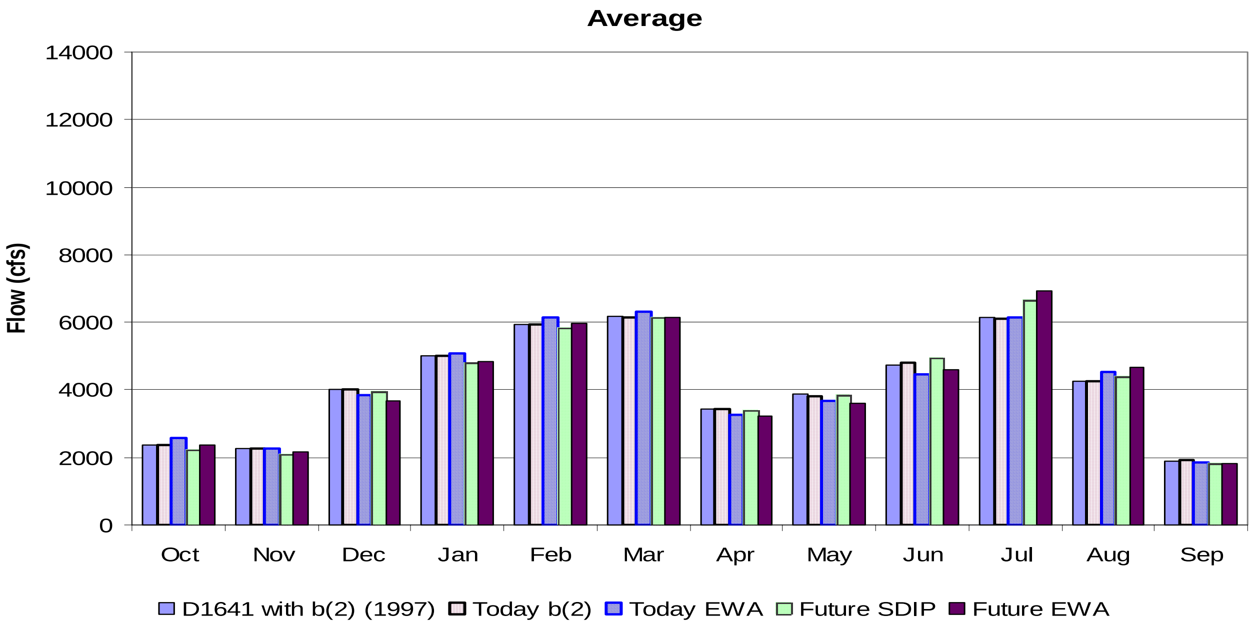


Figure 9-38 Average Monthly Flow Below Thermolito

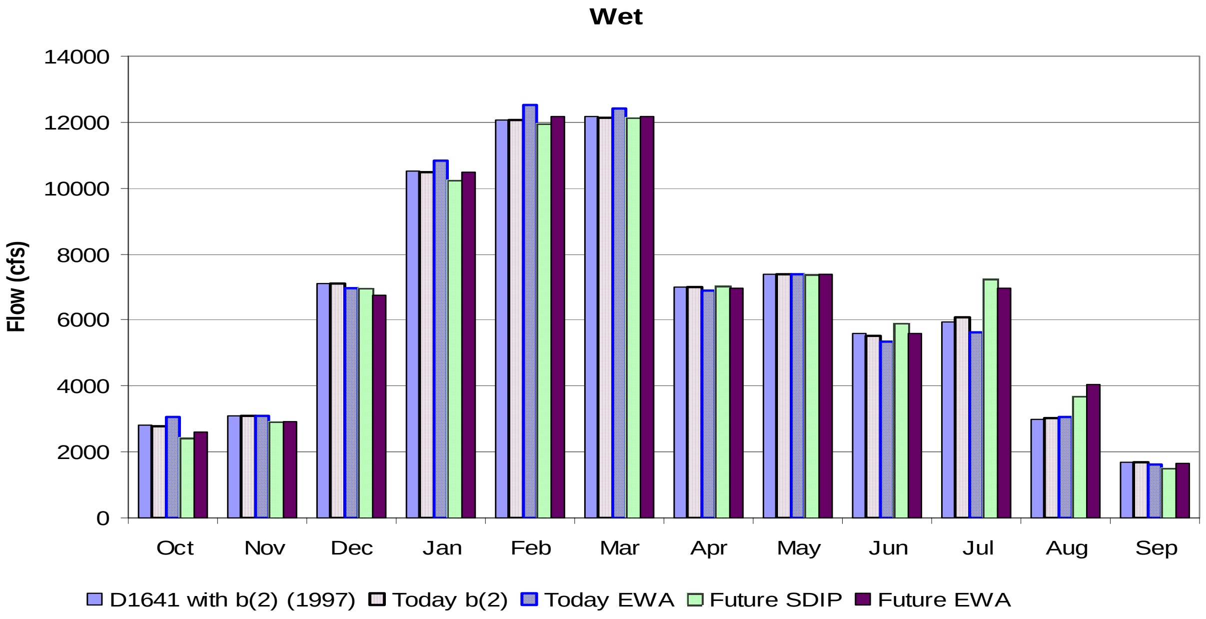


Figure 9-39 Average wet year (40-30-30 Classification) monthly Flow Below Thermolito

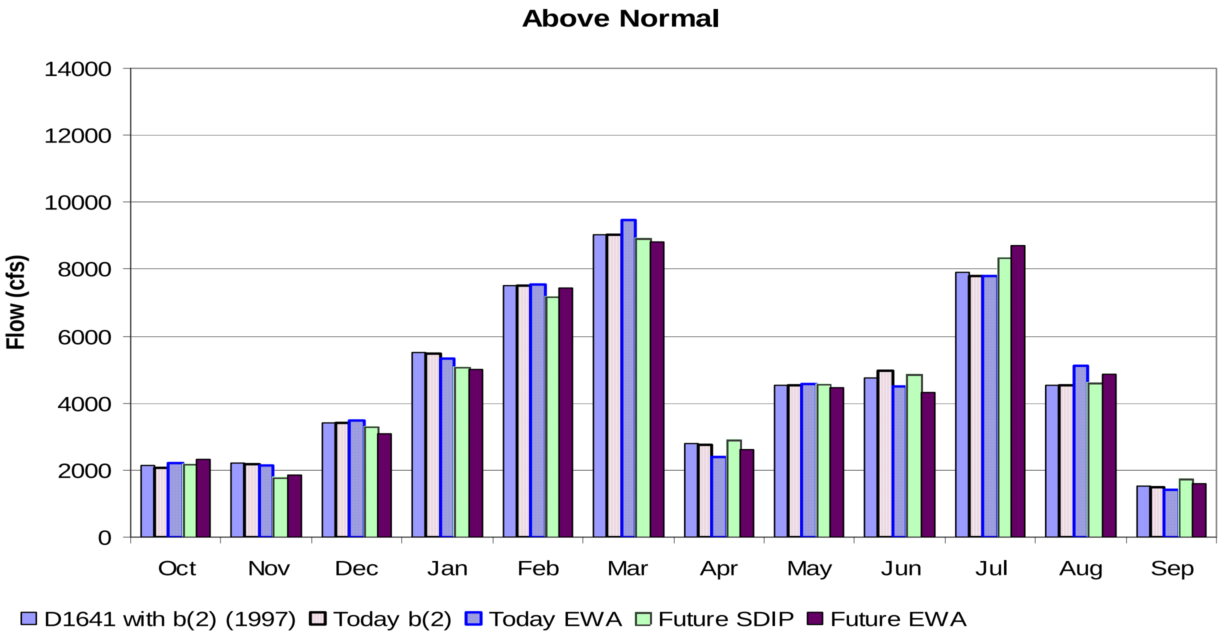


Figure 9-40 Average above normal year (40-30-30 Classification) monthly Flow Below Thermolito

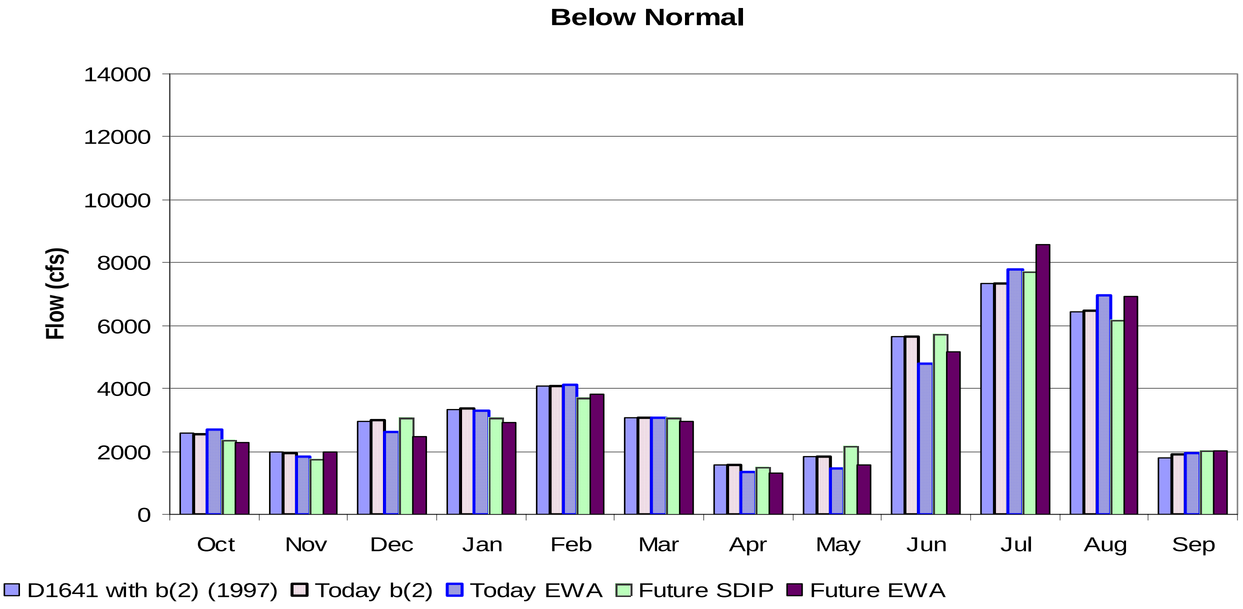


Figure 9-41 Average below normal year (40-30-30 Classification) monthly Flow Below Thermolito

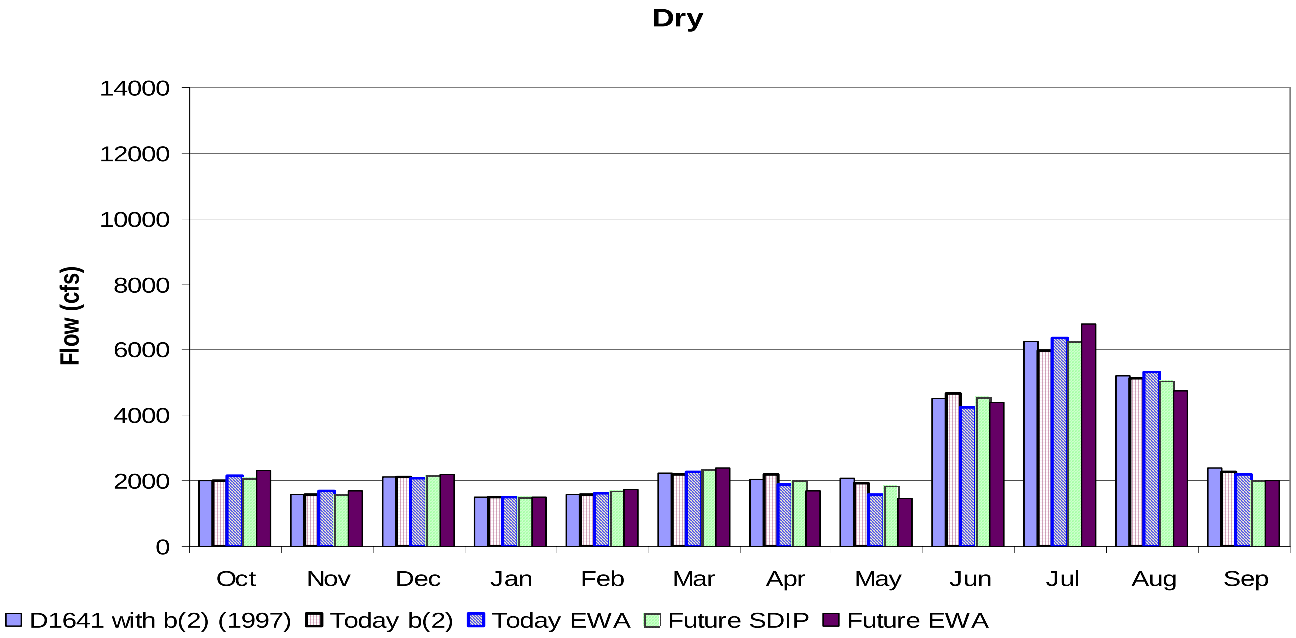


Figure 9-42 Average dry year (40-30-30 Classification) monthly Flow Below Thermolito

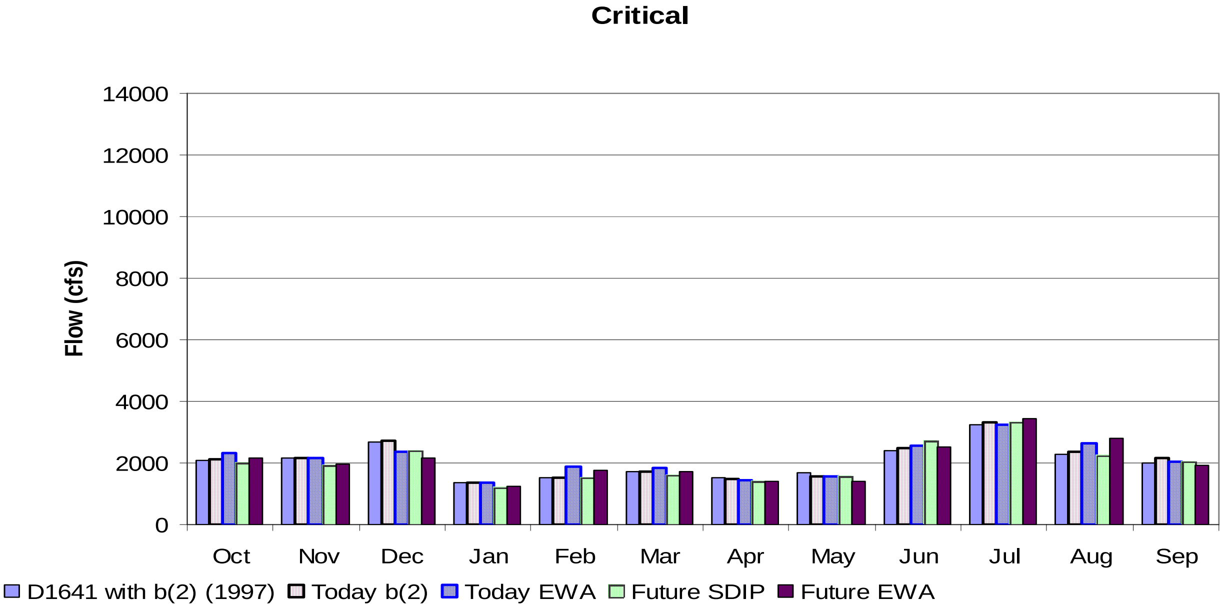


Figure 9-43 Average critical year (40-30-30 Classification) monthly Flow Below Thermolito

The approach to analyze the effects of proposed operations on steelheadss and spring–run Chinook salmon in the Feather River was similar to the approach used for CVP streams. Mean monthly flows and temperatures were simulated for a range of exceedance level hydrologies and compared to recommended temperature ranges for different life history stages of steelheads and spring–run Chinook salmon. For Chinook salmon only, the previously described temperature and mortality models were used to simulate egg mortality during the egg incubation period for fall–run and spring–run. As noted previously, a limitation of this approach is that the flow and temperature simulations were performed using a monthly operations model, which cannot predict diurnal temperature fluctuations that may be out of the recommended range for the two fish species.

Historical Feather River flow and temperature data were presented in DWR and Reclamation (1999). Projected Feather River flows downstream of Thermalito After bay for a range of exceedance levels are shown in CALSIM Modeling Appendix (UpstreamFlows.xls). Temperature results for a range of exceedance levels are presented in Temperature Modeling Appendix (Feather Temperature.xls).

Steelheads

Flow in the LFC is projected to remain constant at 600 cfs during the period addressed in this biological assessment except during occasional flood control releases that occur less than 10 percent of the time between December and May. This flow is less than pre-dam levels during all months of the year as a result of water diversions through the Thermalito Facilities (DWR and Reclamation 1999). The significance of these flow conditions for steelheads spawning and rearing is uncertain. The LFC is the primary reach for steelheads spawning and rearing. Although there is relatively little natural steelheads production in the river, most steelheads spawning and rearing appears to occur in the LFC in habitats associated with well-vegetated side channels (Kindopp and Kurth 2003, Cavallo et al 2003). Since these habitats are relatively uncommon they could limit natural steelheads production. Feather River RST data suggests that salmonids initiate emigration regardless of flow regime (i.e. they aren't waiting for a high flow pulse). The LFC is the primary reach for all salmonid spawning and rearing, so the direct effect of constant flow regime is, if anything, positive. Water temperatures in the LFC could also affect the quality of habitat for steelheads. However, studies have revealed that steelheads rear successfully at the downstream extent of the LFC where summer temperatures reach or occasionally exceed 65° F (Figure 9–44). A recent laboratory study also found that Feather River steelheads have a relatively high thermal preference (Myrick 2000). This study also found that in-channel produced steelheads displayed a higher thermal tolerance than steelheads from the Feather River hatchery.

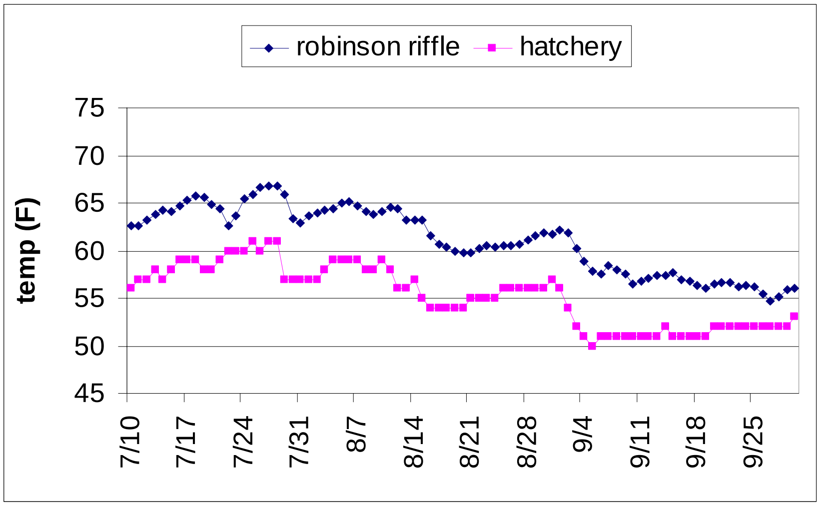


Figure 9–44 Summer temperature differences in the Feather River LFC between the fish hatchery dam and Robinson Riffle based on data collected by continuous temperature loggers during summer 1998.

Predicted water temperatures will not be harmful to steelheads Temperature Modeling Appendix (Feather Temperature.xls). Temperatures are at or below the 52° F recommended upper limit for most of the November through April adult migration and spawning periods. This should provide suitable habitat conditions for spawning, egg incubation and fry emergence during the winter and early spring. Overall, these analyses suggest that water temperatures should be satisfactory for steelheads even at the 50 percent exceedance.

Daily water temperatures in the LFC can also be affected by pump-back operations through the Thermalito complex. This practice typically occurs in summer or fall during “off-peak” periods. The effects of pump back operations are most noticeable in extreme drought periods such as 1990 through 1992, when the reservoir storage dropped below 1.2 million acre-feet. Low reservoir elevation causes the cold water level to drop below the power plant intake shutters, which provide control over the temperature of dam releases. Operational simulations indicate that reservoir elevations are unlikely to drop below 1.2 million acre-feet, even at the 90/75 percent exceedance hydrology. As a result, if pump back operations are conducted, they are not expected to adversely affect steelheads in the LFC.

Water conditions below the Thermalito After bay are not as favorable for steelheads. The projected exceedance flows for the Feather River below Thermalito After bay are shown in Temperature Modeling Appendix (Feather Temperature.xls). Like other post-dam years, predicted temperatures are less than 52° F during the winter, but rise above the recommended level during March, when egg incubation and emergence may still be occurring. Water temperatures near the mouth of the river are projected to exceed 65° F by May. By June, the entire river below the outlet is projected to be >65° F. As a result, and like most years, conditions below the outlet are expected to be marginal for steelheads rearing except during fall and winter. Although young-of-the-year steelheadss are occasionally observed in this area, we have not found evidence of substantial steelheads spawning or rearing below the Thermalito outlet (Kindopp and Kurth 2003, Cavallo et al 2003). As indicated above, most young steelheads rear in the LFC, which has several miles of habitat with appropriate water temperatures. The river channel below Thermalito offers essentially none of the habitat types upon which steelheads appear to rely in the LFC. Experiments and fish observations also suggest that predation risk is higher below Thermalito outlet (DWR unpublished). Increased predation risk is likely a function of water temperature, where warm water exotic species are more prevalent, and in general, predators have greater metabolic requirements. Thus, excessively warm summer temperatures and the absence of preferred steelheads habitat; appear to limit steelheads below the Thermalito outlet. However, the relative importance of these two factors is unknown. For example, it is unclear whether a reduction in summer water temperatures below Thermalito would be enough to induce or allow successful steelheads rearing and spawning.

Spring–run Chinook Salmon

Predicted flow conditions were discussed previously for steelheads. It is unclear whether there is substantial in-channel spawning of spring–run Chinook salmon, so the following analysis is highly speculative. However, the analysis makes the conservative assumption that there is some in-channel spring–run Chinook salmon spawning. The fact that spring–run hold during summer in the upper reaches of the LFC suggests any such spawning would most likely be restricted to that reach. LFC spawners are unlikely to be limited by the amount of "space" created by the predicted flow level because they would be the first to arrive at the spawning riffles. However, superimposition on spring–run redds by fall–run spawners, which spawn later, could be a major source of egg mortality. Studies by Sommer and others (2001a) indicate superimposition rates may be determined by the percentage of the population that spawns in the LFC, which is in turn influenced by flow distribution, escapement level and perhaps hatchery operations. Flow distribution is defined as the percentage of total October and November river flow that passes through the LFC. In the case of both the Base and Future operations, the LFC releases would be fixed at 600 cfs. We predict that superimposition rates would be higher at the higher exceedance levels (e.g. >75 percent) because the LFC would comprise a greater percentage of total flow.

The Base and Future temperatures at the Fish Barrier Dam should be generally suitable for all life history stages Temperature Modeling Appendix (Feather Temperature.xls). Most spring–run adults typically hold in the upper three miles of the LFC (Dick Painter, personal communication, 1998), where temperatures remain closer to the recommended thresholds Temperature Modeling Appendix (Feather Temperature.xls). Temperatures in most of the LFC are expected to be within the recommended range for spring–run spawning beginning about September, but temperatures will be marginal for spring–run spawning in the downstream portion of the LFC until October, when fall–run Chinook salmon begin spawning. Temperatures throughout the LFC should be suitable for rearing and emigration during January through April for the Base and Future cases.

Base and Future temperatures below Thermalito After bay Outlet will be marginal for adult spring–run, but suitable for fry. Predicted Base and Future temperatures downstream of the outlet could begin affecting adult immigration about May. Summer holding temperatures below Thermalito will be marginal. Temperatures are projected to be too high for spawning until November Temperature Modeling Appendix (Feather Temperature.xls). Therefore it is unlikely that adult spring–run will use the river downstream of the outlet, except perhaps as a migration corridor. As stated above, the entire river from the Fish Barrier Dam to the mouth should be suitable for rearing and emigrating fry until at least April, by which time most fry have historically emigrated from the river (DWR 1999a, 1999b, 1999c).

Egg survival model results are summarized in Figure 9–45. Egg mortality during the fall incubation period was less that 2.5 percent for all but critically dry year types when mortality was about 4 percent. Mortality values for current and future operations are very similar.

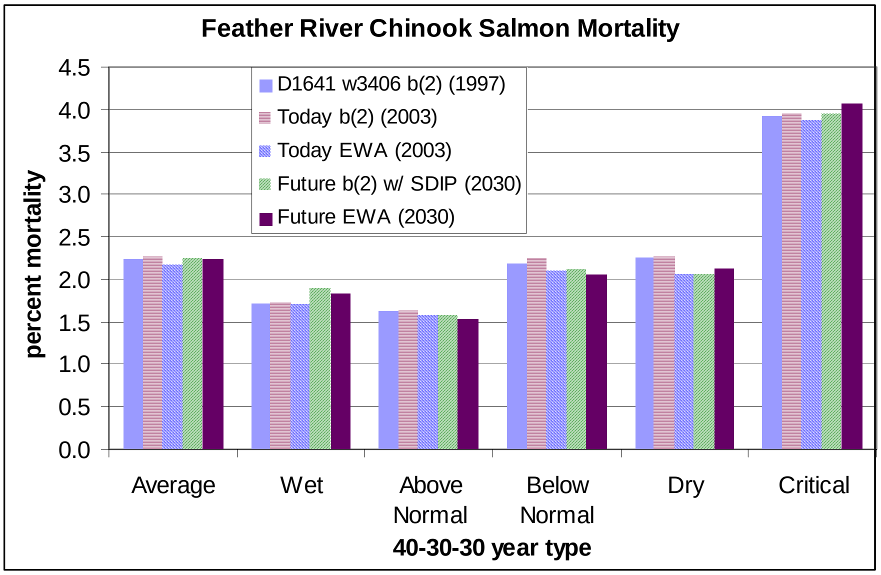


Figure 9–45 Percent mortality from egg to fry due to water temperature for Chinook in the Feather River by water year type.

Fall–run Chinook Salmon

Predicted base and future flow and temperature conditions were discussed previously for steelheads and spring–run salmon. Fall–run Chinook salmon compose the largest population of the anadromous salmonids in the Feather River. Fall–run Chinook salmon begin arriving in September and spawn in-channel from October through December. Unlike spring–run salmon, there is a distinct and substantial amount of in-channel spawning and rearing among fall–run salmon in the Feather River. Generally, the arrival, spawning, and rearing timing of fall–run minimizes their exposure to unfavorable water temperatures and flows. Fall–run spawning activity begins in the LFC and then gradually intensifies downstream. Typically the peak of spawning occurs about one month earlier in the LFC than in the river below Thermalito Outlet (DWR unpublished). Approximately two-thirds of total fall–run spawning occurs in the LFC, while roughly one-third occurs below Thermalito Outlet (Cavallo 2001). Due to the success of the FRH, large numbers of fall–run salmon spawn in the Feather River. This large, hatchery supported salmon population often outstrips the habitat available for spawning, which results in competition for spawning area in the lower Feather River. This competition, and resulting superimposition of fall–run redds, is most intense in the LFC where flows are predicted to remain at 600 cfs, and where the highest density of spawning occurs.

The base and future temperatures should generally be suitable for all life history stages of fall–run Chinook salmon. As with spring–run, any fall–run salmon arriving early in the river (before September) may hold in the upper three miles of the LFC where temperatures remain closer to the recommended thresholds. Temperatures in most of the LFC are expected to be within the recommended range for fall–run spawning beginning about September. Temperatures below the Thermalito outlet, while marginal in September, are predicted adequate by October when the bulk of fall–run spawning generally begins.

The majority of Feather River fall–run Chinook salmon emigrate from the system by the end of March (Figure 12−13). Temperatures throughout the lower river should be suitable for rearing and emigration during this period.

As described for spring–run, the egg survival model results are provided in Figure 9-x. Again, egg mortality during the fall incubation period was less that 2.5 percent for all but critically dry year types when mortality was about 4 percent. Mortality values for current and future operations are very similar.

Feather River Fish Studies

Fish monitoring and studies in the Feather River will continue take of steelheads and spring–run salmon. DWR is likely to modify and perhaps expand on such activities to gather information needed by the NOAA Fisheries and California Department of Fish and Game during the relicensing of the Oroville Facilities with the Federal Energy Regulatory Commission.

Steelheads and spring–run salmon take could occur during RST sampling, fyke net sampling, beach seine sampling, or snorkeling. Low numbers of steelheads are typically collected in the RSTs between February and July (2002), although the RST is not considered an effective gear for monitoring steelheads emigration. Fyke net sampling is supplemental to RSTs, and began in the 1999-2000 season.

RSTs have been in use since 1996. Fyke nets are supplemental to RSTs, and began in the 1999-2000 season. Combined RST and fyke net catch for the 2001-02 season was as follows:

- 194 spring–run sized young-of-year salmon, four juveniles, and seven mortalities
- 306 wild, YOY steelheads trout, 44 juveniles, and four mortalities

DWR discontinued its regular seining program after 2001. Collective findings of the seining program are summarized in DWR 2002a. We anticipate that seining will only be used as required by stranding surveys. NOAA Fisheries requested the juvenile fish stranding survey in the 2000-01 season. Stranded fish will be assessed and removed from isolated pools and released into the river. This will occasionally require transporting fish over short distances. Catch in the 2001 stranding survey was as follows:

- 147 spring–run sized young-of-year salmon, including five mortalities
- 2 wild, juvenile steelheads trout, zero mortalities

Snorkel surveys conducted during spring and summer will not result in the lethal take of any steelheads or spring–run size salmon. Snorkel survey observations include repeated observations of some individuals. As an example of typical numbers of fish observed, 1999 data was as follows:

- steelheads, 5,856 YOY, 739 juveniles of unknown age;
- spring–run sized salmon, 3,034 juveniles of unknown age.

The total annual potential steelheads take for the Feather River fish monitoring program, is estimated to be 7,855 (6,835 YOY, 980 juveniles (age unknown), and 40 adults). Total annual lethal take is estimated to be 2 percent or 157 steelheads. These estimates are based on the largest seasonal catch to date and the relative proportions of the different life stages in the catch combined with the estimate of take for the sampling elements. The lethal take estimate is based on the average incidental take over four seasons of sampling (1.4 percent) and rounded up to the next whole number.

The total annual potential spring–run take is estimated to be 6,500 (6,355 YOY, 146 juveniles (age unknown), and seven adults). Total annual lethal take is estimated to be 2 percent or 130 spring–run salmon. These estimates are based on the largest seasonal catch to date and the relative proportions of the different life stages in the catch combined with the estimate of take for the sampling elements. The lethal take estimate is based on the average of incidental take over four seasons of sampling (1.8 percent) and rounded up to the next whole number.

Steelheads and spring–run sized salmon mortalities incidental to the sampling efforts will be retained for diet, scale, and otolith analyses.

Measures to Reduce Handling Stress

Several measures will be incorporated as standard operating procedures to reduce the exposure to physiological stress and minimize harm associated with the capture and handling of steelheads and spring–run salmon. These measures are intended to maximize the survival after release.

1. Captured steelheads and spring–run salmon shall be handled with extreme care and kept in cool, aerated local water to the maximum extent possible during sampling and processing procedures. Artificial slime products or anesthetics may be used to reduce physiological or osmotic stress. Steelheads and spring–run salmon handled out-of-water for the purpose of recording biological information or taking scale samples will be anesthetized when necessary to prevent mortality. Anesthetized fish will be allowed to recover (in untreated river water) before being released.
2. With sampling gear that captures a mixture of species, steelheads and spring–run salmon will be removed and processed first and returned to the river as soon as practicably possible.

Sampling by traps will be suspended by raising the trapping cone or removing the live box on the fyke net during periods of high debris load.

American River

Modeling

The greatest impact to the American River is the increases in demands from the 2001 to the 2020 Level of Development (LOD) see (see Chapter 8, Tables 8-3 and 8-4.) The actual deliveries, based on long-term average, increase from a total of 251,000 af in the 2001 LOD (total Water Rights and M&I) to 561,000 af in the 2020 LOD. Based on the 1928 to 1934 average, deliveries increase from 242,000 af to 530,000 af in the Future see Table 9-12. From Figure 9-47 the ability to fill Folsom Reservoir in May is reduced from 50 percent of the time to 40 percent of the time between the Today and Future runs. Carryover September storage in Folsom Reservoir is reduced by 30,000 to 45,000 af on a long-term average basis from the Today to the Future, (Chapter 8, Table 8-5.) It also trends lower in the Future runs relative to the Today runs see Figure 9-48.

The future studies 4 and 5 do take water forum cuts on the demands see (see Chapter 8, Tables 8-3 and 8-4) and provide 47,000 af of mitigation water. Since the Water Forum contracts are not final and the EIR/EIS has not been completed the representation of the American River in the OCAP CALSIM II modeling may be different than what the actual Future operation could be. The 47,000 af of mitigation water in the dry years could also show a transfer ability in the Delta that might actually be part of the future operations.

Sacramento County Water Agency (SCWA) takes water in all years at Freeport with an annual average of 59 TAF, see Figure 9-56. From Figure 9-56 SCWA diversions decrease as the 40-30-30 Index gets drier due to allocation reductions in the dry and critical years to an annual average of 48 and 41 TAF respectively. East Bay Municipal Utility District (EBMUD) in the dry and critical years take an annual average of 36 and 63 TAF/yr when the EBMUD system storage of most likely to be less than 500,000 af.

Figure 9-57 shows results from Study 4 on annual (Mar – Feb) Freeport diversions for SCWA and EBMUD for Study 4. EBMUD can only take 133,000 af in any one year in which EBMUD’s total system storage forecast remains below 500,000 af, not to exceed 165,000 af in any consecutive 3-year drought period. EBMUD takes an annnual max of 94,000 af five times in the 72 years that are analyzed (1939, 1959, 1962, 1968, and 1987). The 165,000 af limit is reached in two consecutive years 3 times (1929-1930, 1959-1960, and 1987-1988) and in three consecutive years 4 times (1962-1964, 1976-1978, 1977-1979 and 1990-1992).

Figure 9-49 shows the monthly percentile values for Nimbus releases. Figure 9-50 to Figure 9-55 show the average monthly Nimbus Releases by long-term average and 40-30-30 Water Year Classification. The average monthly flows for all water year types generally decrease because of implementing minimum flow requirments or from decreased flood releases due to lower storage values.

Table 9-12. American River Deliveries for each of the five studies

	D1641 with (b)(2) (1997)		Today (b)(2)		Today EWA		Future SDIP		Future EWA	
	Average	Dry	Average	Dry	Average	Dry	Average	Dry	Average	Dry
American River Water Rights Deliveries										
PCWA at Auburn Dam Site	8.5	8.5	8.5	8.5	8.5	8.5	65.5	57.8	65.5	57.7
NRWD	0.0	0.0	0.0	0.0	0.0	0.0	16.5	8.3	16.5	8.3
City of Folsom	20.0	20.0	20.0	20.0	20.0	20.0	26.7	26.6	26.7	26.6
Folsom Prison	2.0	2.0	2.0	2.0	2.0	2.0	5.0	5.0	5.0	5.0
SJWD (Placer County)	10.0	10.0	10.0	10.0	10.0	10.0	23.7	22.5	23.7	22.5
SJWD (Sac County)	33.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0
El Dorado ID & WA	0.0	0.0	0.0	0.0	0.0	0.0	17.0	17.0	17.0	17.0
City of Roseville	0.0	0.0	0.0	0.0	0.0	0.0	30.0	30.0	30.0	30.0
So. Cal WC/ Arden Cordova WC	3.5	3.5	3.5	3.5	3.5	3.5	5.0	5.0	5.0	5.0
California Parks and Rec	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SMUD MI	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Folsom South Canal Losses	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
City of Sac/ Arcade Water District/ Carmichael WD	73.2	73.0	73.2	73.0	73.2	73.0	110.8	104.7	110.9	104.7
City of Sac	38.8	39.0	38.8	39.0	38.8	39.0	42.8	49.1	42.7	49.1
SCWA "other" water at Freeport	0.0	0.0	0.0	0.0	0.0	0.0	14.8	15.2	14.8	15.2
SCWA appropriated excess water at Freeport	0.0	0.0	0.0	0.0	0.1	0.2	13.5	5.4	14.0	6.1
Total	205.0	205.0	205.0	205.0	205.1	205.2	420.3	395.6	420.7	396.2
American River CVP Deliveries										
City of Folsom	0.0	0.0	0.0	0.0	0.0	0.0	5.5	3.3	5.5	3.3
SJWD (Sac County)	10.0	7.7	9.9	7.4	9.9	7.4	20.9	15.4	20.9	15.4
El Dorado ID & WA	4.9	4.6	4.9	4.6	4.9	4.5	12.9	9.6	12.9	9.5
City of Roseville	25.1	21.3	24.9	20.5	24.9	20.3	22.8	19.1	22.8	19.1
California Parks and Rec	0.1	0.1	0.1	0.1	0.1	0.1	4.3	3.2	4.3	3.2
SMUD MI	0.0	0.0	0.0	0.0	0.0	0.0	12.4	8.8	12.4	8.8
South Sac County Ag	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCWA at Sac River	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SCWA CVP diversion at Sac Water Treatment Plant	6.4	5.0	6.3	4.8	6.3	4.7	8.6	6.4	8.6	6.3
EBMUD Freeport diversion	0.0	0.0	0.0	0.0	0.0	0.0	23.2	45.8	23.2	45.8
SCWA CVP diversion at Freeport	0.0	0.0	0.0	0.0	0.0	0.0	30.2	22.3	30.2	22.2
Total	46.4	38.7	46.1	37.3	46.1	36.9	140.9	134.0	140.9	133.6

Note

1) "Average" is the average value of 73 year simulation period (1922-1993).

2) "Dry" is the average value of 1928-1934 dry period.

3) All units are in TAF

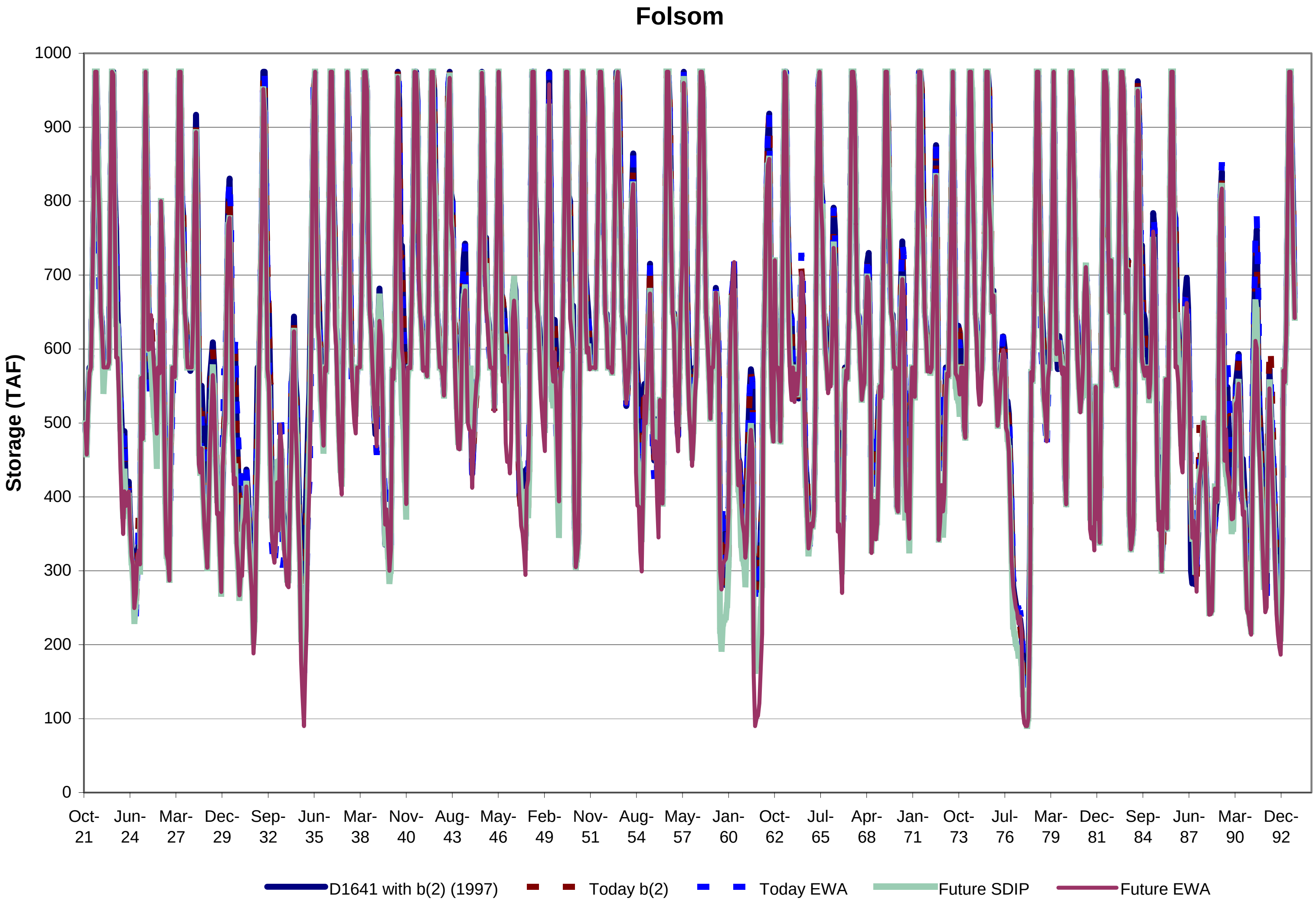


Figure 9-46. Chronology of Folsom Storage Water Year 1922 - 1993

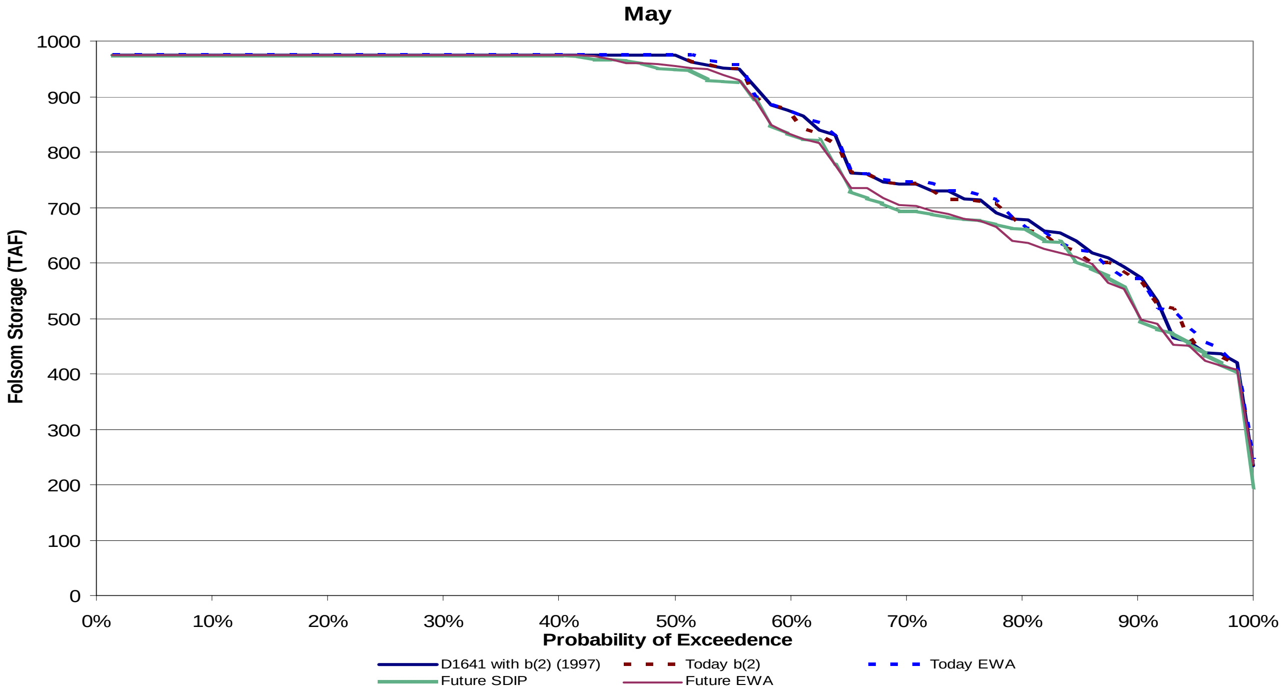


Figure 9-47 Folsom Reservoir End of May Exceedance

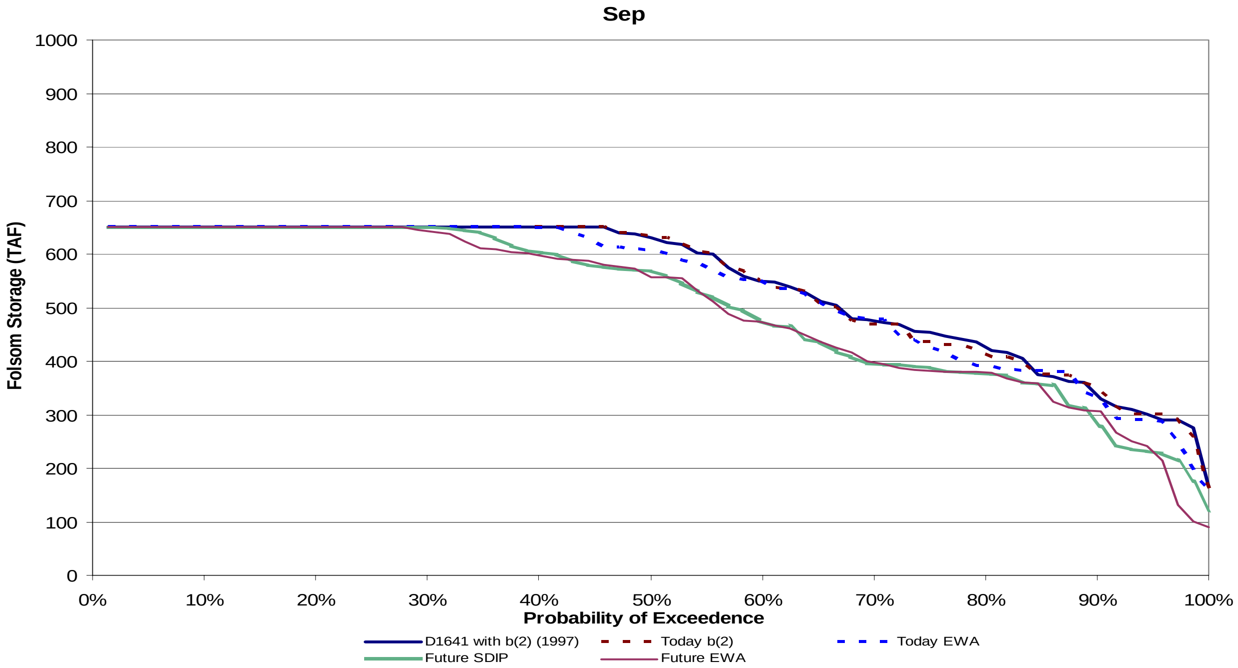


Figure 9-48 Folsom Reservoir End of September Exceedance

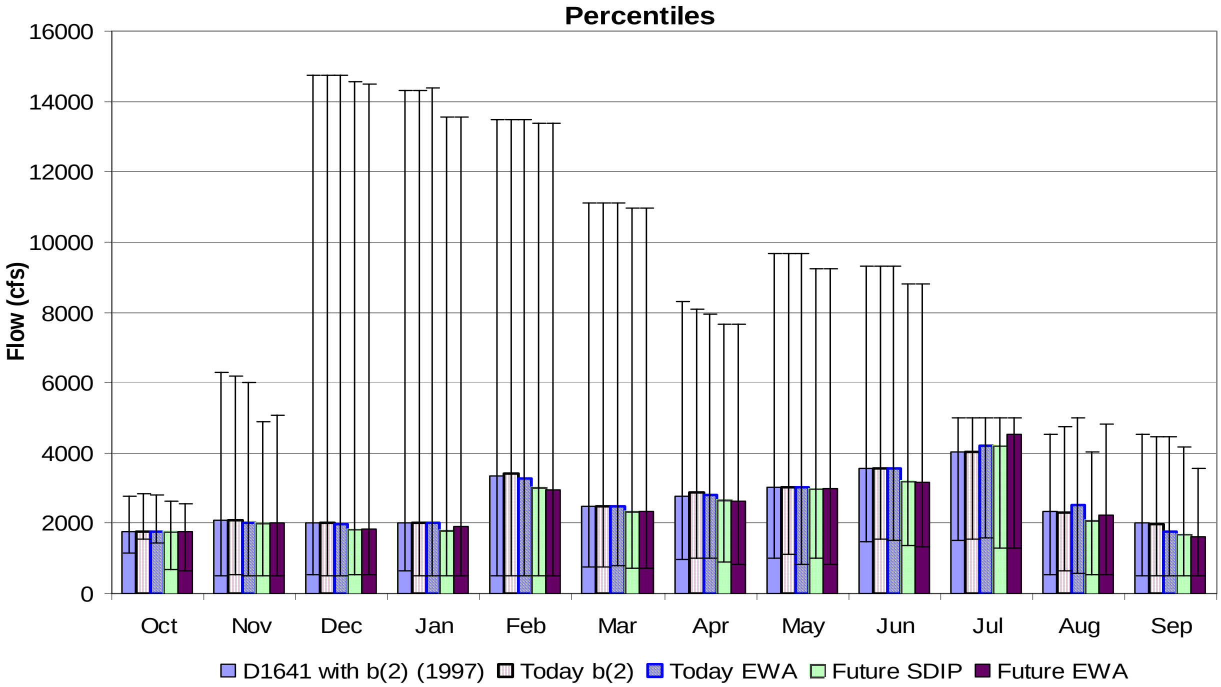


Figure 9-49 Nimbus Release 50th Percentile Monthly Releases with the 5th and 95th as the bars

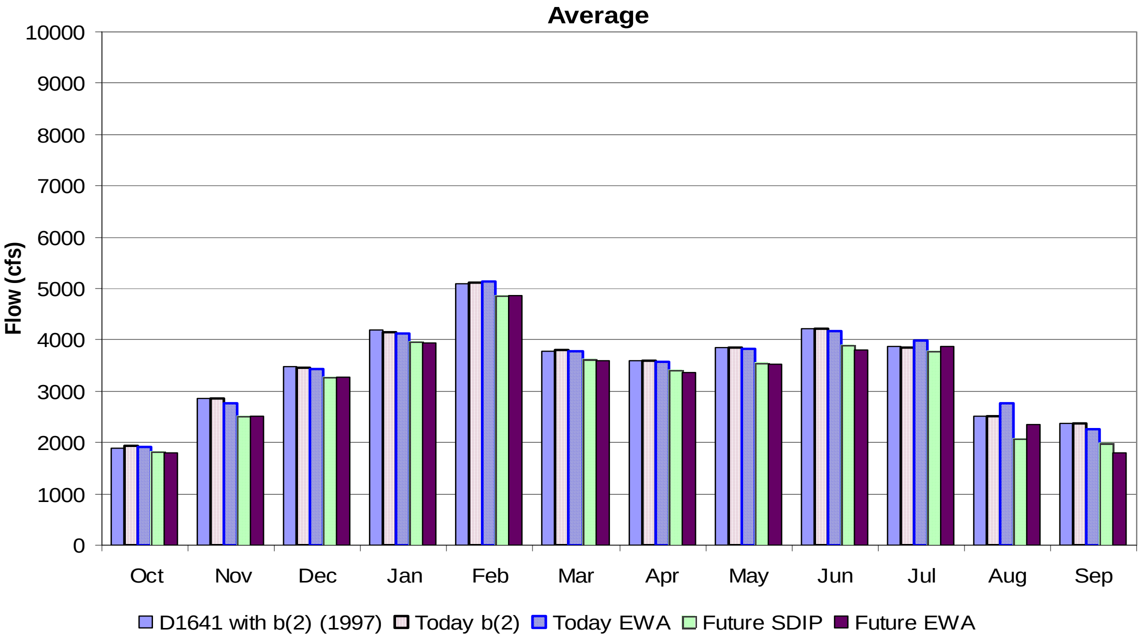


Figure 9-50 Average Monthly Nimbus Release

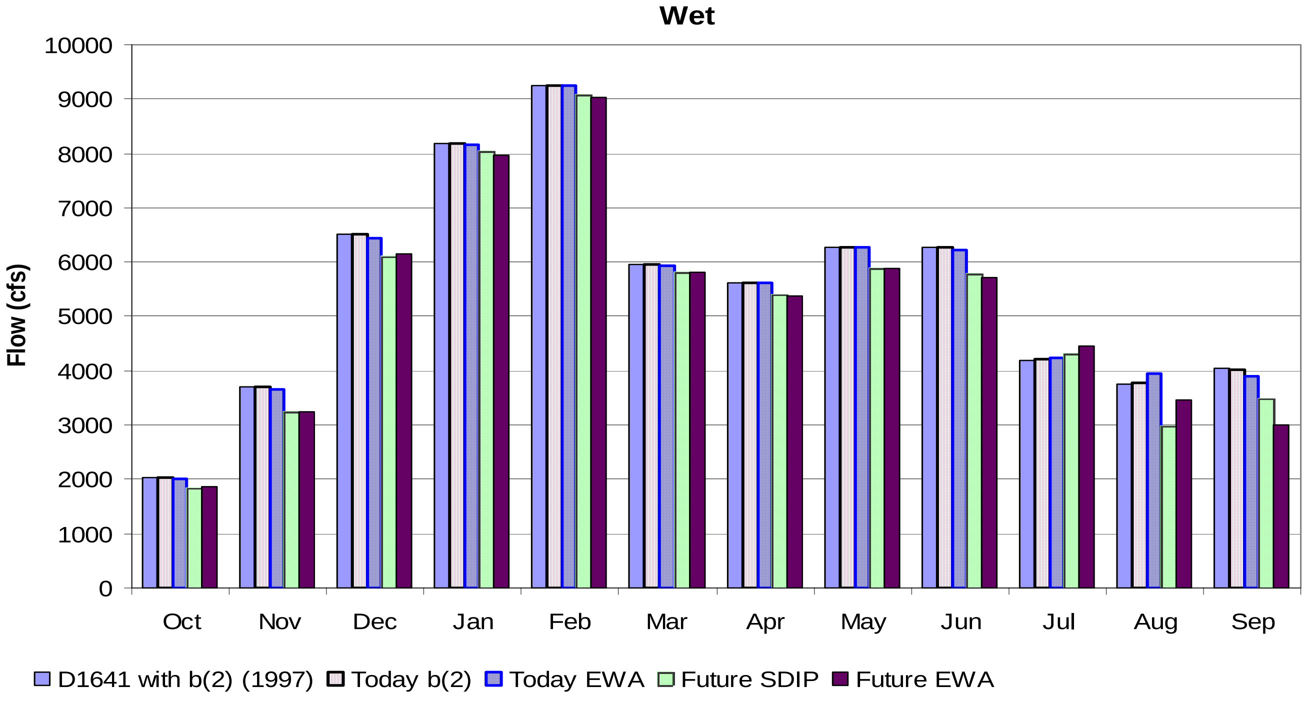


Figure 9-51 Average wet year (40-30-30 Classification) monthly Nimbus Release

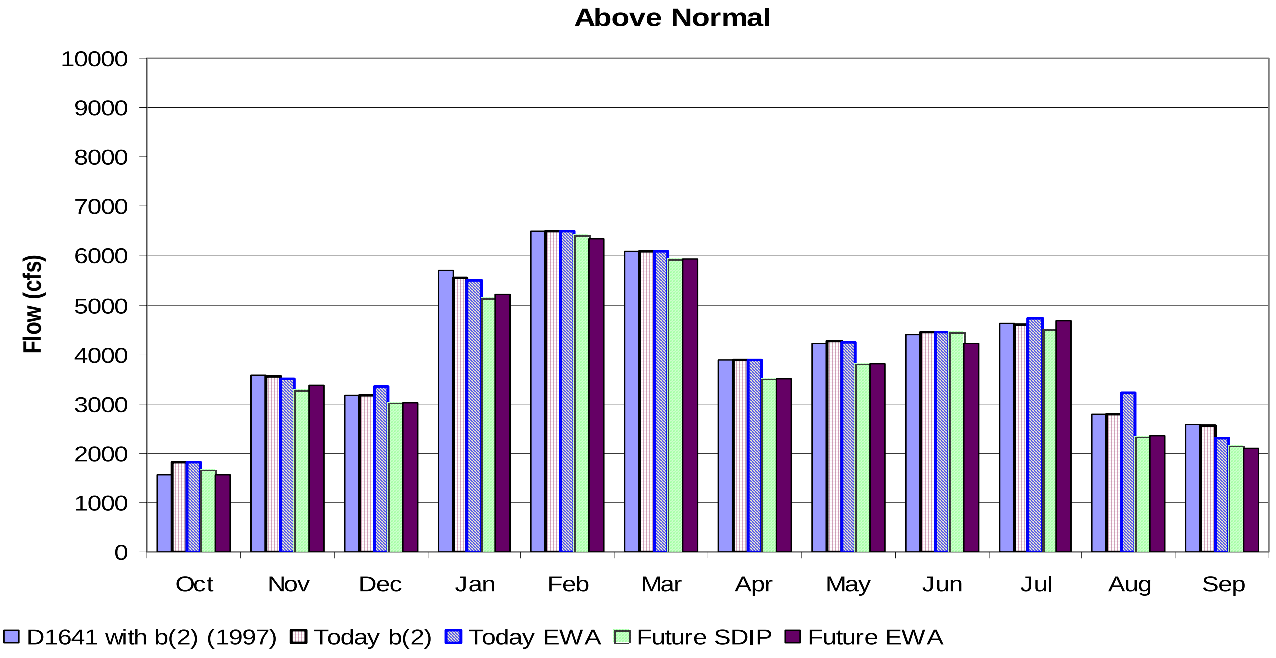


Figure 9-52 Average above normal year (40-30-30 Classification) monthly Nimbus Release

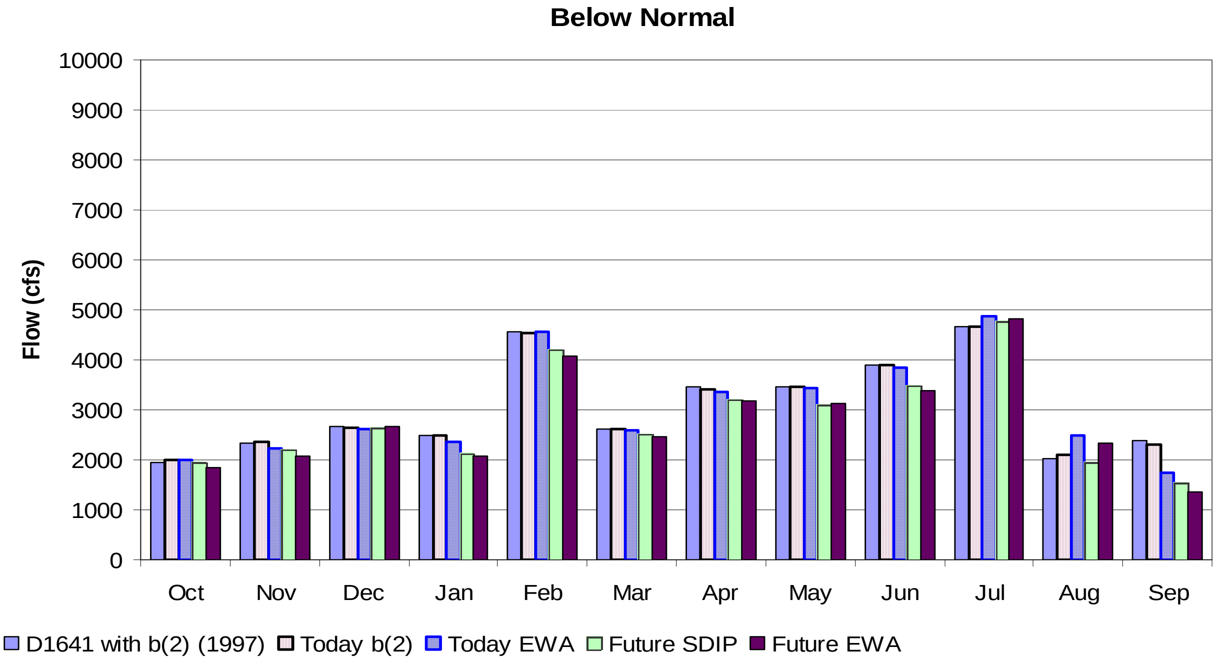


Figure 9-53 Average below normal year (40-30-30 Classification) monthly Nimbus Release

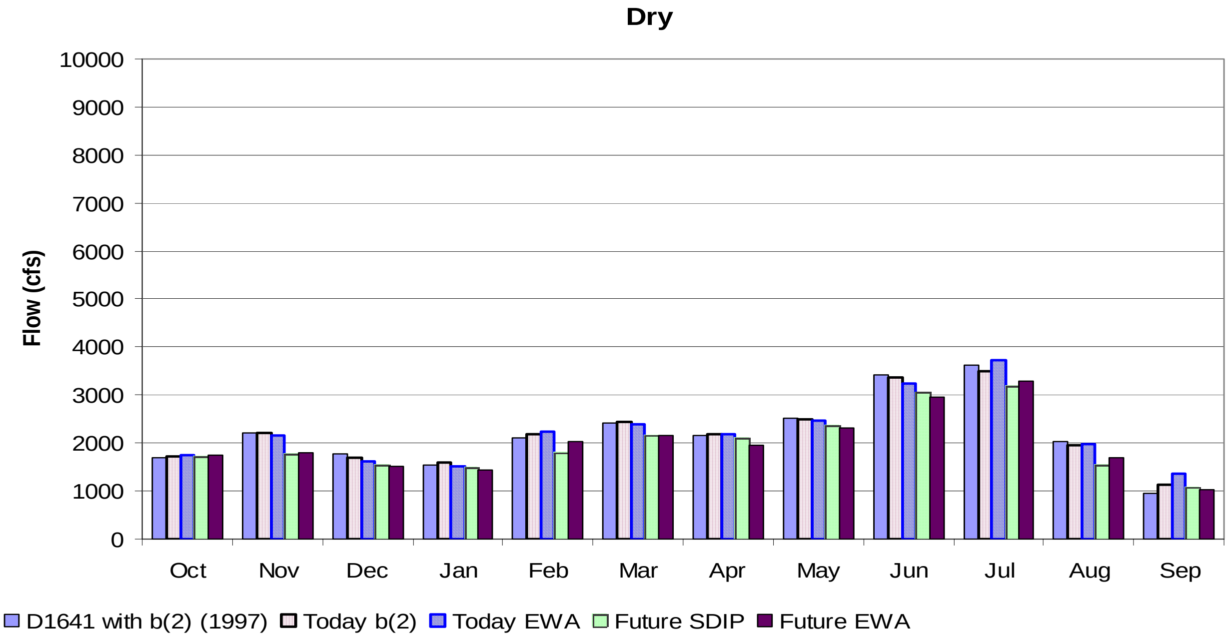


Figure 9-54 Average dry year (40-30-30 Classification) monthly Nimbus Release

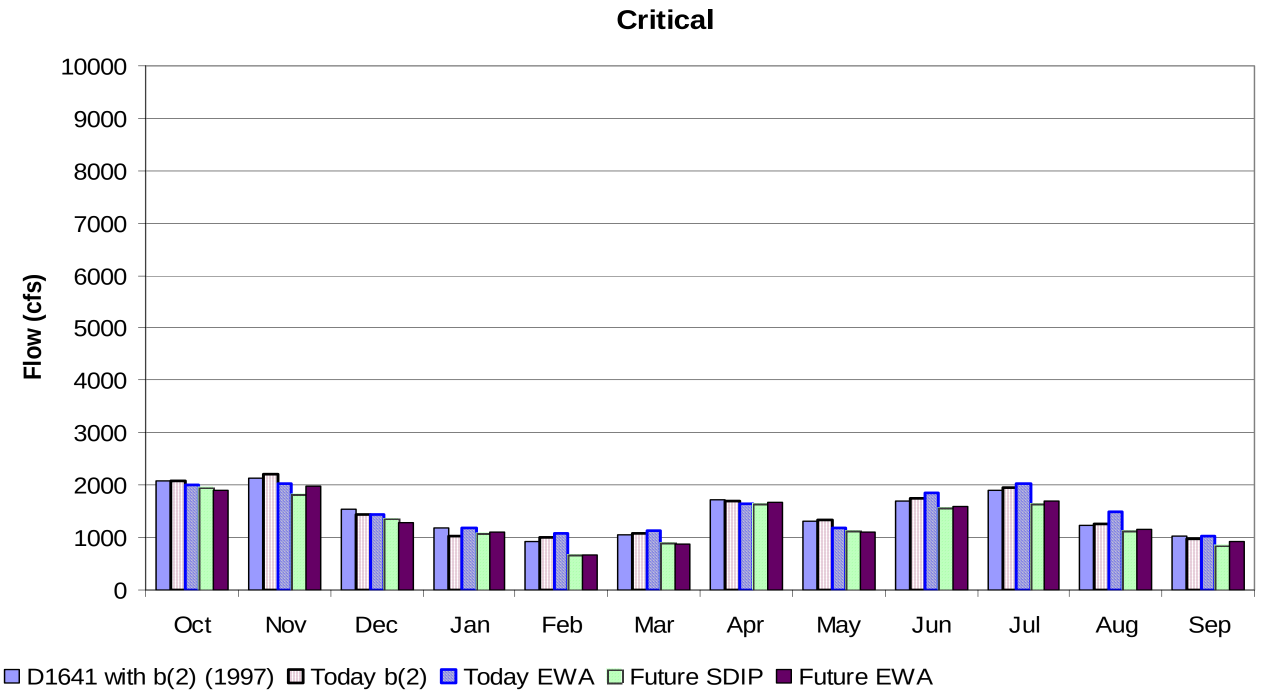
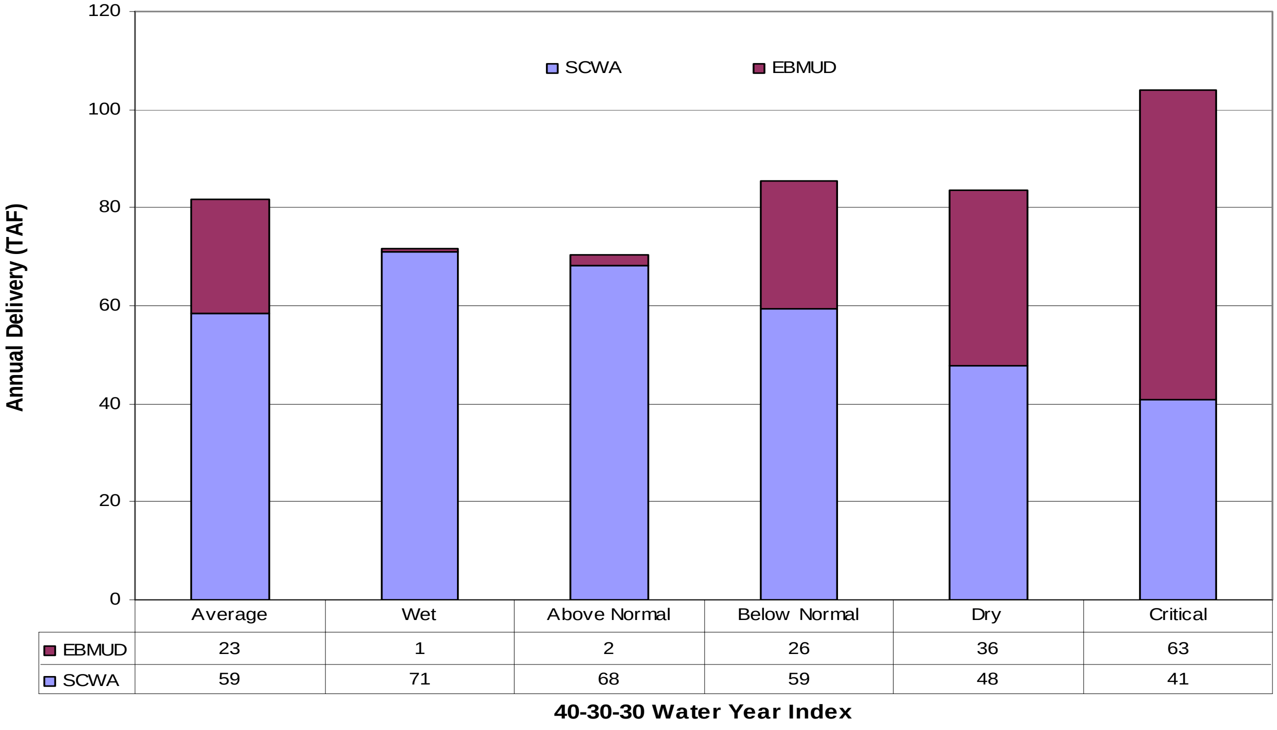


Figure 9-55 Average critical year (40-30-30 Classification) monthly Nimbus Release



	Average	Wet	Above Normal	Below Normal	Dry	Critical
EBMUD	23	1	2	26	36	63
SCWA	59	71	68	59	48	41

Figure 9-56 Average Annual Freeport Diversion for SCWA and EBMUD from Study 4

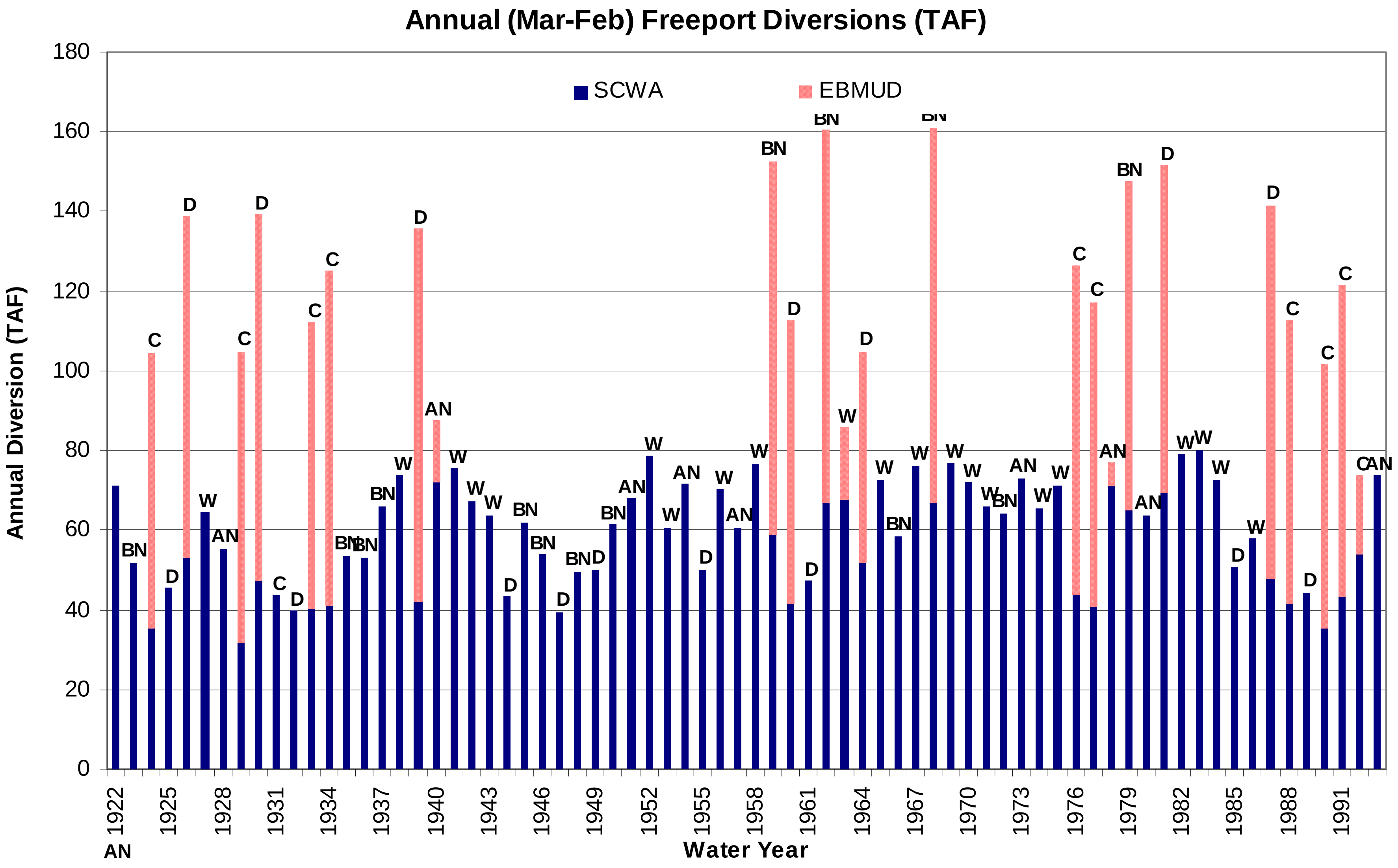


Figure 9-57. Shows the Mar – Feb annual diversions at Freeport for SCWA and EBMUD with 40-30-30 water year classifications

Adult Migration, Spawning, and Incubation

The American River supports a steelheads run but no spring–run or winter–run Chinook. Adult steelheads migration in the American River typically occurs from November through April and peaks in December through March (McEwan and Jackson 1996; SWRI 1997). Predicted flows could drop as low as 500 cfs in up to 10 percent of years and be as high as 33,000 cfs as a monthly average. Flows in the future will be lower in these months with or without EWA. Steelheads spawning habitat area peaks at 2,400 cfs (Table 4–2) but shows very little variability in spawning habitat area between 1,000 and 4,000 cfs. Flows during the spawning period would be below 2,400 cfs in about 30 to 60 percent of years, depending on the month. Average monthly flows could range up over 30,000 cfs in the wettest years with instantaneous flows likely over 100,000 cfs for flood control. The flows over about 50,000 cfs could scour some redds (Ayres Associates 2001), but will provide needed reconfiguration of the channel for long-term maintenance of good spawning and rearing habitat. At the 90 percent exceedance level flows could average as low as 500 cfs. Spawning habitat area was not predicted for flows below 1,000 cfs but spawning habitat would certainly be less and important side channel spawning habitat would be nearly absent. The steelheads population in the American River does not appear to be ultimately limited by spawning habitat availability, but by factors following fry emergence such as summer water temperatures and predation. The number of juvenile steelheads in the river drops quickly at the beginning of the summer, possibly due to predation. Predators likely take more steelheads when the water is warmer. Flow conditions are expected to provide suitable depths and velocities for upstream passage of adults to spawning areas within the lower American River. No migration barriers exist below Nimbus Dam, except when the hatchery picket weir is in operation.

Steelheadss prefer 46° F to 52° F water for upstream migration. Temperatures of 52° F or lower are best for steelheads egg incubation. Average temperatures at Watt Avenue are generally within this range much of the time between December and March. During dry years temperatures in November, March, April, and May would be higher than preferred and could be as high as 71° F in May of warm dry years. Over 90 percent of the steelheads spawning activity is thought to occur during late December through March when temperatures are generally within an acceptable range for spawning (Hannon et al. 2003). Steelheads eggs are in the gravel from December until mid-May. Temperatures from March through May could be above the preferred range for egg incubation at Watt Avenue in about 50 percent of years during March, and in all years in April and May. Fish surveys identify newly emerged steelheads in the American through May indicating that eggs do survive at temperatures above the preferred range. Temperatures are relatively unchanged between all modeling runs during the steelheads spawning and incubation period.

Fall–run Chinook migration typically begins in August and peaks in October, although a few Chinook sometimes show up as early as May. Spawning generally initiates in late October or early November depending on water temperature and continues through December with a few later fish still spawning in January. Chinook-spawning habitat peaks at 1,800 cfs based on PHABSIM studies (Table 4–2). Snider et al (2002) calculated that a flow of 2,625 cfs would best support a spawning population of 70,000 Chinook and that 3,000 cfs provides 340 acres of spawning habitat and 1,000 cfs provides 275 acres of spawning habitat. The extent to which the naturally spawning Chinook population is limited by spawning habitat availability in the American River has not been determined, nor can it be determined without knowing the proportion of adult returns that is hatchery produced each year. Flows of 1,000 cfs or below would occur during October and November in about 20-25 percent of the years. Flows would generally increase after November and through the spring. A flow of 1,200 cfs in 1991 supported a spawning population of 18,145 adult Chinook with an 8 percent superimposition rate (Snider et al 2002). Most spawning occurs in the upper three miles of the river. Under reduced flow conditions in this area fish tend to spawn in overlapping areas rather than extending spawning distribution downstream, resulting in superimposition. Flows in the future would be lower than under present conditions throughout much of the year due to increased diversions upstream of Folsom. Flows in the river could potentially be as low as 300 cfs in May under the driest condition in the future in both scenarios. Most Chinook have left the river by May.

A temperature below 60° F is considered suitable for Chinook spawning and egg incubation in the American River with the preferred temperature being less than 56° F. The primary Chinook spawning area is from Goethe Park upstream to Nimbus Dam, but some spawning occurs downstream as far as mile 5 at Paradise Beach. Monthly average temperatures meet 60° F at Watt Avenue in October in all but 25 percent of the years and in November in all but about five percent of years. Meeting temperature objectives for steelheads during the summer and for Chinook in the fall involves trade-offs between whether to use more cool water during the summer for steelheads rearing or saving some amount of cool water until fall to increase Chinook spawning success. Temperatures during upstream migration are increased in the future scenarios in September and October.

Reclamation manages the cold water pool in Folsom reservoir with regular input from the American River Operations Group. Temperature shutters on each of the power penstocks are raised throughout the summer and fall when needed to provide cool water in the lower American River for steelheads and Chinook. The shutters allow releases to be made from four different levels of the reservoir, depending on the desired water temperature in the lower river.

Flood flows that are not reflected in the operations forecasts have the potential to scour steelheads redds resulting in the injury and mortality of steelheads eggs and sac-fry. Most flood control operations are not expected to result in flow conditions that are likely to create scour (>50,000 cfs). Flow reductions following flood control releases have the potential to dewater redds constructed during the higher flow period. Higher flood control releases over a one or two-day period rather than lower releases over an extended period would preclude steelheads spawning in areas that will be later dewatered. The American River Operations Group can consider such releases. Planning for the normal operations of Folsom Reservoir during this period considers the potential for high flood control releases during spawning and incubation period. Non-flood control operations are typically designed to avoid large changes in flow that may create stranding problems. Because Folsom Reservoir is the closest water source to the Delta, releases from Folsom can be needed to maintain delta water quality requirements when delta water quality deterioration occurs. Once requirements are met or increased flows from other reservoirs make it to the delta Folsom releases can be cut back to conserve storage, sometimes affecting fish or redds in the river. CVPIA section (b)(2) water may be used during this period to support higher flows or avoid reductions that otherwise would be made. Dewatered steelheads redds likely lowered the number of steelheads fry produced in 2003. The limiting period to in-river steelheads production seems to occur after fry emergence.

Fry, Juveniles, and Smolts

The freshwater life stages of steelheads occupy the American River throughout the year. Most literature has indicated that rearing fry and juvenile steelheads prefer water temperatures between 45°

F and 60° F (Reiser and Bjorn 1979; Bovee 1978; Bell 1986). However, Myrick (1998) found the preferred temperatures for Mokelumne River Hatchery steelheads placed into thermal gradients were between 62.6° F and 68° F. NOAA Fisheries generally uses a daily average temperature of 65° F at Watt Avenue as a temperature objective for steelheads rearing in the American River and then adjusts the temperature objective and point depending on Folsom cold-water pool each year. Temperatures could exceed a monthly average of 65° F at times between May and October with the highest temperatures of up to 75° F in occurring in July and August of years with a low cold-water pool storage in Folsom. Temperatures are modeled to be almost always higher than 65° F at Nimbus Dam in July through September. Temperatures would exceed 70° F during July in 20 percent of years and in August in 50 percent of years at Watt Avenue. These high summer temperatures are likely what limits the naturally spawned steelheads population in the American River. Monitoring during 2001 and 2002 indicated that steelheads did not appear to be finding water cooler than that found in the thalweg and they persisted below Watt Avenue in water with a daily average temperature of 72° F and a daily maximum over 74° F. Water temperature in the future runs is predicted to be approximately 1° F warmer from July to October and about 0.5° F warmer in June and November. Temperatures are about the same with and without EWA. Temperatures the rest of the year will be relatively unchanged. The increased temperatures will put additional temperature stress on rearing steelheads during summer and adult Chinook holding and spawning. Due to the high temperatures the steelheads run in the American River will likely remain primarily supported by the hatchery.

Juvenile salmon emigration studies using rotary screw traps in the lower American River at Watt Avenue generally capture steelheads fry from March through June while steelheads yearlings and smolts emigrate from late December till May, with most captured in January (Snider and Titus 2000). Specific flow needs for emigration in the American River have not been determined. Steelheads emigrate at a relatively large size so are good swimmers and presumably do not need large pulses to emigrate effectively from the American River as long as temperatures are suitable through the lower river and in the Sacramento River. Modeled flows are expected to provide suitable depth and velocity conditions for emigration during most years. Flows could drop below 1,000 cfs between December and May in about 5 to 15 percent of years depending on month. Low flows would occur slightly more often in the future than under current operations. Reductions could be as great as 700 cfs in February with EWA and would result in significantly less rearing habitat available in dry years. This would probably affect juvenile salmon more than juvenile steelheads due to the high salmonid densities. The habitat is generally not fully seeded with steelheads fry. December through March forecast mean monthly temperatures are expected to be generally within the optimum smoltification and emigration range (44° F to 52° F) during most years but temperatures may exceed 52° F in February in about 10 percent of years and in about 50 percent of years in March. No change in temperatures between current and future operations during December through March is expected to occur.

Rearing steelheads fry and juveniles can be exposed to stranding and isolation from main channel flows when high flows are required for flood control or Delta outflow requirements and then subsequently reduced after the requirement subsides. After high flow events when rearing steelheads fry and juveniles issues are a concern, Reclamation coordinates flow reduction rates utilizing the B2IT and American River Operation Group adaptive management processes to minimize the stranding and isolation concerns versus current hydrologic conditions and future hydrologic projections to Folsom cold-water management. Reclamation attempts to avoid flow fluctuations during non-flood control events that raise flows above 4,000 cfs and then drop them back below 4,000 cfs as recommended by

Snider et al (2002). Flow fluctuations are sometimes difficult to avoid with competing standards to meet in the Delta and upstream so some stranding will continue to occur.

Chinook fry generally emerge from the gravel starting in late December, peaking in February and continuing up through March (Snider and others 1997, Snider and others 1998, Snider and Titus 2000). More than 99 percent of the Chinook fry emigrate from the river as pre-smolts. Peak emigration occurs around late February. Nearly all Chinook leave the river before the end of June. Preferred temperature for juvenile Chinook is 53° F to 57.5° F (Boles and others 1988). Water temperature generally exceeds this range starting in April of over 50 percent of years. The majority of Chinook (>90 percent) leave the river prior to April. Although most Chinook leave before April, those that stay in the river longer grow larger before emigration so survival through the Delta is likely better than for smaller fish. As mentioned above the temperature control shutters have the capability to provide water within the preferred range for Chinook rearing. The timing of cool water releases through the year involves trade-offs between providing cool water for the Chinook life cycle or providing cool water so that juvenile steelheads can survive in the river through the warm summer months.

The Chinook egg mortality model results for the American River indicate that Chinook egg to fry water temperature related mortality will increase during all except critically dry year types in the future (Figure 9–58). The increase in mortality is greatest in the wettest year types. The effect of decreased egg to fry survival on the returning adult population is impossible to determine because there is currently no marking program to determine what proportion of the returning adults consists of naturally spawned fish versus hatchery fish.

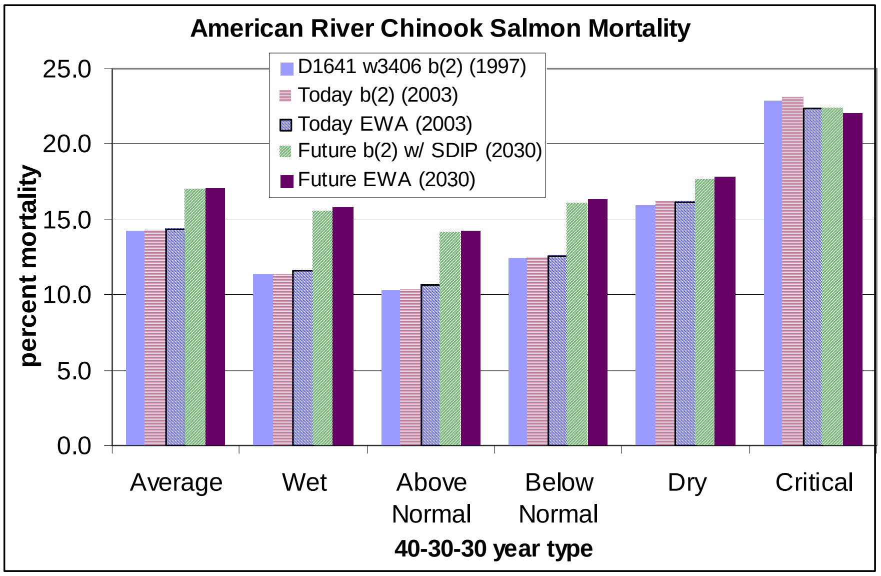


Figure 9–58 Percent mortality of Chinook salmon from egg to fry in the American River based on water temperature by water year type.

Mokelumne River

Mokelumne River information is included in this assessment because the new diversions from the Sacramento River at Freeport will be affected by the change in EBMUD operations in the Mokelumne River.

Adult steelheads begin to immigrate up the Mokelumne River in August with peak upstream migration in December through February. Spawning occurs December through March with the peak in January and February (EBMUD data). Flow releases from Camanche Dam are not controlled by Reclamation so release data was not available. Delta inflow data from Mokelumne is available but is not representative of releases at Camanche Dam. Diversions downstream of Camanche Dam remove much of the water so that delta inflow is generally less than what is released from Camanche Dam. Delta inflow from the Mokelumne is less than 50 cfs in about 70 percent of years in November, 40 percent of years in December, 30 percent of years in January, 25 percent of years in February, 20 percent of years in March 8 percent of years in April and May. At times there would be no inflow to the Delta during November through March when adult steelheads are migrating upstream. Low Delta inflow could result in steelheads returning to the Mokelumne not being able to find the river in years of low inflow and Mokelumne Hatchery fish showing up in other rivers. This may be why steelheads returns (hatchery and wild) have been below 100 fish greater than 380 mm since 1999 (EBMUD data). For the steelheads that make it into the upper river, based on past release data reservoir releases are generally greater than 200 cfs and provide adequate flow for spawning and incubation. Delta inflow is projected to be generally slightly higher in the future. EBMUD indicated that releases to the river will be improved in the future with the extra water from the Freeport Diversion. Twenty percent (up to 20,000 acre-feet) of the amount of water diverted at Freeport will be made available for Camanche Reservoir releases to the Mokelumne. EBMUD provides an extensive fisheries monitoring and restoration program in the Mokelumne River to better understand the life cycle and assist in recovery of steelheads.

Steelheads fry were found to emigrate from the Mokelumne River in the spring, primarily April through June and sub-yearling smolts emigrate April through June. Fewer juveniles stay in the river the rest of the year to emigrate as yearlings. Mokelumne flows are intended to maintain suitable rearing habitat through the year but specific flow information is not available. Delta inflows would exceed 50 cfs during March in 75 percent of years, during April 92 percent of years, and during May and June in most years.

Stanislaus River

Modeling

Between the five studies there is no change in operations on the Stanislaus and no significant effects of the previously mentioned changes in assumptions. Figure 9-59 shows the chronology of New Melones and Figure 9-60 shows the End of September exceedance plot. Both figures show that there are no significant differences in storage between the five studies. Figure 9-61 shows the percentile values for the releases out of Goodwin Reservoir and Figure 9-62 to Figure 9-67 show the monthly averages by 60-20-20 water year types. The Goodwin release graphs also show no significant effect to operations between the five studies.

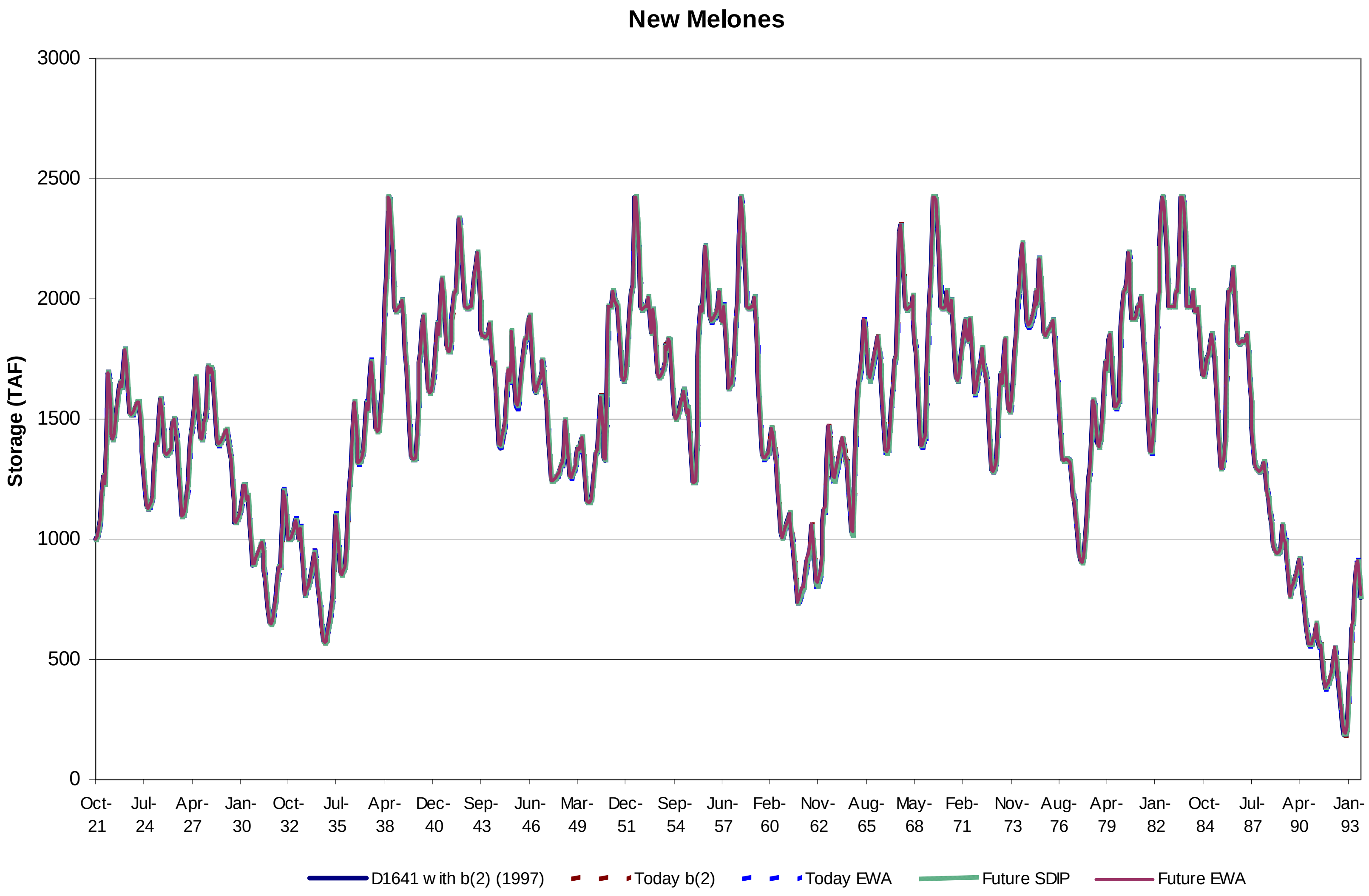


Figure 9-59 Chronology of New Melones Storage Water Year 1922 - 1993

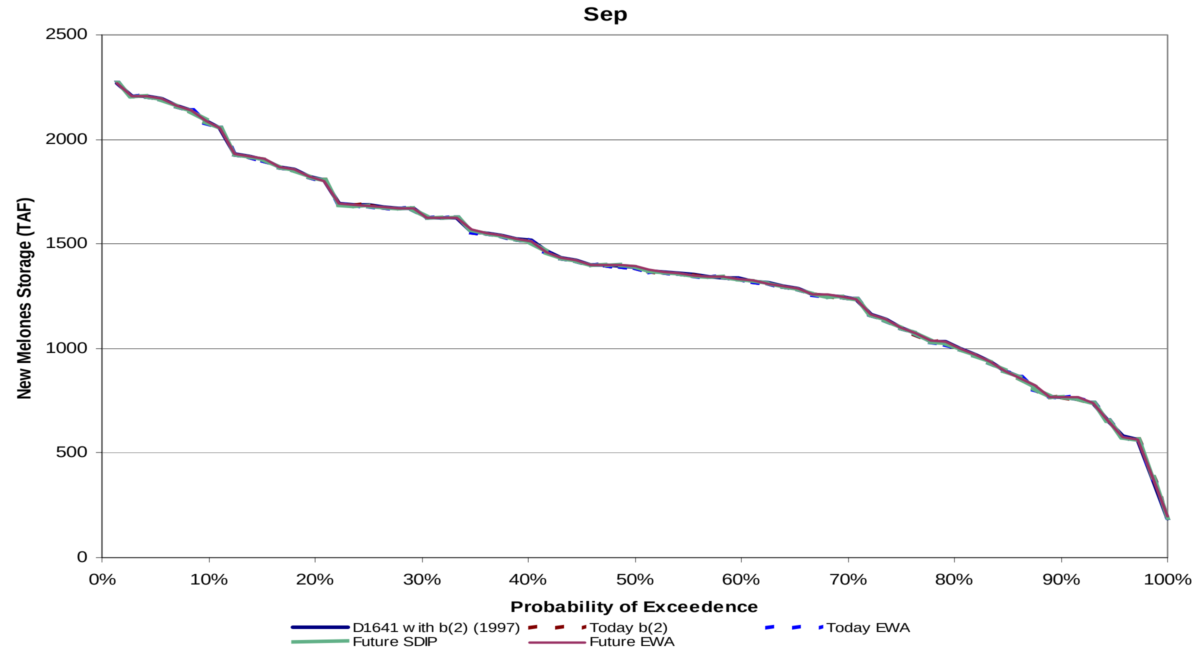


Figure 9-60 New Melones Reservoir End of September Exceedance

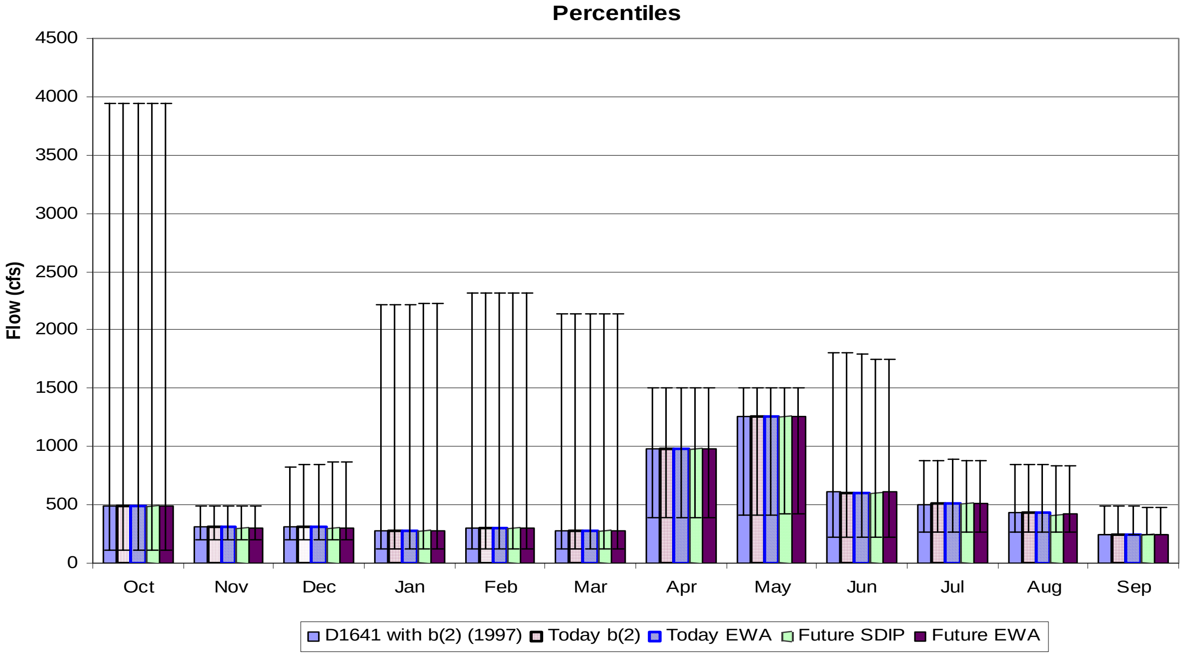


Figure 9-61 Goodwin Releases 50th Percentile Monthly Releases with the 5th and 95th as the bars

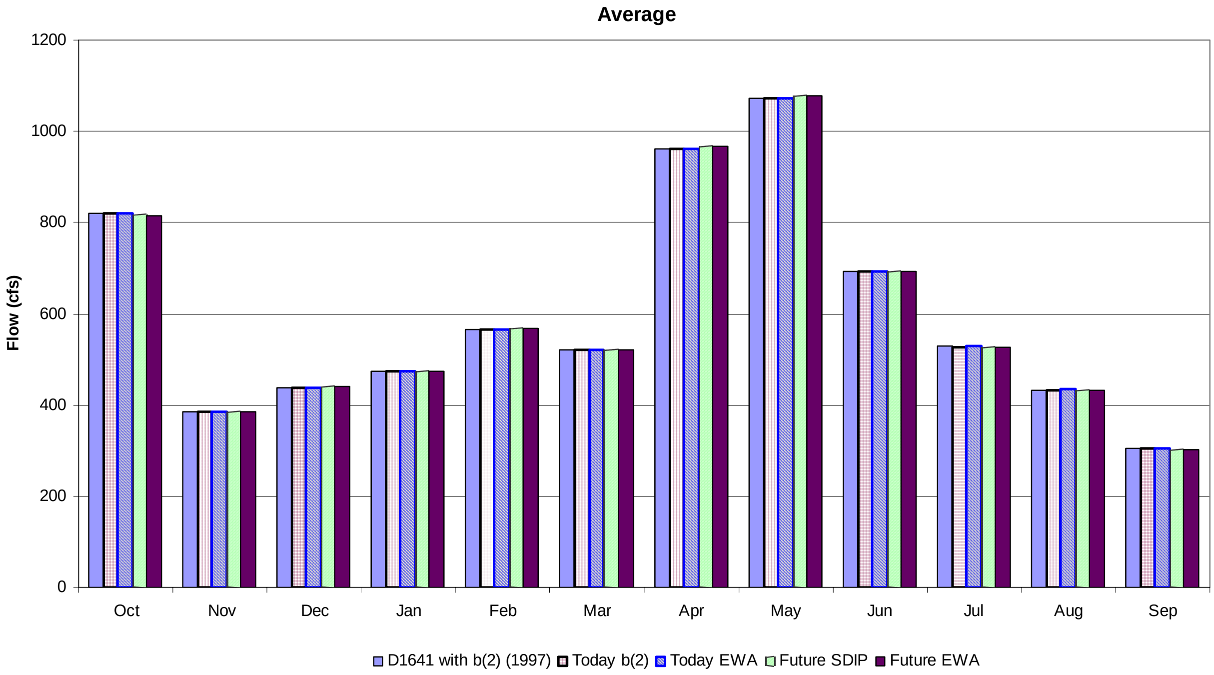


Figure 9-62 Average Monthly Goodwin Releases

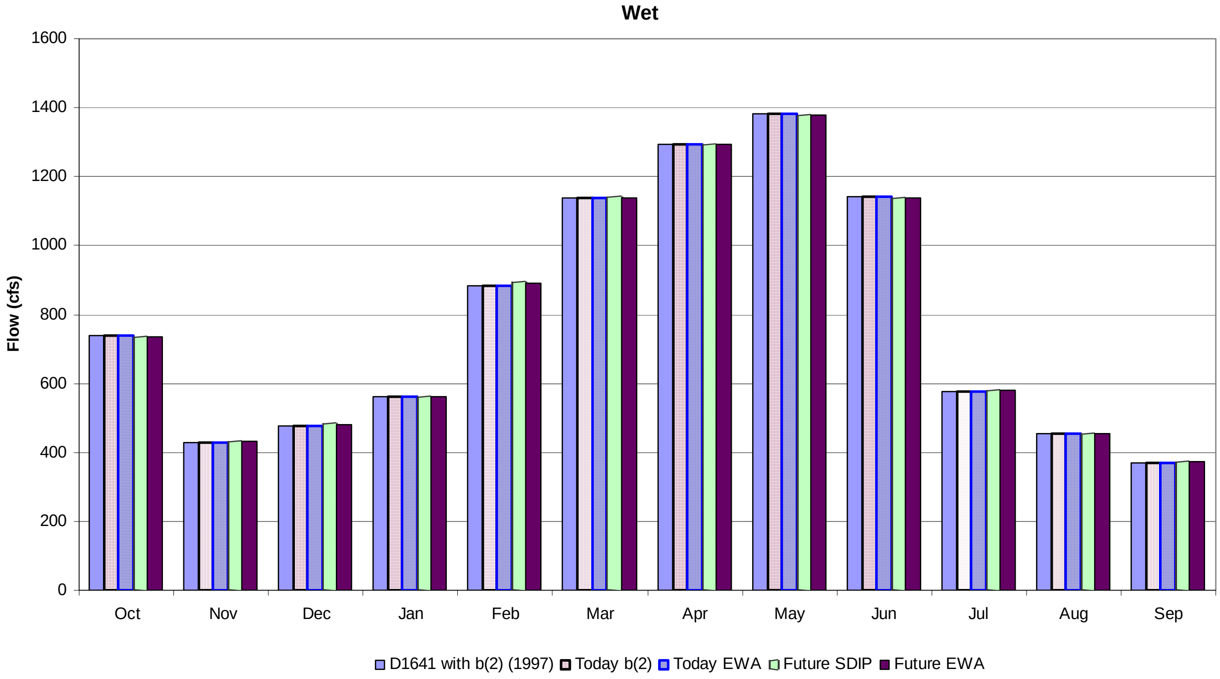


Figure 9-63 Average wet year (40-30-30 Classification) monthly Goodwin Releases

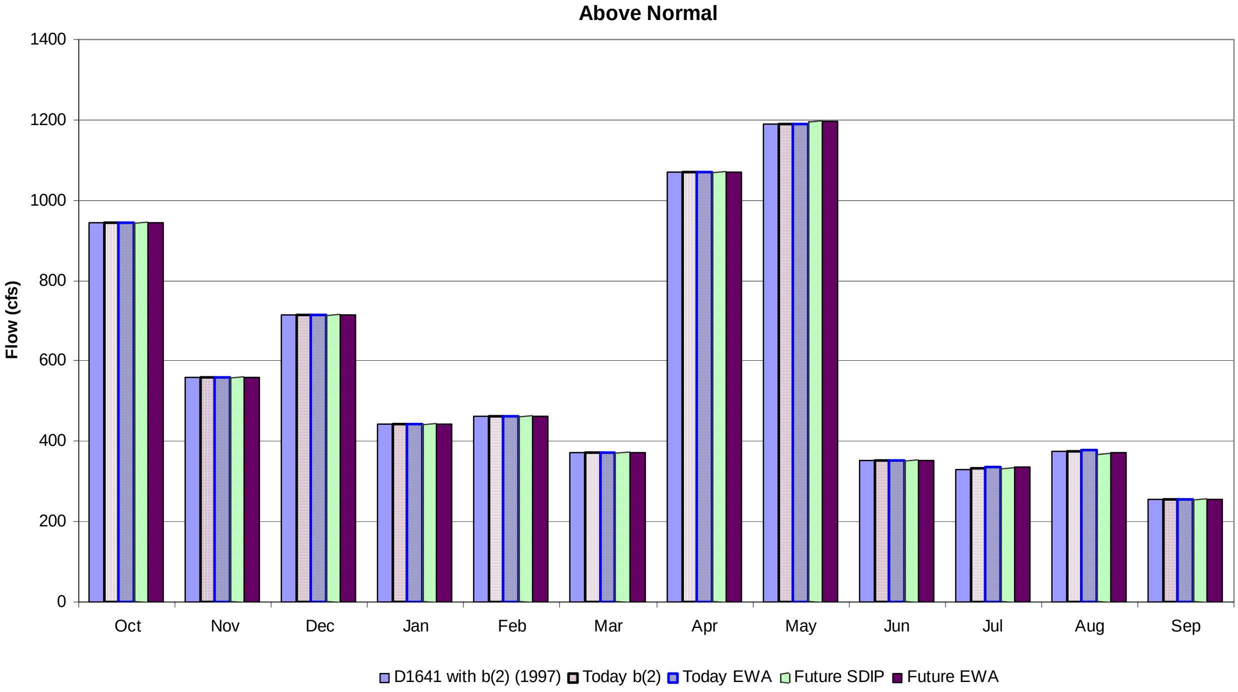


Figure 9-64 Average above normal year (40-30-30 Classification) monthly Goodwin Releases

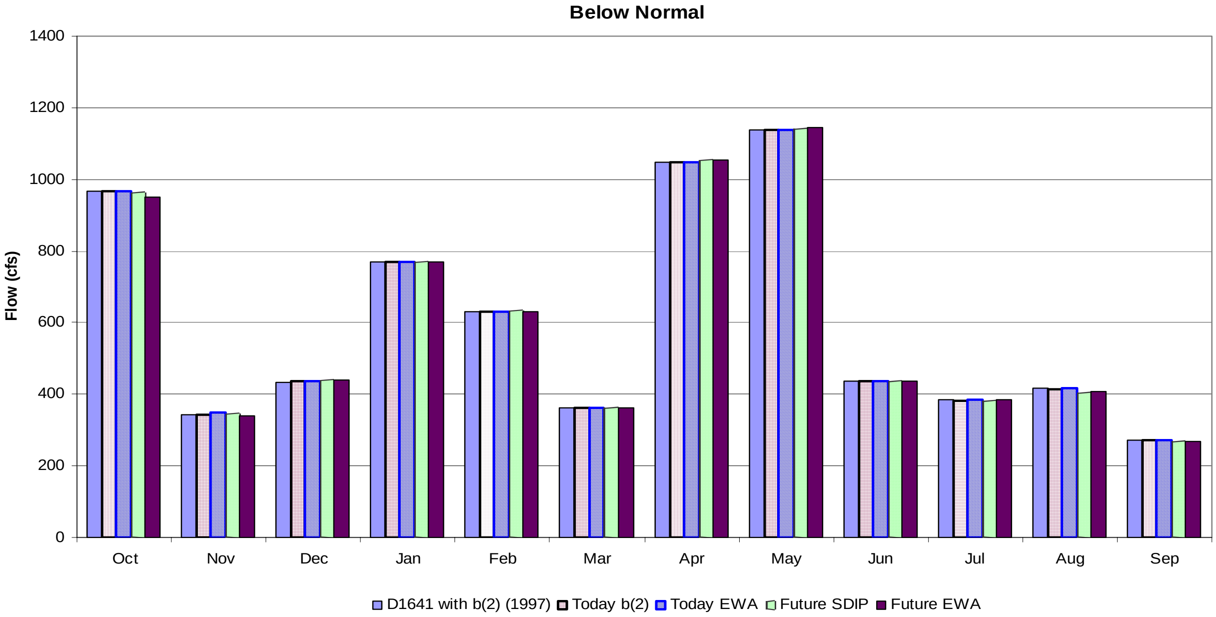


Figure 9-65 Average below normal year (40-30-30 Classification) monthly Goodwin Releases

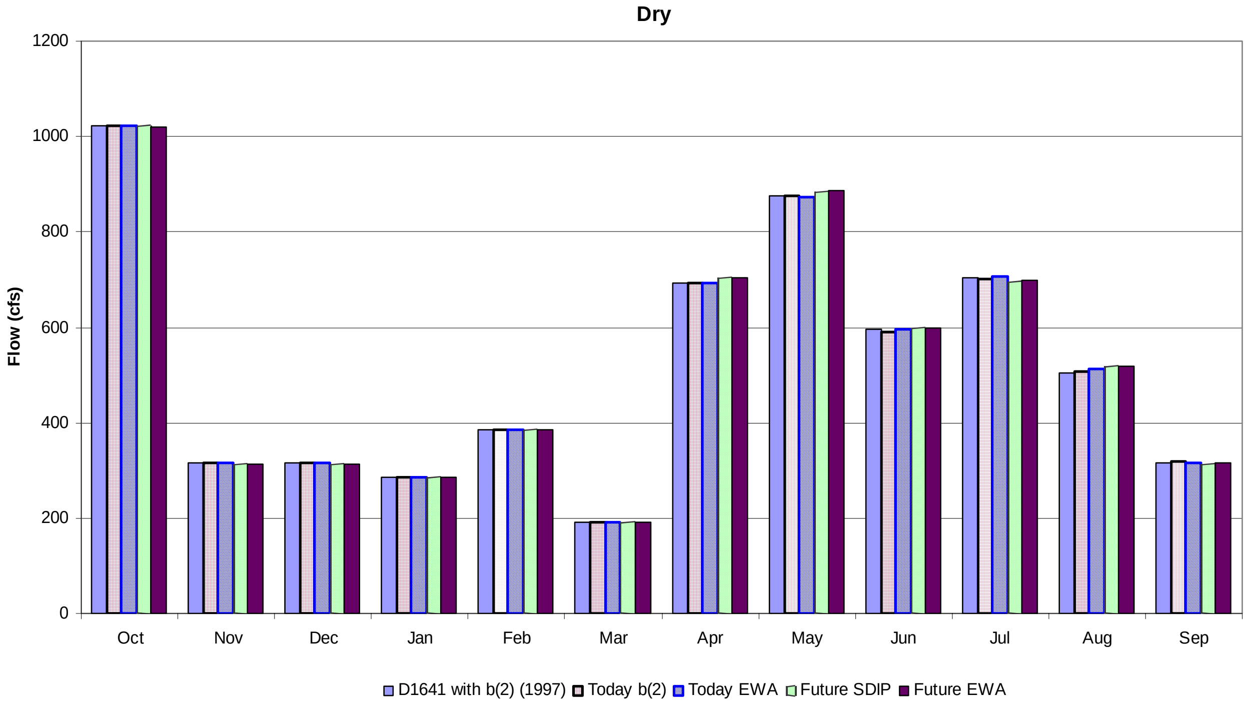


Figure 9-66 Average dry year (40-30-30 Classification) monthly Goodwin Releases

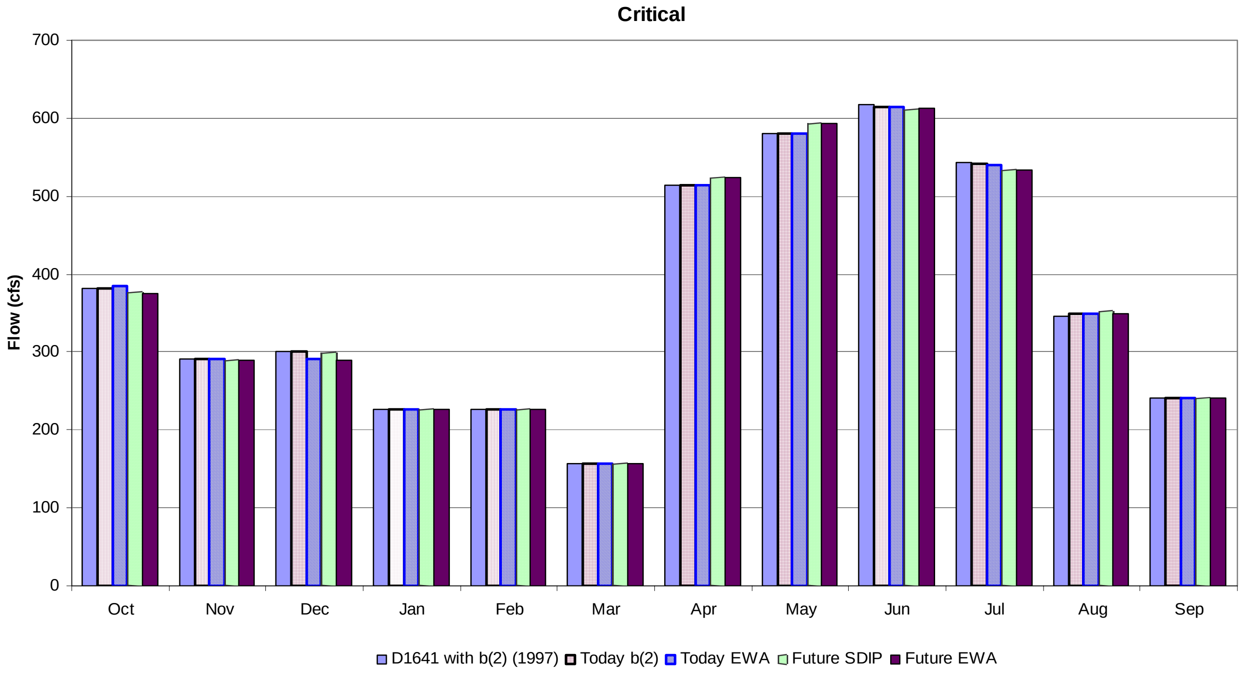


Figure 9-67 Average critical year (40-30-30 Classification) monthly Goodwin Releases

Adult Migration, Spawning, and Incubation

Steelheads life history patterns in the Stanislaus River and the rest of the San Joaquin River system are only partially understood, but studies are underway to determine steelheads populations, extent of anadromy, and run timing. Resident rainbow trout are abundant in the first 10 miles downstream from Goodwin Dam. Anglers report catches of adults that appear to them to be steelheads based on large size and coloration. Rotary screw traps at Oakdale and Caswell catch downstream migrating steelheads with smolting characteristics each year. Because the full life cycle of steelheads is not known for the Stanislaus, some life history patterns from Sacramento River steelheads are used in this assessment. The Stanislaus River receives the highest year-round flows and has the coolest water of the three major San Joaquin tributaries. A high population of resident trout in the Stanislaus indicates conditions are favorable year round for the resident form of the species.

A weir was installed near Riverbank during part of the 2002-2003 run. Permitting issues prevented weir operations during the anticipated primary upstream migration period. No steelheadss were captured at the weir during the 2002-2003 run. Take authorization for steelheads monitoring using the weir and rotary screw traps will be needed for continuation of the monitoring program.

There is essentially no difference in Goodwin releases between the five modeling scenarios. Stanislaus operations will be the same in the future as they are now. Steelheadss in Sacramento River tributaries migrate upstream to spawn primarily between December and March. Spawning occurs during this period and may extend through April. Based on trout fry observations in Stanislaus snorkel surveys, spawning timing appears to be about the same in the Stanislaus. Goodwin Dam releases during this period would be mostly from 200 to 500 cfs in December and 125 to 400 cfs in January through March. Flows in April and May would be between 400 and 1,500 cfs. Steelheads spawning flows were estimated to be maximized at 200 cfs and in stream habitat for adult migration and rearing was estimated to be maximized at 500 cfs (Table 4–3). Spawning or holding habitat for adult steelheads is not likely limiting in the Stanislaus because the anadromous component of the population does not appear to be large. Monthly mean flows as high as 5,000 cfs and as low as 125 cfs could occur throughout the range of precipitation regimes. Flows above about 5,000 cfs could affect egg survival in redds or scour some redds. Spawning occurs on a number of gravel addition sites. Bed mobility flows are likely lower at these sites until the initial high flows distribute the gravel in a more natural manner. The flows as low as 125 cfs in 90 percent exceedance years and dryer would still provide some spawning habitat for steelheadss. The recommended spawning flows for rainbow trout were 100 cfs (Table 4–3). Low flows for upstream migration and attraction during dry years may result in fewer steelheadss reaching the spawning areas. During years when flows are low in the Stanislaus they would likely be low in other rivers so that Stanislaus flows should still be a similar proportion of total San Joaquin River flow and Delta outflow.

During low flows from the San Joaquin River dissolved oxygen sometimes reaches lethal levels in the Stockton deep-water ship channel. The low DO can cause a barrier to upstream migrating steelheads and Chinook so that they are delayed or migrate up the Sacramento River or other tributary instead. Flows from the Stanislaus help to address the low DO problem by meeting the Vernalis flow standard when possible, although there is not always enough water available from New Melones to meet the flow standard at all times.

Chinook begin to enter the Stanislaus River in August and the peak in upstream migration occurs in October. Adult Chinook have occasionally been documented in the river as early as May but these fish are believed to be strays from Feather River. Most spawning occurs in November and December. The lowest flows modeled would occur in October and could be as low as 110 cfs. Chinook should still be able to migrate upstream at this flow provided temperatures are suitable and enough water is coming out of the mouth of the river for attraction. Other rivers would likely be proportionately lower in the same years so the proportion of Stanislaus River water in the San Joaquin and Delta should be similar. Flows during November and December would be as low as 200 cfs in about 25 percent of the years. Aceituno (1993) estimated that 200 cfs would provide the maximum amount of spawning habitat for Chinook and 150 cfs would be best for incubation and fry rearing. Between January and March flows could drop down to 125 cfs. This should provide sufficient flow to keep most redds that were constructed at 200 cfs underwater. The configuration of the Stanislaus River channel is such that dewatering of spawning areas is an uncommon occurrence. Most of the channel perimeter remains wetted at low flows.

No change in Stanislaus River temperatures is projected to occur between any of the model runs. Temperatures at Orange Blossom Bridge would be 52° F or below most of the time from December to February. In March and April temperatures would exceed 52° F in about 45 percent of years and in May in 80 percent of years. Because these temperatures are unchanged from past operations and the Stanislaus River supports a large trout population year round with these temperatures, these temperatures appear to provide sufficient cold water for the current trout population. Figure 9–68 shows Chinook temperature model results. There is no difference in mortality between the modeled scenarios.

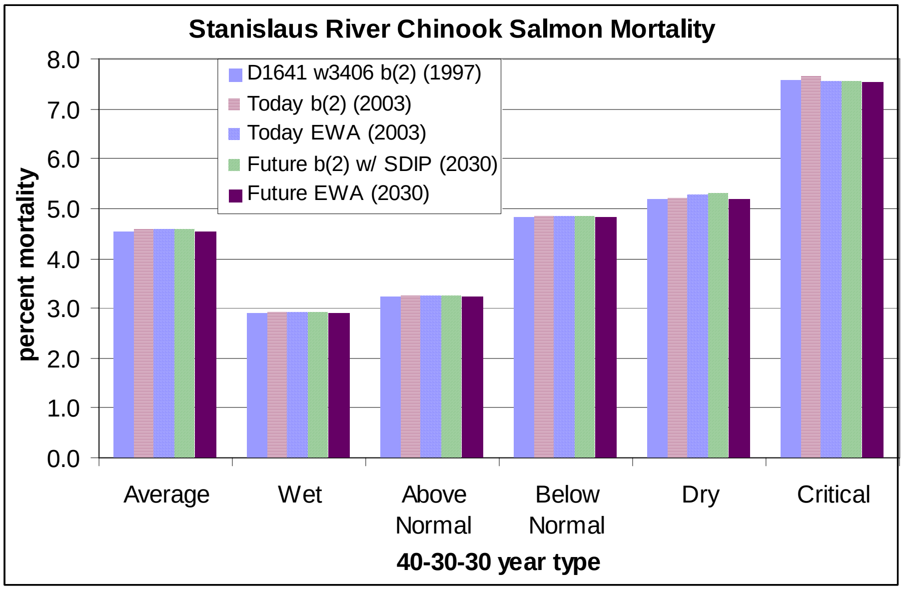


Figure 9–68 Temperature related mortality of fall–run Chinook salmon eggs in the Stanislaus River.

Fry, Juveniles, and Smolts

Most literature has indicated that rearing fry and juvenile steelheads prefer water temperatures between 45° F and 60° F (Reiser and Bjorn 1979; Bovee 1978; Bell 1986). However, Myrick (1998) found the preferred temperatures for Mokelumne River Hatchery steelheads placed into thermal gradients were between 62.6° F and 68° F.

Snorkel surveys (Kennedy and Cannon 2002) identified trout fry starting in April in 2000 and 2001 with the first fry observed in upstream areas each year. During 2003 a few trout fry were identified as early as January but most did not appear until April as in 2000 and 2001. Rotary screw trap fishing at Oakdale and Caswell has captured rainbow trout/steelheads that appear to exhibit smolting characteristics (Demko and others 2000). These apparent smolts are typically captured from January to mid-April and are 175 to 300 mm fork length. Because steelheads smolts are generally large (>200 mm) and strong swimmers, predicted Goodwin Dam releases are expected to provide adequate depth and velocity conditions for emigration at all times. Spring storms that generally occur during this period provide pulse flows from tributaries below Goodwin Dam that will stimulate and assist in out migration. The lowest flows predicted between January and April would be 125 cfs. Flows would pick up in mid-April for the VAMP period and provide an out migration pulse for any steelheads smolts still in the river that late.

Smolts are thought to migrate through the lower reaches rather quickly so should be able to withstand the few days of warmer temperatures when migrating to the estuary or ocean. The current temperature compliance point is 65° F at Orange Blossom Bridge. Temperatures would be below 65° F through July. In August and September temperatures could exceed 65° F at Orange Blossom in about 1 percent of years. Year round temperatures for steelheads in the upper river above Orange Blossom Bridge are suitable for steelheads rearing. Once steelheads reach the ocean, the ocean temperature in February through May outside San Francisco averages about 52° F (San Francisco buoy data).

Chinook fry rearing and out migration occurs from January through June with peak out migration generally occurring around February (Demko and others 2000). Flows during this period would be a minimum of 125 cfs and would be this low in about 20 percent of years. Aceituno (1993) found that a release of 200 cfs would maximize juvenile Chinook rearing habitat. The lower flows in the 125 cfs range could lower fry survival to out migration if sufficient peak flows do not occur from tributaries to stimulate out migration. When pulse flows do not occur during the fry life-stage the fry may remain in the river rather than outmigrating as fry (Demko and others 2000). This situation could result in increased mortality from in-river predation. No one knows whether it is more advantageous to have a large number of fry out-migrate early in the year or a small number of larger smolts leave later in the spring. Higher flows are provided during April and May as part of the VAMP. These flows will assist in out migration of smolts and late emerging fry from the Stanislaus. These high flows may be too late in the year for many of the Chinook fry in the Stanislaus (data provided by SP Cramer 2001). Studies are underway in the Stanislaus to determine the best springtime flow regimes to maximize survival of outmigrating Chinook.

San Joaquin River

Adult Migration, Spawning, and Incubation

The modeling shows essentially no difference in flows in the San Joaquin River between the modeled scenarios. Steelheads life history patterns in the San Joaquin River system are only partially understood, but studies are underway to determine steelheads populations, extent of anadromy, and run timing. Steelheads/rainbow populations exist in the San Joaquin tributaries and a few smolt-sized fish get captured by trawling in the lower river near Mossdale (Figure 3-10). Adult steelheads are assumed to migrate up the San Joaquin River in late fall and winter, after temperatures and dissolved oxygen conditions become suitable for migrations to occur. Spawning, although not well documented, likely occurs in the tributaries primarily from January through March. No steelheads spawning or incubation occurs in the main stem San Joaquin River.

Supplemental water released down the Stanislaus River per D-1641 in October will generally provide conditions (attraction flow, lower temperature, and higher dissolved oxygen) in the lower San Joaquin River and through the Stockton Deep-water Ship Channel suitable for upstream migrating steelheads. During November and through the rest of the upstream migratory period ambient cooling generally provides suitable conditions for migrations up through the San Joaquin. Prior to the October pulse, conditions in the lower San Joaquin and Stockton Deepwater Ship Channel are sometimes unsuitable for migrating steelheads (Lee 2003). Early returning fish could be delayed or stray to the Sacramento River tributaries when San Joaquin River conditions are unsuitable. Based on initial results from the Stanislaus River weir (no steelheads identified during September through November 2003) early returning steelheads are not expected to make up a high proportion of the run. During pre-dam days temperatures were likely higher and flows in the lower San Joaquin were likely lower than what occurs currently (although dissolved oxygen was probably not as much of an issue then) so there were not likely historically steelheads returning to the San Joaquin during late summer and fall before ambient cooling occurred.

Fry, Juveniles, and Smolts

Habitat conditions in the San Joaquin River do not appear well suited to young steelheads rearing. Fry and juvenile steelheads rearing for long periods in the San Joaquin River is not likely a common occurrence. The river likely serves primarily as a migratory corridor for smolts heading to saltwater. Out migration from the San Joaquin tributaries to saltwater probably occurs from November through May. The lowest flows during this period would be 1,030 cfs in January of 1 percent of years. The 50th percentile flows range from about 1,800 cfs in December to 5,000 cfs in April. The larger size of steelheads smolts makes them stronger swimmers than juvenile salmon so they should be better able to out-migrate during the low water velocity years when flows are lower. Conditions during the summer and fall are not conducive to successful out migration because water is warmer and dissolved oxygen sags occur.

Drought Period Operations

Operational flexibility of the CVP to meet seasonal flow and temperature needs of salmonids is severely limited in dry and critically dry years, see the Adaptive Management section in Chapter

2. During drought periods, CVP operations are driven by minimum fish flow releases, temperature requirements, water right deliveries (at reduced levels), and Delta water quality requirements. Under these dry conditions, there is no operational flexibility in the CVP/SWP system as it is over-committed, and storage must be drawn down to meet legally mandated requirements and non-discretionary actions. As Shasta storage drops and the cold water pool reserve is depleted, Sacramento River in stream temperatures increase to a level deleterious to cold water fish species such as winter and spring run Chinook salmon and steelheads. Further, recent court rulings on the use of Trinity River water have resulted in reduced availability of cold water inputs into the Sacramento River system from the Trinity River

The following actions serve to guide Reclamation's operations of the CVP during periods of drought, and are intended to provide either direct or ancillary benefits to listed fish species and help minimize adverse effects associated with elevated in stream temperatures. These actions are non-discretionary and driven by existing regulation or mandated environmental commitments.

Sacramento River watershed:

- Minimum flow releases of 3,250 cfs on the Sacramento River below Keswick Dam from October 1 through March 31 during all water year types (per the 1993 NOAA Fisheries winter-run Chinook salmon biological opinion). Additional RPA's define ramping constraints for Keswick releases.
- Maintain a minimum end-of-water-year (September 30) carryover storage in Shasta Reservoir of 1.9 million acre-feet (per the 1993 NOAA Fisheries winter-run Chinook salmon biological opinion). In the driest years when this amount of water is not available to retain in storage, Reclamation is required to re-consult with NOAA Fisheries in order to determine the most appropriate actions for continued protection of salmonids during critical months of their life cycle.
- D-1641 of the SWRCB Water Quality Control Plan of 1994, which requires minimum water quality standards, is maintained in the Delta. During dry years, much of Shasta's releases may go toward meeting this purpose, as Folsom Reservoir holds only 1 MAF and New Melones is already severely over appropriated.
- Implementation of the CVP water shortage policy: (1) M&I allocations are decreased to a maximum of 50 percent for basic health and safety; (2) irrigation allocations are decreased 25 percent or a maximum of 100 percent; and (3) water rights settlement and exchange contractors and wildlife refuges are reduced a maximum of 25 percent .
- Maintain a minimum navigation flow requirement of 5,000 cfs at Wilkins Slough on the Sacramento River under all but the most critical water supply conditions in order to keep agricultural diversion pumps in the water. While no criteria have been established for critically dry years, Reclamation can relax the standard to a minimum flow target of 3,500 cfs for short durations in order to conserve water storage in Shasta Reservoir and manage for multiple project and environmental objectives.
- Establishment of the Sacramento River Temperature Task Group (consisting of Reclamation, NOAA Fisheries, FWS, DFG, Western, DWR, and the Hoopa Indian Tribe) to formulate, monitor, and coordinate temperature control plans for the upper Sacramento and

Trinity rivers in order to best manage cold water resources based on the location of spawning Chinook salmon.

In dry and critically dry water years, operation of the Shasta Temperature Control Device has limited effectiveness because Shasta storage is reduced so significantly there ceases to be a cold water pool to draw from. Additionally, environmental water under both section 3406 b (3) of CVPIA and Calfed's Environmental Water Account (EWA) is not available for acquisition.

San Joaquin River Watershed:

- D-1422 issued by the SWRCB requires a minimum release of 69,000 acre-feet from New Melones Reservoir on the Stanislaus River during critically dry years. This was superceded by a 1987 Agreement between Reclamation and DFG providing a minimum of 98,300 acre-feet per year from New Melones Reservoir. D-1422 also requires water releases from New Melones Reservoir on the Stanislaus River to meet established minimum dissolved oxygen concentrations on the Stanislaus River, and total dissolved solids in the San Joaquin River at Vernalis.
- Implementation of the CVP water shortage policy: (1) M&I allocations are decreased to a maximum of 50 percent; (2) irrigation allocations are decreased 25 percent or a maximum of 100 percent; and (3) water rights settlement and exchange contractors and wildlife refuges are reduced a maximum of 25 percent . Be careful here as the Friant Division has its own CVP water allocation that is independent of the overall CVP.
- Bay-Delta Vernalis Flow Requirements. SWRCB D-1641 sets flow requirements on the San Joaquin River at Vernalis from February to June. These flows are commonly known as San Joaquin River base flows. During critically dry and dry water years the flows range from 710 to 1140, and 1420 to 2280, respectively.
- Vernalis Adaptive Management Plan (VAMP) providing 31-day pulse flows during April and May of each year. Target flow at Vernalis for the spring pulse flow period is determined each year and adapts to prevailing hydrologic conditions. The minimum target flow in the agreement is 2000 cfs. The VAMP program also includes Delta pumping limitations during the pulse flow period. A maximum pumping limitation of 1500 cfs is enacted in drought years when pulse flows are a minimum of 2000 cfs.

The current goal for temperature management on the lower Stanislaus River is 65° F at Orange Blossom Bridge for steelheads incubation and rearing during the late spring and summer. This goal is often unachieved due to an insufficient cold-water pool in New Melones Reservoir resulting from competing environmental and project demands for New Melones water.

Chapter 10 CVP and SWP Delta Effects on Steelhead, Chinook Salmon, and Delta Smelt

This section addresses the effects associated with Delta pumping on steelhead, spring and winter run Chinook salmon, and delta smelt. Fish monitoring programs for CVP and SWP facilities are described, and salvage and loss estimates provided by species and life stage. Effects associated with water transfers and cumulative effects are also described, and an overall effects determination made for each species. Instream temperature effects on salmonids resulting from CVP and SWP operations were discussed in Chapter 9, and addressed separately in the effects determination for that section.

Steelhead and Chinook Salmon

CVP and SWP South Delta Pumping Facilities

Steelhead salvage is seasonally significant with a positive correlation to exports at both the CVP and SWP facilities in the south Delta, (Figures 4-1 and 4-2). As discussed in Chapter 4, the steelhead salvage-export relationships are confounded by (1) breakdown in the relationships during months fringing the salvage "season;" (2) a decline in steelhead salvage since 1992; and (3) a positive correlation between salvage and abundance. Steelhead salvage records are shown in tables 4–7 and 4–8.

There is a weak relationship between the Delta survival of juvenile Chinook released into the interior Delta in Georgiana Slough relative to the Sacramento mainstem and exports (as presented in Figure 6–26). In Newman's extended quasi-likelihood model using paired data, there was a significant export effect on survival (approximate *P* value of 0.02 for a one-sided test) (Newman 2000).

It is unclear what proportion of naturally migrating Sacramento River salmon uses a central Delta emigration route, or how that proportion changes with environmental conditions. Modeling conducted by Newman and Rice in 2002 show a weak relationship between juvenile Chinook Delta survival and exports (the export to inflow ratio in this case). In both cases, it would take a very large change in exports to affect a small change in Delta survival, and it is not statistically significant. At the request of the resource agencies, we have estimated future loss and salvage for winter run and spring run Chinook salmon and steelhead using the assumption that changes salvage and loss are directly proportional to changes in export.

Data from the FWS Chipps Island Trawl suggest steelhead emigration occurs between October and June (Figure 3–5). However, steelhead salvage at the Delta fish facilities has typically occurred between January and June, with consistently low salvage after April (Figure 10–1 and Figure 10–2). October through June encompasses the emigration periods of all Chinook runs. The highest salvage occurs in February through June but salvage of winter–run and spring–run can be significant in December and January.

Both steelhead and Chinook are expected to receive protection from actions such as reduced Delta exports during periods of high fish salvage, export-to-inflow ratios, and DCC gate closures during spring. These actions are believed to reduce take of emigrating salmonids. Older juvenile Chinook will receive additional protection from the Salmon Protection Decision Process outlined in Chapter 2 of this biological assessment.

The modeled monthly CVP and SWP Delta export exceedance plots are shown in CALSIM Modeling Appendix (Delta-ExportsDeliveries.xls) for Chapter 10. The export levels are within the range defined by the 1995-2001 post-Bay-Delta Accord period for essentially all of the October through June period when juvenile salmon and steelhead are present in the Delta. Exports are also at or below the existing export-to-inflow ratio standards during all months (Figure 10-34 and Figure 10-39).

Direct Losses to Entrainment by CVP and SWP Export Facilities

Exports would increase in the future with the implementation of the South Delta Improvement Program. Exports would generally be greater without EWA than with EWA during months when listed species are not present near the export facilities (July – October) as exported water is stored to be used to decrease exports when needed to lower entrainment of listed species. Exports would generally be less in the future with EWA during months when listed species are near the export facilities (December through May). Increased take of salmon and steelhead is more likely in the future without an EWA program than with an EWA program because EWA allows more flexibility to modify pumping rates when listed species are being taken at the pumps.

Table 10–1 shows potential loss and salvage changes for winter-run, spring-run and steelhead comparing operations today to future operations (model 2 vs 4, model 3 vs 5, and model 1 vs 5) if we assumed that salvage is directly proportional to the amount of water exported (i.e. doubling the amount of water exported doubles the number of fish salvaged). Average loss and salvage numbers used in the calculations is shown in Table 10–2. Loss for steelhead was calculated from salvage by multiplying the monthly salvage totals by 0.579 for Tracy and by 4.34 at Banks.

Typically close to 1.5 million steelhead are released each year from the Central Valley hatcheries at a relatively large size, ready to smolt, and begin to show up in the salvage facilities quickly following release. If at least 50% of these smolts make it to the Delta then 750,000 hatchery steelhead would be in the Delta. During 2003, a year of high hatchery steelhead salvage, the salvage facilities captured 10,189 clipped and 1,752 unclipped steelhead. The clipped (hatchery) salvage equates to 1.4% of 750,000. If unclipped fish were salvaged at a similar rate (1.4%) with 1,752 salvaged then about 130,000 wild (unclipped) steelhead smolts passed through the Delta.

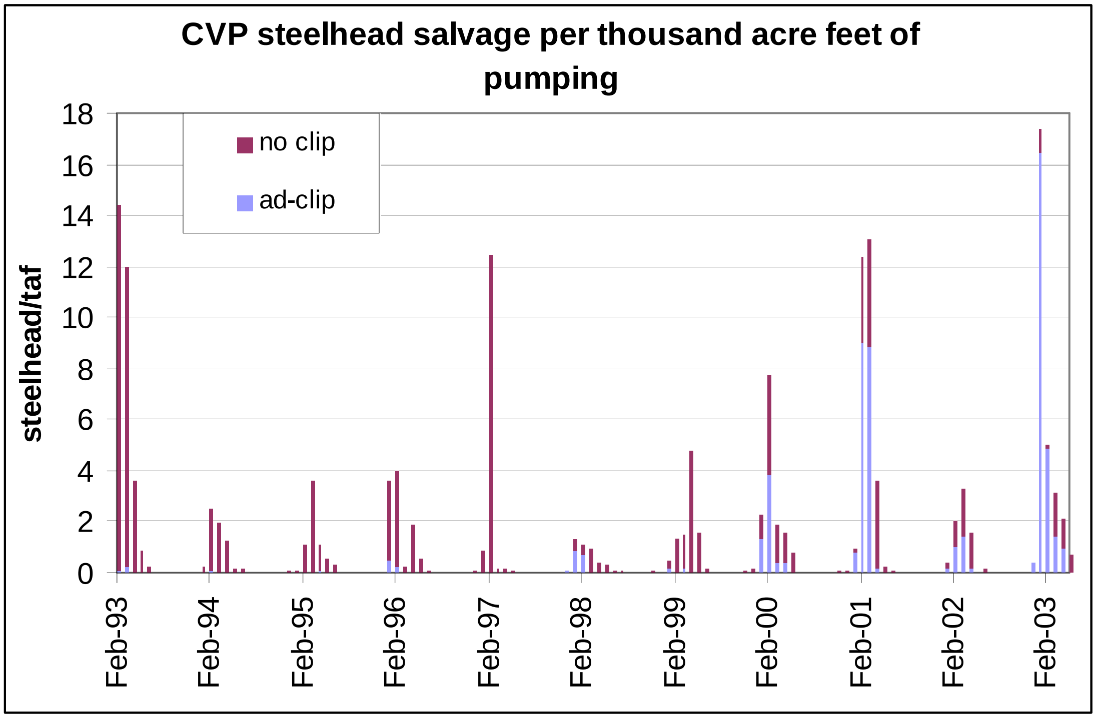


Figure 10–1 CVP steelhead salvage density, 1993-2003.

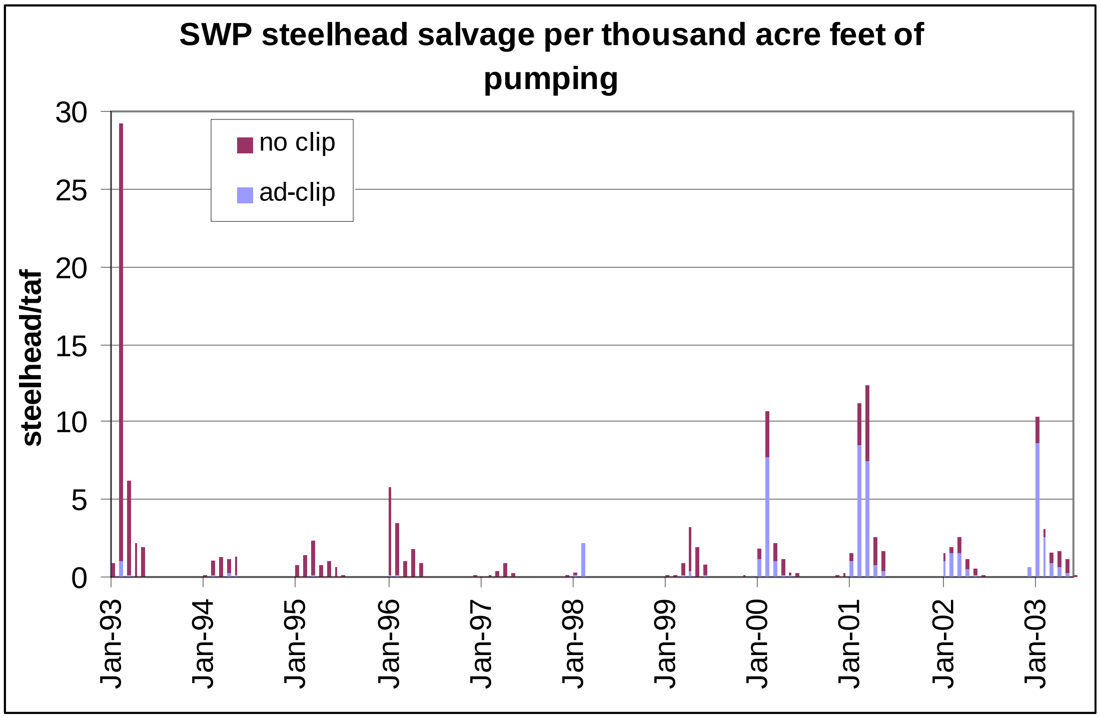


Figure 10–2 SWP steelhead salvage density, 1993-2003.

Table 10–1 Average change in winter run, spring run, and steelhead loss (first 10 charts) and salvage (last 10 charts) by water year type and export facility assuming a direct relationship between monthly exports and monthly salvage. Steelhead salvage calculations are based on unclipped fish 1998 – 2003, salmon salvage data was broken into runs based on fish lengths measured in 1993 – 2003 and calculated separately for wet years (1993, 1995-2000 ,2003) and dry years (1994, 2001, 2002).

Banks

Critical	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Overall**
2 v 4 change in loss												
Winter-run number	0	0	40	79	149	249	0	1	0	0	0	518
Winter-run percent			2.4%	3.6%	4.6%	3.8%	0.0%	6.2%				3.7%
Spring-run number	0	0	0	0	0	113	4	181	0	0	0	299
Spring-run percent				3.6%	4.6%	3.8%	0.0%	6.2%	1.8%			1.5%
Steelhead number	0	-1	2	33	86	84	0	16	2	0	0	222
Steelhead percent	3.8%	-1.4%	2.4%	3.6%	4.6%	3.8%	0.0%	6.2%	1.8%	-1.0%	-1.4%	3.4%
3 v 5 change in loss												
Winter-run number	0	0	-32	49	31	175	0	-1	0	0	0	222
Winter-run percent			-2.0%	2.2%	1.0%	2.7%	-0.1%	-4.9%				1.6%
Spring-run number	0	0	0	0	0	79	-14	-143	0	0	0	-78
Spring-run percent				2.2%	1.0%	2.7%	-0.1%	-4.9%	-5.4%			-0.4%
Steelhead number	0	-1	-1	21	18	59	-1	-13	-6	0	0	77
Steelhead percent	3.5%	-0.8%	-2.0%	2.2%	1.0%	2.7%	-0.1%	-4.9%	-5.4%	-0.2%	2.6%	1.2%
1 v 5 change in loss												
Winter-run number	0	0	-30	-95	178	90	-8	-3	0	0	0	133
Winter-run percent			-1.8%	-4.3%	5.5%	1.4%	-2.5%	-26.7%				1.0%
Spring-run number	0	0	0	0	0	41	-362	-782	0	0	0	-1,104
Spring-run percent				-4.3%	5.5%	1.4%	-2.5%	-26.7%	1.5%			-5.5%
Steelhead number	0	0	-1	-40	102	30	-24	-70	2	3	1	3
Steelhead percent	6.7%	-0.5%	-1.8%	-4.3%	5.5%	1.4%	-2.5%	-26.7%	1.5%	15.4%	23.4%	0.0%

Tracy

Critical	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in loss												
Winter-run number	0	0	64	76	29	153	8	-1	0	0	0	329
Winter-run percent			3.9%	3.4%	0.9%	2.3%	2.5%	-9.1%				2.4%
Spring-run number	0	0	0	0	0	69	359	-267	0	0	0	161
Spring-run percent				3.4%	0.9%	2.3%	2.5%	-9.1%	-7.8%			0.8%
Steelhead number	0	-2	3	32	17	51	24	-24	-8	-1	0	91
Steelhead percent	-0.9%	-3.4%	3.9%	3.4%	0.9%	2.3%	2.5%	-9.1%	-7.8%	-3.4%	-4.6%	1.4%
3 v 5 change in loss												
Winter-run number	0	0	-12	65	40	85	13	0	0	0	0	190
Winter-run percent			-0.7%	3.0%	1.2%	1.3%	4.2%	-3.6%				1.4%
Spring-run number	0	0	0	0	0	38	605	-107	0	0	0	536
Spring-run percent				3.0%	1.2%	1.3%	4.2%	-3.6%	-4.3%			2.7%
Steelhead number	0	-2	0	28	23	28	40	-10	-5	0	0	103
Steelhead percent	-2.9%	-2.7%	-0.7%	3.0%	1.2%	1.3%	4.2%	-3.6%	-4.3%	0.4%	-3.8%	1.6%
1 v 5 change in loss												
Winter-run number	0	0	-42	-35	-10	69	8	-3	0	0	0	-12
Winter-run percent			-2.6%	-1.6%	-0.3%	1.1%	2.7%	-26.2%				-0.1%
Spring-run number	0	0	0	0	0	31	389	-770	-1	0	0	-350
Spring-run percent				-1.6%	-0.3%	1.1%	2.7%	-26.2%	-8.4%			-1.7%
Steelhead number	0	-3	-2	-15	-6	23	26	-69	-9	0	0	-54
Steelhead percent	-3.0%	-4.0%	-2.6%	-1.6%	-0.3%	1.1%	2.7%	-26.2%	-8.4%	-1.5%	-6.0%	-0.8%

Banks

Dry	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in loss												
Winter-run number	0	0	72	135	121	237	3	0	0	0	0	568
Winter-run percent			4.4%	6.1%	3.7%	3.6%	1.1%	3.0%				4.1%
Spring-run number	0	0	0	0	0	107	153	88	0	0	0	348
Spring-run percent				6.1%	3.7%	3.6%	1.1%	3.0%	-6.8%			1.7%
Steelhead number	0	1	3	57	70	79	10	8	-7	0	0	221
Steelhead percent	1.8%	1.6%	4.4%	6.1%	3.7%	3.6%	1.1%	3.0%	-6.8%	2.0%	3.0%	3.4%
3 v 5 change in loss												
Winter-run number	0	0	125	160	125	280	4	-1	0	0	0	693
Winter-run percent			7.5%	7.2%	3.9%	4.3%	1.3%	-5.3%				5.0%
Spring-run number	0	0	0	1	0	127	180	-155	0	0	0	153
Spring-run percent				7.2%	3.9%	4.3%	1.3%	-5.3%	2.3%			0.8%
Steelhead number	0	2	5	68	72	94	12	-14	2	1	0	242
Steelhead percent	1.0%	3.2%	7.5%	7.2%	3.9%	4.3%	1.3%	-5.3%	2.3%	6.6%	-4.0%	3.7%
1 v 5 change in loss												
Winter-run number	0	0	87	18	134	289	-34	-7	0	0	0	487
Winter-run percent			5.2%	0.8%	4.2%	4.4%	-11.1%	-67.9%				3.5%
Spring-run number	0	0	0	0	0	131	-1,586	-1,992	0	0	0	-3,447
Spring-run percent				0.8%	4.2%	4.4%	-11.1%	-67.9%	-4.0%			-17.0%
Steelhead number	0	0	3	8	77	97	-106	-178	-4	5	0	-98
Steelhead percent	3.9%	0.7%	5.2%	0.8%	4.2%	4.4%	-11.1%	-67.9%	-4.0%	23.6%	1.7%	-1.5%

Tracy

Dry	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Overall**
2 v 4 change in loss												
Winter-run number	0	0	36	15	-37	-58	8	0	0	0	0	-36
Winter-run percent			2.1%	0.7%	-1.2%	-0.9%	2.6%	-2.9%				-0.3%
Spring-run number	0	0	0	0	0	-26	372	-84	0	0	0	261
Spring-run percent				0.7%	-1.2%	-0.9%	2.6%	-2.9%	-5.8%			1.3%
Steelhead number	0	-1	1	6	-21	-19	25	-8	-6	-1	0	-24
Steelhead percent	0.9%	-1.5%	2.1%	0.7%	-1.2%	-0.9%	2.6%	-2.9%	-5.8%	-6.2%	-8.5%	-0.4%
3 v 5 change in loss												
Winter-run number	0	0	23	61	122	70	-6	0	0	0	0	271
Winter-run percent			1.4%	2.8%	3.8%	1.1%	-2.0%	-0.5%				1.9%
Spring-run number	0	0	0	0	0	32	-282	-14	-1	0	0	-264
Spring-run percent				2.8%	3.8%	1.1%	-2.0%	-0.5%	-8.6%			-1.3%
Steelhead number	0	0	1	26	70	24	-19	-1	-9	-1	0	90
Steelhead percent	0.7%	-0.4%	1.4%	2.8%	3.8%	1.1%	-2.0%	-0.5%	-8.6%	-5.2%	-9.5%	1.4%
1 v 5 change in loss												
Winter-run number	0	0	-50	-132	103	-288	-3	-4	0	0	0	-373
Winter-run percent			-3.0%	-6.0%	3.2%	-4.4%	-1.0%	-32.6%				-2.7%
Spring-run number	0	0	0	0	0	-130	-141	-958	-1	0	0	-1,230
Spring-run percent				-6.0%	3.2%	-4.4%	-1.0%	-32.6%	-12.3%			-6.1%
Steelhead number	0	-2	-2	-56	59	-97	-9	-86	-13	-2	0	-207
Steelhead percent	0.5%	-2.9%	-3.0%	-6.0%	3.2%	-4.4%	-1.0%	-32.6%	-12.3%	-9.4%	-16.8%	-3.2%

Banks

Below Norma	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Overall**
2 v 4 change in loss												
Winter-run number	0	0	134	164	125	552	8	3	0	0	0	986
Winter-run percent			8.1%	7.4%	3.9%	8.4%	2.6%	25.0%				7.1%
Spring-run number	0	0	0	1	0	250	371	735	0	0	0	1,357
Spring-run percent				7.4%	3.9%	8.4%	2.6%	25.0%	-0.8%			6.7%
Steelhead number	0	2	5	70	72	185	25	66	-1	1	0	425
Steelhead percent	-0.2%	3.2%	8.1%	7.4%	3.9%	8.4%	2.6%	25.0%	-0.8%	5.8%	3.1%	6.6%
3 v 5 change in loss												
Winter-run number	0	0	134	108	6	350	5	-2	0	0	0	601
Winter-run percent			8.1%	4.9%	0.2%	5.4%	1.5%	-14.9%				4.3%
Spring-run number	0	0	0	0	0	159	210	-436	1	0	0	-67
Spring-run percent				4.9%	0.2%	5.4%	1.5%	-14.9%	9.7%			-0.3%
Steelhead number	0	2	5	46	4	117	14	-39	10	2	0	161
Steelhead percent	-2.2%	3.1%	8.1%	4.9%	0.2%	5.4%	1.5%	-14.9%	9.7%	7.8%	2.4%	2.5%
1 v 5 change in loss												
Winter-run number	0	0	63	40	163	411	-102	-11	0	0	0	564
Winter-run percent			3.8%	1.8%	5.0%	6.3%	-33.1%	-99.5%				4.0%
Spring-run number	0	0	0	0	0	186	-4,748	-2,921	-1	0	0	-7,484
Spring-run percent				1.8%	5.0%	6.3%	-33.1%	-99.5%	-11.4%			-37.0%
Steelhead number	0	1	2	17	94	138	-317	-261	-12	4	0	-333
Steelhead percent	2.0%	1.9%	3.8%	1.8%	5.0%	6.3%	-33.1%	-99.5%	-11.4%	22.0%	14.3%	-5.2%

Tracy

Below Norma	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in loss												
Winter-run number	0	0	10	65	-66	-332	-5	-1	0	0	0	-328
Winter-run percent			0.6%	3.0%	-2.0%	-5.1%	-1.5%	-5.2%				-2.3%
Spring-run number	0	0	0	0	0	-150	-210	-154	0	0	0	-514
Spring-run percent				3.0%	-2.0%	-5.1%	-1.5%	-5.2%	0.1%			-2.5%
Steelhead number	0	1	0	28	-38	-111	-14	-14	0	0	0	-148
Steelhead percent	0.5%	1.4%	0.6%	3.0%	-2.0%	-5.1%	-1.5%	-5.2%	0.1%	-2.4%	-1.8%	-2.3%
3 v 5 change in loss												
Winter-run number	0	0	14	37	97	-199	-3	-1	0	0	0	-56
Winter-run percent			0.8%	1.7%	3.0%	-3.0%	-1.1%	-11.6%				-0.4%
Spring-run number	0	0	0	0	0	-90	-161	-342	0	0	0	-593
Spring-run percent				1.7%	3.0%	-3.0%	-1.1%	-11.6%	0.3%			-2.9%
Steelhead number	0	1	1	16	56	-67	-11	-31	0	0	0	-35
Steelhead percent	0.0%	1.3%	0.8%	1.7%	3.0%	-3.0%	-1.1%	-11.6%	0.3%	-2.5%	-1.1%	-0.5%
1 v 5 change in loss												
Winter-run number	0	0	-62	-58	76	-589	-13	-4	0	0	0	-650
Winter-run percent			-3.8%	-2.6%	2.4%	-9.0%	-4.1%	-36.9%				-4.7%
Spring-run number	0	0	0	0	0	-267	-593	-1,084	0	0	0	-1,944
Spring-run percent				-2.6%	2.4%	-9.0%	-4.1%	-36.9%	0.3%			-9.6%
Steelhead number	0	0	-2	-24	44	-197	-40	-97	0	-1	0	-318
Steelhead percent	-0.1%	-0.2%	-3.8%	-2.6%	2.4%	-9.0%	-4.1%	-36.9%	0.3%	-4.7%	-2.6%	-4.9%

Banks

Above Norma	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in loss												
Winter-run number	0	0	-16	-73	75	217	35	0	0	0	0	238
Winter-run percent			-2.9%	-1.1%	4.7%	19.9%	10.5%	4.1%	2.2%			2.3%
Spring-run number	0	0	0	0	3	1,109	3,703	512	47	0	0	5,375
Spring-run percent	6.4%			-1.1%	4.7%	19.9%	10.5%	4.1%	2.2%			9.7%
Steelhead number	0	2	-2	-10	79	353	106	15	3	1	0	547
Steelhead percent	5.8%	3.3%	-2.4%	-1.1%	4.3%	16.1%	11.0%	5.7%	2.6%	5.9%	1.0%	8.5%
3 v 5 change in loss												
Winter-run number	0	0	20	162	5	185	24	0	0	0	0	396
Winter-run percent			3.6%	2.4%	0.3%	16.9%	7.3%	-4.1%	3.5%			3.8%
Spring-run number	0	0	0	0	0	946	2,579	-508	74	0	0	3,093
Spring-run percent	7.8%			2.4%	0.3%	16.9%	7.3%	-4.1%	3.5%			5.6%
Steelhead number	0	5	2	23	5	301	73	-15	4	2	0	400
Steelhead percent	7.1%	7.0%	3.0%	2.5%	0.3%	13.7%	7.7%	-5.6%	4.1%	8.3%	-7.3%	6.2%
1 v 5 change in loss												
Winter-run number	0	0	7	-241	-31	277	-74	-4	0	0	0	-66
Winter-run percent			1.2%	-3.5%	-1.9%	25.4%	-22.4%	-56.2%	-0.4%			-0.6%
Spring-run number	0	0	0	0	-1	1,417	-7,886	-7,016	-9	0	0	-13,495
Spring-run percent	8.5%			-3.5%	-1.9%	25.4%	-22.4%	-56.2%	-0.4%			-24.3%
Steelhead number	0	3	1	-34	-33	451	-225	-204	-1	3	0	-38
Steelhead percent	7.7%	4.5%	1.0%	-3.6%	-1.7%	20.6%	-23.5%	-77.9%	-0.5%	16.1%	6.3%	-0.6%

Tracy

Above Normal	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in loss												
Winter-run number	0	0	2	-1	22	-33	0	0	0	0	0	-9
Winter-run percent			0.3%	0.0%	1.4%	-3.0%	0.1%	6.8%	2.9%			-0.1%
Spring-run number	0	0	0	0	2	-317	62	570	20	0	0	336
Spring-run percent	0.4%			0.0%	2.5%	-5.7%	0.2%	4.6%	0.9%			0.6%
Steelhead number	0	2	0	0	70	-123	3	28	2	0	0	-17
Steelhead percent	1.9%	3.2%	0.7%	0.0%	3.8%	-5.6%	0.3%	10.6%	2.2%	-0.7%	-1.4%	-0.3%
3 v 5 change in loss												
Winter-run number	0	0	1	78	14	-11	0	0	0	0	0	82
Winter-run percent			0.2%	1.1%	0.9%	-1.0%	0.1%	0.3%	1.0%			0.8%
Spring-run number	0	0	0	0	1	-109	51	27	7	0	0	-23
Spring-run percent	-0.3%			3.3%	1.6%	-2.0%	0.1%	0.2%	0.3%			0.0%
Steelhead number	0	1	0	35	45	-42	3	1	1	0	0	44
Steelhead percent	-1.4%	1.7%	0.5%	3.8%	2.4%	-1.9%	0.3%	0.5%	0.8%	-0.5%	-3.0%	0.7%
1 v 5 change in loss												
Winter-run number	0	0	-9	-74	-33	-8	0	-1	0	0	0	-125
Winter-run percent			-1.6%	-1.1%	-2.1%	-0.8%	0.0%	-8.2%	1.8%			-1.2%
Spring-run number	0	0	0	0	-2	-79	-5	-689	12	0	0	-763
Spring-run percent	0.0%			-3.1%	-3.7%	-1.4%	0.0%	-5.5%	0.6%			-1.4%
Steelhead number	0	1	-3	-33	-107	-31	0	-34	1	0	0	-205
Steelhead percent	0.0%	2.3%	-3.9%	-3.6%	-5.7%	-1.4%	0.0%	-12.8%	1.4%	-0.5%	-3.3%	-3.2%

Banks

Wet	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in loss												
Winter-run number	0	0	90	435	72	187	52	1	0	0	0	838
Winter-run percent			16.3%	6.3%	4.5%	17.1%	15.9%	11.7%	4.3%			8.0%
Spring-run number	0	0	0	0	3	956	5,598	1,458	92	0	0	8,108
Spring-run percent	7.6%			6.3%	4.5%	17.1%	15.9%	11.7%	4.3%			14.6%
Steelhead number	0	4	9	61	77	304	159	42	5	1	0	663
Steelhead percent	6.9%	5.4%	13.5%	6.6%	4.1%	13.9%	16.7%	16.2%	5.1%	4.8%	-3.8%	10.2%
3 v 5 change in loss												
Winter-run number	0	0	111	463	48	105	31	0	0	0	0	759
Winter-run percent			20.0%	6.7%	3.0%	9.6%	9.6%	5.1%	11.1%			7.2%
Spring-run number	0	0	0	0	2	534	3,371	639	238	0	0	4,785
Spring-run percent	8.2%			6.7%	3.0%	9.6%	9.6%	5.1%	11.1%			8.6%
Steelhead number	0	1	11	65	51	170	96	19	14	1	0	428
Steelhead percent	7.5%	1.2%	16.6%	7.0%	2.7%	7.8%	10.0%	7.1%	13.2%	7.2%	0.8%	6.6%
1 v 5 change in loss												
Winter-run number	0	0	77	284	25	349	-47	-4	0	0	0	684
Winter-run percent			14.0%	4.1%	1.6%	31.9%	-14.2%	-60.3%	4.4%			6.5%
Spring-run number	1	0	0	0	1	1,783	-5,000	-7,540	94	0	0	-10,661
Spring-run percent	13.8%			4.1%	1.6%	31.9%	-14.2%	-60.3%	4.4%			-19.2%
Steelhead number	1	2	8	40	26	567	-142	-219	6	1	0	289
Steelhead percent	12.6%	3.7%	11.6%	4.3%	1.4%	25.9%	-14.9%	-83.7%	5.2%	4.9%	4.9%	4.5%

Tracy

Wet	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Overall**
2 v 4 change in loss												
Winter-run number	0	0	8	18	-6	-17	-8	0	0	0	0	-3
Winter-run percent			1.5%	0.3%	-0.3%	-1.5%	-2.4%	-0.2%	-0.3%			0.0%
Spring-run number	0	0	0	0	0	-160	-1,006	-17	-2	0	0	-1,186
Spring-run percent	0.4%			0.8%	-0.6%	-2.9%	-2.9%	-0.1%	-0.1%			-2.1%
Steelhead number	0	1	2	8	-18	-62	-52	-1	0	0	0	-121
Steelhead percent	1.7%	1.9%	3.7%	0.9%	-1.0%	-2.8%	-5.4%	-0.3%	-0.2%	0.6%	0.4%	-1.9%
3 v 5 change in loss												
Winter-run number	0	0	1	7	12	9	0	0	0	0	0	29
Winter-run percent			0.2%	0.1%	0.7%	0.8%	0.0%	-0.3%	0.7%			0.3%
Spring-run number	0	0	0	0	1	86	-11	-21	5	0	0	60
Spring-run percent	0.0%			0.3%	1.3%	1.5%	0.0%	-0.2%	0.2%			0.1%
Steelhead number	0	2	0	3	38	34	-1	-1	1	0	0	75
Steelhead percent	-0.2%	3.1%	0.4%	0.3%	2.0%	1.5%	-0.1%	-0.4%	0.5%	-0.3%	0.4%	1.2%
1 v 5 change in loss												
Winter-run number	0	0	-12	-153	-38	17	-4	0	0	0	0	-190
Winter-run percent			-2.3%	-2.2%	-2.4%	1.6%	-1.1%	-4.8%	0.1%			-1.8%
Spring-run number	0	0	0	0	-3	165	-465	-403	1	0	0	-706
Spring-run percent	0.1%			-6.5%	-4.3%	2.9%	-1.3%	-3.2%	0.0%			-1.3%
Steelhead number	0	0	-4	-69	-123	64	-24	-20	0	0	0	-175
Steelhead percent	0.3%	0.7%	-5.5%	-7.4%	-6.6%	2.9%	-2.5%	-7.5%	0.1%	0.1%	0.4%	-2.7%

Banks

Critical	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in salvage												
Winter-run number	0	0	13	28	86	83	0	0	0	0	0	210
Winter-run percent			2.4%	3.6%	4.6%	3.8%	0.0%	6.2%				3.8%
Spring-run number	0	0	0	0	0	51	3	54	0	0	0	109
Spring-run percent				3.6%	4.6%	3.8%	0.0%	6.2%	1.8%			1.0%
Steelhead number	0	0	0	11	34	31	0	7	1	0	0	85
Steelhead percent	3.8%	-1.4%	2.4%	3.6%	4.6%	3.8%	0.0%	6.2%	1.8%	-1.0%	-1.4%	3.4%
3 v 5 change in salvage												
Winter-run number	0	0	-10	17	18	59	0	0	0	0	0	83
Winter-run percent			-2.0%	2.2%	1.0%	2.7%	-0.1%	-4.9%				1.5%
Spring-run number	0	0	0	0	0	36	-9	-43	0	0	0	-16
Spring-run percent				2.2%	1.0%	2.7%	-0.1%	-4.9%	-5.4%			-0.1%
Steelhead number	0	0	0	7	7	22	0	-5	-2	0	0	28
Steelhead percent	3.5%	-0.8%	-2.0%	2.2%	1.0%	2.7%	-0.1%	-4.9%	-5.4%	-0.2%	2.6%	1.1%
1 v 5 change in salvage												
Winter-run number	0	0	-10	-34	102	30	-6	-1	0	0	0	83
Winter-run percent			-1.8%	-4.3%	5.5%	1.4%	-2.5%	-26.7%				1.5%
Spring-run number	0	0	0	-1	0	19	-224	-235	0	0	0	-440
Spring-run percent				-4.3%	5.5%	1.4%	-2.5%	-26.7%	1.5%			-4.0%
Steelhead number	0	0	0	-13	41	11	-11	-29	1	1	0	0
Steelhead percent	6.7%	-0.5%	-1.8%	-4.3%	5.5%	1.4%	-2.5%	-26.7%	1.5%	15.4%	23.4%	0.0%

Tracy

Critical	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in salvage												
Winter-run number	0	0	21	27	17	51	6	0	0	0	0	121
Winter-run percent			3.9%	3.4%	0.9%	2.3%	2.5%	-9.1%				2.2%
Spring-run number	0	0	0	0	0	32	222	-80	-1	0	0	173
Spring-run percent				3.4%	0.9%	2.3%	2.5%	-9.1%	-7.8%			1.6%
Steelhead number	0	-1	1	11	7	19	11	-10	-3	0	0	35
Steelhead percent	-0.9%	-3.4%	3.9%	3.4%	0.9%	2.3%	2.5%	-9.1%	-7.8%	-3.4%	-4.6%	1.4%
3 v 5 change in salvage												
Winter-run number	0	0	-4	23	23	28	10	0	0	0	0	80
Winter-run percent			-0.7%	3.0%	1.2%	1.3%	4.2%	-3.6%				1.4%
Spring-run number	0	0	0	0	0	17	374	-32	0	0	0	359
Spring-run percent				3.0%	1.2%	1.3%	4.2%	-3.6%	-4.3%			3.2%
Steelhead number	0	-1	0	9	9	11	18	-4	-2	0	0	41
Steelhead percent	-2.9%	-2.7%	-0.7%	3.0%	1.2%	1.3%	4.2%	-3.6%	-4.3%	0.4%	-3.8%	1.6%
1 v 5 change in salvage												
Winter-run number	0	0	-14	-12	-6	23	6	-1	0	0	0	-3
Winter-run percent			-2.6%	-1.6%	-0.3%	1.1%	2.7%	-26.2%				0.0%
Spring-run number	0	0	0	0	0	14	240	-231	-1	0	0	23
Spring-run percent				-1.6%	-0.3%	1.1%	2.7%	-26.2%	-8.4%			0.2%
Steelhead number	0	-1	-1	-5	-2	9	12	-29	-3	0	0	-20
Steelhead percent	-3.0%	-4.0%	-2.6%	-1.6%	-0.3%	1.1%	2.7%	-26.2%	-8.4%	-1.5%	-6.0%	-0.8%

Banks

Dry	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Overall**
2 v 4 change in salvage												
Winter-run number	0	0	23	48	70	79	3	0	0	0	0	222
Winter-run percent			4.4%	6.1%	3.7%	3.6%	1.1%	3.0%				4.0%
Spring-run number	0	0	0	1	0	49	94	26	-1	0	0	170
Spring-run percent				6.1%	3.7%	3.6%	1.1%	3.0%	-6.8%			1.5%
Steelhead number	0	0	1	19	28	30	5	3	-2	0	0	84
Steelhead percent	1.8%	1.6%	4.4%	6.1%	3.7%	3.6%	1.1%	3.0%	-6.8%	2.0%	3.0%	3.3%
3 v 5 change in salvage												
Winter-run number	0	0	40	57	72	93	3	0	0	0	0	265
Winter-run percent			7.5%	7.2%	3.9%	4.3%	1.3%	-5.3%				4.7%
Spring-run number	0	0	0	1	0	58	111	-47	0	0	0	124
Spring-run percent				7.2%	3.9%	4.3%	1.3%	-5.3%	2.3%			1.1%
Steelhead number	0	1	2	23	29	35	5	-6	1	1	0	90
Steelhead percent	1.0%	3.2%	7.5%	7.2%	3.9%	4.3%	1.3%	-5.3%	2.3%	6.6%	-4.0%	3.6%
1 v 5 change in salvage												
Winter-run number	0	0	28	7	77	96	-26	-1	0	0	0	180
Winter-run percent			5.2%	0.8%	4.2%	4.4%	-11.1%	-67.9%				3.2%
Spring-run number	0	0	0	0	0	60	-980	-598	0	0	0	-1,518
Spring-run percent				0.8%	4.2%	4.4%	-11.1%	-67.9%	-4.0%			-13.7%
Steelhead number	0	0	1	3	31	36	-47	-74	-1	2	0	-50
Steelhead percent	3.9%	0.7%	5.2%	0.8%	4.2%	4.4%	-11.1%	-67.9%	-4.0%	23.6%	1.7%	-2.0%

Tracy

Critical	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Overall**
2 v 4 change in salvage												
Winter-run number	0	0	11	5	-21	-19	6	0	0	0	0	-18
Winter-run percent			2.1%	0.7%	-1.2%	-0.9%	2.6%	-2.9%				-0.3%
Spring-run number	0	0	0	0	0	-12	230	-25	0	0	0	192
Spring-run percent				0.7%	-1.2%	-0.9%	2.6%	-2.9%	-5.8%			1.7%
Steelhead number	0	0	0	2	-9	-7	11	-3	-2	0	0	-8
Steelhead percent	0.9%	-1.5%	2.1%	0.7%	-1.2%	-0.9%	2.6%	-2.9%	-5.8%	-6.2%	-8.5%	-0.3%
3 v 5 change in salvage												
Winter-run number	0	0	7	22	70	24	-5	0	0	0	0	118
Winter-run percent			1.4%	2.8%	3.8%	1.1%	-2.0%	-0.5%				2.1%
Spring-run number	0	0	0	0	0	15	-174	-4	-1	0	0	-164
Spring-run percent				2.8%	3.8%	1.1%	-2.0%	-0.5%	-8.6%			-1.5%
Steelhead number	0	0	0	9	28	9	-8	-1	-3	0	0	33
Steelhead percent	0.7%	-0.4%	1.4%	2.8%	3.8%	1.1%	-2.0%	-0.5%	-8.6%	-5.2%	-9.5%	1.3%
1 v 5 change in salvage												
Winter-run number	0	0	-16	-47	59	-96	-2	-1	0	0	0	-103
Winter-run percent			-3.0%	-6.0%	3.2%	-4.4%	-1.0%	-32.6%				-1.8%
Spring-run number	0	0	0	-1	0	-59	-87	-287	-1	0	0	-435
Spring-run percent				-6.0%	3.2%	-4.4%	-1.0%	-32.6%	-12.3%			-3.9%
Steelhead number	0	-1	-1	-19	24	-36	-4	-36	-4	-1	0	-78
Steelhead percent	0.5%	-2.9%	-3.0%	-6.0%	3.2%	-4.4%	-1.0%	-32.6%	-12.3%	-9.4%	-16.8%	-3.1%

Banks

Below Norma	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Overall**
2 v 4 change in salvage												
Winter-run number	0	0	43	58	72	184	6	1	0	0	0	364
Winter-run percent			8.1%	7.4%	3.9%	8.4%	2.6%	25.0%				6.5%
Spring-run number	0	0	0	1	0	114	229	221	0	0	0	565
Spring-run percent				7.4%	3.9%	8.4%	2.6%	25.0%	-0.8%			5.1%
Steelhead number	0	1	2	23	29	70	11	27	0	0	0	163
Steelhead percent	-0.2%	3.2%	8.1%	7.4%	3.9%	8.4%	2.6%	25.0%	-0.8%	5.8%	3.1%	6.5%
3 v 5 change in salvage												
Winter-run number	0	0	43	38	4	117	3	0	0	0	0	205
Winter-run percent			8.1%	4.9%	0.2%	5.4%	1.5%	-14.9%				3.7%
Spring-run number	0	0	0	1	0	72	130	-131	1	0	0	73
Spring-run percent				4.9%	0.2%	5.4%	1.5%	-14.9%	9.7%			0.7%
Steelhead number	0	1	2	15	1	44	6	-16	3	1	0	57
Steelhead percent	-2.2%	3.1%	8.1%	4.9%	0.2%	5.4%	1.5%	-14.9%	9.7%	7.8%	2.4%	2.3%
1 v 5 change in salvage												
Winter-run number	0	0	20	14	94	137	-78	-2	0	0	0	185
Winter-run percent			3.8%	1.8%	5.0%	6.3%	-33.1%	-99.5%				3.3%
Spring-run number	0	0	0	0	0	85	-2,934	-877	-1	0	0	-3,727
Spring-run percent				1.8%	5.0%	6.3%	-33.1%	-99.5%	-11.4%			-33.5%
Steelhead number	0	0	1	6	37	52	-142	-109	-4	2	0	-157
Steelhead percent	2.0%	1.9%	3.8%	1.8%	5.0%	6.3%	-33.1%	-99.5%	-11.4%	22.0%	14.3%	-6.3%

Tracy

Below Norma	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Overall**
2 v 4 change in salvage												
Winter-run number	0	0	3	23	-38	-111	-3	0	0	0	0	-126
Winter-run percent			0.6%	3.0%	-2.0%	-5.1%	-1.5%	-5.2%				-2.3%
Spring-run number	0	0	0	0	0	-68	-130	-46	0	0	0	-244
Spring-run percent				3.0%	-2.0%	-5.1%	-1.5%	-5.2%	0.1%			-2.2%
Steelhead number	0	0	0	9	-15	-42	-6	-6	0	0	0	-59
Steelhead percent	0.5%	1.4%	0.6%	3.0%	-2.0%	-5.1%	-1.5%	-5.2%	0.1%	-2.4%	-1.8%	-2.4%
3 v 5 change in salvage												
Winter-run number	0	0	4	13	56	-66	-3	0	0	0	0	4
Winter-run percent			0.8%	1.7%	3.0%	-3.0%	-1.1%	-11.6%				0.1%
Spring-run number	0	0	0	0	0	-41	-100	-103	0	0	0	-243
Spring-run percent				1.7%	3.0%	-3.0%	-1.1%	-11.6%	0.3%			-2.2%
Steelhead number	0	0	0	5	22	-25	-5	-13	0	0	0	-15
Steelhead percent	0.0%	1.3%	0.8%	1.7%	3.0%	-3.0%	-1.1%	-11.6%	0.3%	-2.5%	-1.1%	-0.6%
1 v 5 change in salvage												
Winter-run number	0	0	-20	-20	44	-197	-10	-1	0	0	0	-204
Winter-run percent			-3.8%	-2.6%	2.4%	-9.0%	-4.1%	-36.9%				-3.6%
Spring-run number	0	0	0	0	0	-122	-366	-325	0	0	0	-813
Spring-run percent				-2.6%	2.4%	-9.0%	-4.1%	-36.9%	0.3%			-7.3%
Steelhead number	0	0	-1	-8	18	-74	-18	-40	0	0	0	-124
Steelhead percent	-0.1%	-0.2%	-3.8%	-2.6%	2.4%	-9.0%	-4.1%	-36.9%	0.3%	-4.7%	-2.6%	-5.0%

Banks

Above Normal	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in salvage												
Winter-run number	0	0	-5	-23	25	95	16	0	0	0	0	107
Winter-run percent			-2.9%	-1.1%	4.7%	19.9%	10.5%	4.1%	2.2%			3.1%
Spring-run number	0	0	0	0	2	909	2,041	305	23	0	0	3,280
Spring-run percent	6.4%			-1.1%	4.7%	19.9%	10.5%	4.1%	2.2%			10.1%
Steelhead number	0	1	0	-4	33	149	57	10	2	1	0	248
Steelhead percent	5.5%	3.2%	-1.9%	-1.2%	4.5%	18.0%	13.3%	8.7%	4.9%	7.6%	1.2%	9.9%
3 v 5 change in salvage												
Winter-run number	0	0	7	50	2	81	11	0	0	0	0	150
Winter-run percent			3.6%	2.4%	0.3%	16.9%	7.3%	-4.1%	3.5%			4.3%
Spring-run number	0	0	0	0	0	775	1,422	-302	37	0	0	1,932
Spring-run percent	7.8%			2.4%	0.3%	16.9%	7.3%	-4.1%	3.5%			5.9%
Steelhead number	0	2	0	8	2	127	40	-9	3	1	0	173
Steelhead percent	6.7%	6.9%	2.4%	2.6%	0.3%	15.4%	9.3%	-8.6%	7.7%	10.6%	-9.0%	6.9%
1 v 5 change in salvage												
Winter-run number	0	0	2	-75	-10	121	-34	-4	0	0	0	1
Winter-run percent			1.2%	-3.5%	-1.9%	25.4%	-22.4%	-56.2%	-0.4%			0.0%
Spring-run number	0	0	0	0	-1	1,161	-4,347	-4,174	-5	0	0	-7,366
Spring-run percent	8.5%			-3.5%	-1.9%	25.4%	-22.4%	-56.2%	-0.4%			-22.6%
Steelhead number	0	1	0	-12	-14	190	-121	-131	0	2	0	-85
Steelhead percent	7.3%	4.4%	0.8%	-3.8%	-1.8%	23.1%	-28.3%	-119.1%	-1.0%	20.6%	7.7%	-3.4%

Tracy

Above Normal	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in salvage												
Winter-run number	0	0	2	-1	22	-33	0	0	0	0	0	-9
Winter-run percent			0.9%	0.0%	4.1%	-6.9%	0.3%	7.7%	1.9%			-0.3%
Spring-run number	0	0	0	0	2	-317	62	570	20	0	0	336
Spring-run percent	2.0%			0.0%	4.1%	-6.9%	0.3%	7.7%	1.9%			1.0%
Steelhead number	0	1	0	0	30	-52	2	18	1	0	0	-1
Steelhead percent	1.7%	3.2%	0.6%	0.0%	4.0%	-6.3%	0.4%	16.3%	4.2%	-0.9%	-1.7%	0.0%
3 v 5 change in salvage												
Winter-run number	0	0	1	78	14	-11	0	0	0	0	0	82
Winter-run percent			0.7%	3.7%	2.6%	-2.4%	0.3%	0.4%	0.7%			2.4%
Spring-run number	0	0	0	0	1	-109	51	27	7	0	0	-23
Spring-run percent	-1.6%			3.7%	2.6%	-2.4%	0.3%	0.4%	0.7%			-0.1%
Steelhead number	0	0	0	13	19	-18	1	1	1	0	0	17
Steelhead percent	-1.3%	1.7%	0.4%	4.0%	2.5%	-2.2%	0.3%	0.8%	1.5%	-0.7%	-3.7%	0.7%
1 v 5 change in salvage												
Winter-run number	0	0	-9	-74	-33	-8	0	-1	0	0	0	-125
Winter-run percent			-4.7%	-3.4%	-6.3%	-1.7%	0.0%	-9.3%	1.2%			-3.6%
Spring-run number	0	0	0	0	-2	-79	-5	-689	12	0	0	-763
Spring-run percent	0.0%			-3.4%	-6.3%	-1.7%	0.0%	-9.3%	1.2%			-2.3%
Steelhead number	0	0	-1	-12	-45	-13	0	-22	1	0	0	-91
Steelhead percent	0.0%	2.2%	-3.0%	-3.8%	-6.0%	-1.6%	0.0%	-19.7%	2.6%	-0.6%	-4.0%	-3.6%

Banks

Wet	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Overall**
2 v 4 change in salvage												
Winter-run number	0	0	31	135	24	82	24	1	0	0	0	296
Winter-run percent			16.3%	6.3%	4.5%	17.1%	15.9%	11.7%	4.3%			8.5%
Spring-run number	0	0	0	0	2	784	3,086	868	45	0	0	4,785
Spring-run percent	7.6%			6.3%	4.5%	17.1%	15.9%	11.7%	4.3%			14.7%
Steelhead number	0	1	2	22	32	128	86	27	3	0	0	303
Steelhead percent	6.5%	5.4%	10.6%	6.9%	4.3%	15.6%	20.1%	24.8%	9.5%	6.1%	-4.6%	12.1%
3 v 5 change in salvage												
Winter-run number	0	0	37	144	16	46	14	0	0	0	0	258
Winter-run percent			20.0%	6.7%	3.0%	9.6%	9.6%	5.1%	11.1%			7.4%
Spring-run number	0	0	0	0	1	438	1,858	380	117	0	0	2,795
Spring-run percent	8.2%			6.7%	3.0%	9.6%	9.6%	5.1%	11.1%			8.6%
Steelhead number	0	0	3	23	21	72	52	12	9	1	0	192
Steelhead percent	7.1%	1.1%	13.0%	7.4%	2.9%	8.7%	12.1%	10.8%	24.6%	9.2%	1.0%	7.7%
1 v 5 change in salvage												
Winter-run number	0	0	26	88	8	152	-21	-4	0	0	0	249
Winter-run percent			14.0%	4.1%	1.6%	31.9%	-14.2%	-60.3%	4.4%			7.2%
Spring-run number	0	0	0	0	1	1,461	-2,756	-4,486	46	0	0	-5,734
Spring-run percent	13.8%			4.1%	1.6%	31.9%	-14.2%	-60.3%	4.4%			-17.6%
Steelhead number	0	1	2	14	11	239	-77	-140	3	0	0	54
Steelhead percent	11.9%	3.7%	9.1%	4.5%	1.5%	29.0%	-18.0%	-128.0%	9.7%	6.2%	6.0%	2.1%

Tracy

Wet	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Overall**
2 v 4 change in salvage												
Winter-run number	0	0	8	18	-6	-17	-8	0	0	0	0	-3
Winter-run percent			4.5%	0.9%	-1.0%	-3.5%	-5.2%	-0.2%	-0.2%			-0.1%
Spring-run number	0	0	0	0	0	-160	-1,006	-17	-2	0	0	-1,186
Spring-run percent	1.9%			0.9%	-1.0%	-3.5%	-5.2%	-0.2%	-0.2%			-3.6%
Steelhead number	0	0	1	3	-7	-26	-28	-1	0	0	0	-59
Steelhead percent	1.6%	1.8%	2.9%	0.9%	-1.0%	-3.2%	-6.6%	-0.5%	-0.4%	0.7%	0.5%	-2.3%
3 v 5 change in salvage												
Winter-run number	0	0	1	7	12	9	0	0	0	0	0	29
Winter-run percent			0.5%	0.3%	2.2%	1.9%	-0.1%	-0.3%	0.4%			0.8%
Spring-run number	0	0	0	0	1	86	-11	-21	5	0	0	60
Spring-run percent	-0.2%			0.3%	2.2%	1.9%	-0.1%	-0.3%	0.4%			0.2%
Steelhead number	0	1	0	1	16	14	0	-1	0	0	0	31
Steelhead percent	-0.2%	3.0%	0.3%	0.4%	2.1%	1.7%	-0.1%	-0.6%	1.0%	-0.4%	0.5%	1.2%
1 v 5 change in salvage												
Winter-run number	0	0	-12	-153	-38	17	-4	0	0	0	0	-190
Winter-run percent			-6.7%	-7.1%	-7.3%	3.6%	-2.4%	-5.4%	0.1%			-5.5%
Spring-run number	0	0	0	0	-3	165	-465	-403	1	0	0	-706
Spring-run percent	0.3%			-7.1%	-7.3%	3.6%	-2.4%	-5.4%	0.1%			-2.2%
Steelhead number	0	0	-1	-25	-52	27	-13	-13	0	0	0	-76
Steelhead percent	0.3%	0.7%	-4.3%	-7.8%	-6.9%	3.3%	-3.0%	-11.5%	0.2%	0.2%	0.5%	-3.0%

Table 10–2 Average monthly loss (top chart) and salvage (bottom chart) for winter-run, spring-run, and steelhead used in loss and salvage change calculations. Dry years = 1994, 2001, 2002, Wet years = 1993, 1995-2000 ,2003, steelhead loss based on unclipped fish 1998 – 2003. Winter run and spring run were categorized into runs by length measurements.

	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Dry Year Loss												
Winter Run	0	0	1,660	2,207	3,232	6,538	307	11	0			
Spring Run	0	0	0	7	3	2,960	14,329	2,936	6			0
Steelhead	4	65	65	935	1,860	2,191	957	262	106	20	3	0
Wet Year Loss												
Winter Run	0	0	554	6,877	1,604	1,093	329	7	1			
Spring Run	5	0	0	6	65	5,583	35,274	12,495	2,137			3
Steelhead	4	65	65	935	1,860	2,191	957	262	106	20	3	0

	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Dry year salvage												
Winter Run			531	782	1,860	2,181	236	2	0			
Spring Run	0			12	4	1,349	8,855	881	8			0
Steelhead unclipped	1	22	20	314	744	824	428	110	35	8	1	0
Wet year salvage												
Winter Run			187	2,137	529	476	151	7	2			
Spring Run	1			5	39	4,576	19,445	7,434	1,053			1
Steelhead unclipped	1	22	20	314	744	824	428	110	35	8	1	0

The unexpanded steelhead salvage for which lengths were measured from 1993 – 2003 contains about 3.5% adults (Figure 10–3). Fish greater than 350 mm were considered adults. Most of the adult salvage occurs in March through May, a time when adults would more likely be moving back downstream than upstream, so the salvaged adults may be mostly post-spawn adults heading back to the ocean. Future adult salvage was not estimated separately but is assumed that it will remain around 3.5% of the total number of steelhead salvaged. Figure 10–4 shows all steelhead fork lengths measured at the salvage facilities from 1993 – 2003.

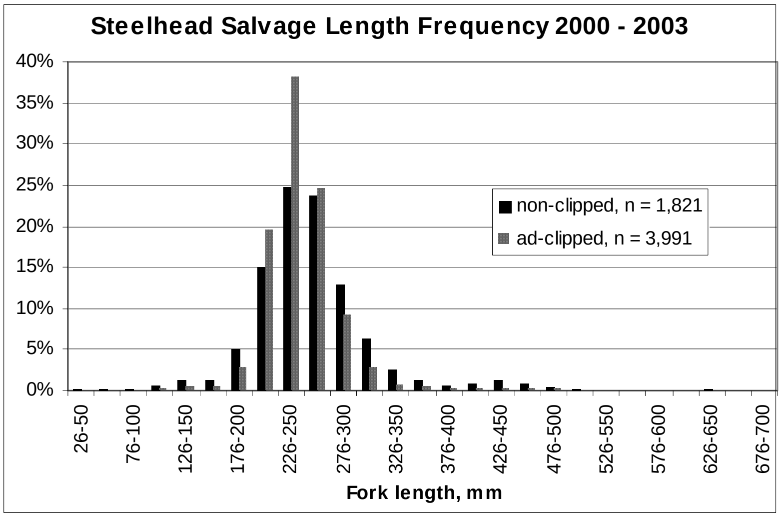


Figure 10–3 Length frequency distribution of steelhead salvaged at the CVP and SWP 2000 – 2003.

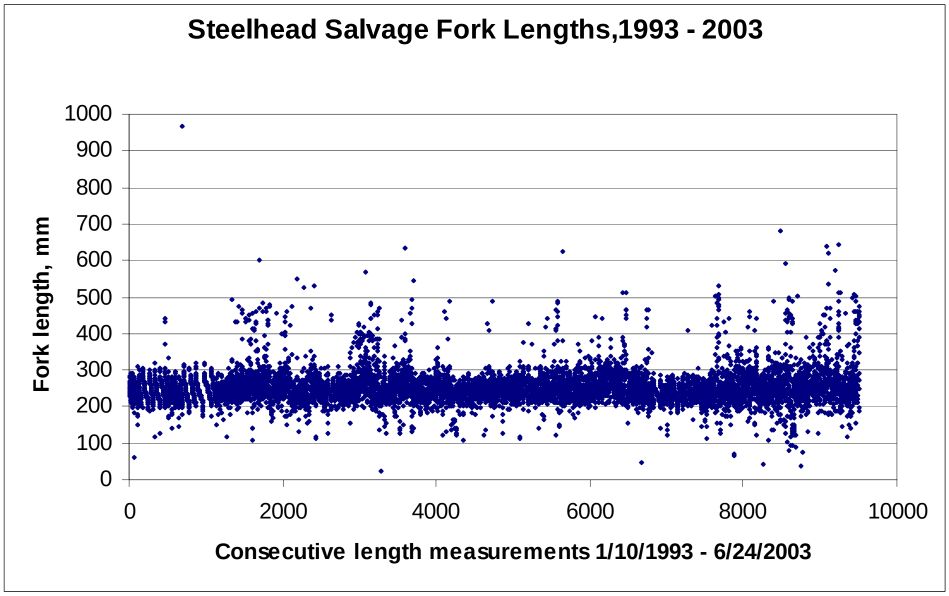


Figure 10–4 Steelhead salvage fork lengths measured since 1993 and listed consecutively as measured.

North Bay Aqueduct

The maximum pumping capacity of the NBA facility is 175 cfs, but its mean is typically lower. The NBA facility has positive barrier fish screens built to DFG specifications to exclude juvenile salmon. The screens have approach velocities ranging between 0.2 and 0.4 feet per second. DFG has determined this is sufficient to prevent entrainment of juvenile salmonids. The facility is located at the end of Barker Slough, more than 10 miles from the mainstem Sacramento River. There is no information on salmonids migrating up Barker Slough.

Sommer et al. (2001b) reported the 1998 and 1999 Chipps Island survival indices were comparable to or higher for CWT Chinook released into Yolo Bypass than for fish released simultaneously in the Sacramento River. Similarly, Brandes and McLain (2001) found survival indices were higher for CWT Chinook that passed through the Steamboat-Sutter slough complex than for fish that traveled down the mainstem Sacramento River. Both Yolo Bypass and Steamboat Slough empty into Cache Slough placing fish closer to the NBA pumping plant than they would have been had they remained in the main river channel. This suggests the NBA facility does not significantly adversely impact juvenile salmonids traveling in the river or Cache Slough. The higher survival of Steamboat-Sutter smolts does not affect the conclusions of the Newman and Rice analyses.

Delta Cross Channel

Juvenile salmon survival is higher when the fish remain in the Sacramento River, than when they migrate through the central Delta (Kjelson et al. 1982, Brandes and McLain 2001; Newman 2002). This has not been studied for steelhead, but they are likely affected in a similar manner, although to a lesser extent because steelhead emigrants are larger than Chinook. SWRCB D-1641 provides for closure of the DCC gates from February 1 through May 20. During November through January, the gates may be closed for up to 45 days for the protection of fish. The gates may also be closed for 14 days during the period May 21 through June 15. Reclamation shall determine the timing and duration of the closures after consultation with FWS, DFG, and NOAA Fisheries. Consultation with the CALFED Operations Group will also satisfy the consultation requirement. The CALFED Ops Group has developed and implemented the Salmon Protection Decision Process. The Salmon Protection Decision Process depends on identifying the time when young salmon are likely entering the Delta and taking actions to avoid or minimize the effects of DCC and other Project operations on their survival in the Delta. The decision process identifies “Indicators of sensitive periods for salmon” such as hydrologic changes, detection of spring–run or spring–run surrogates at monitoring sites or the salvage facilities, and turbidity increases at monitoring sites. These actions should provide protection to both steelhead and Chinook salmon for much of their peak emigration period. Figure 10–5 and Figure 10–6 show the percent of the Sacramento River flow passing through the DCC and through Georgiana Slough during critically dry years. Figure 10–7 shows the percent continuing on down the main Sacramento River channel. During the other water year types a lower percentage of flow passes through the DCC with the lowest percentage occurring in wet years. The percentage passing through the DCC increases in the future in June and August. The increased flow through the DCC occurs when few juvenile salmon or steelhead are present in the Delta. The cross channel gate closure in February through May and low percentage passing through the channel in December and January avoids the majority of salmon and steelhead emigrating from the Sacramento system.

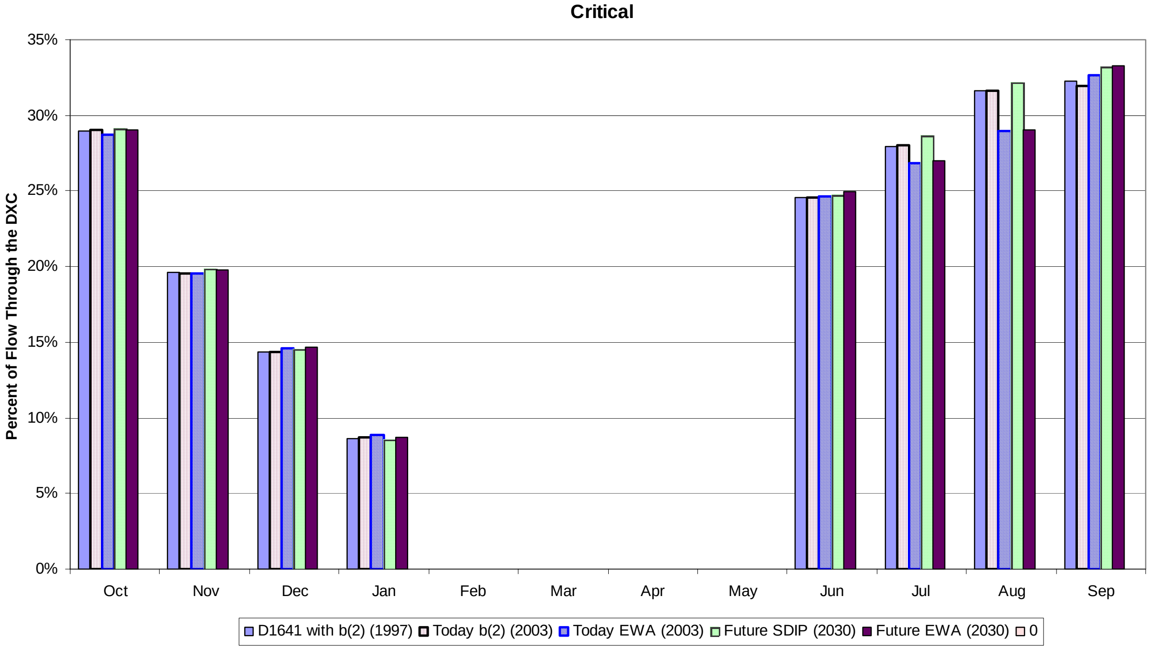


Figure 10–5 Percent of Sacramento River flow passing through the DCC during critically dry years under the five scenarios.

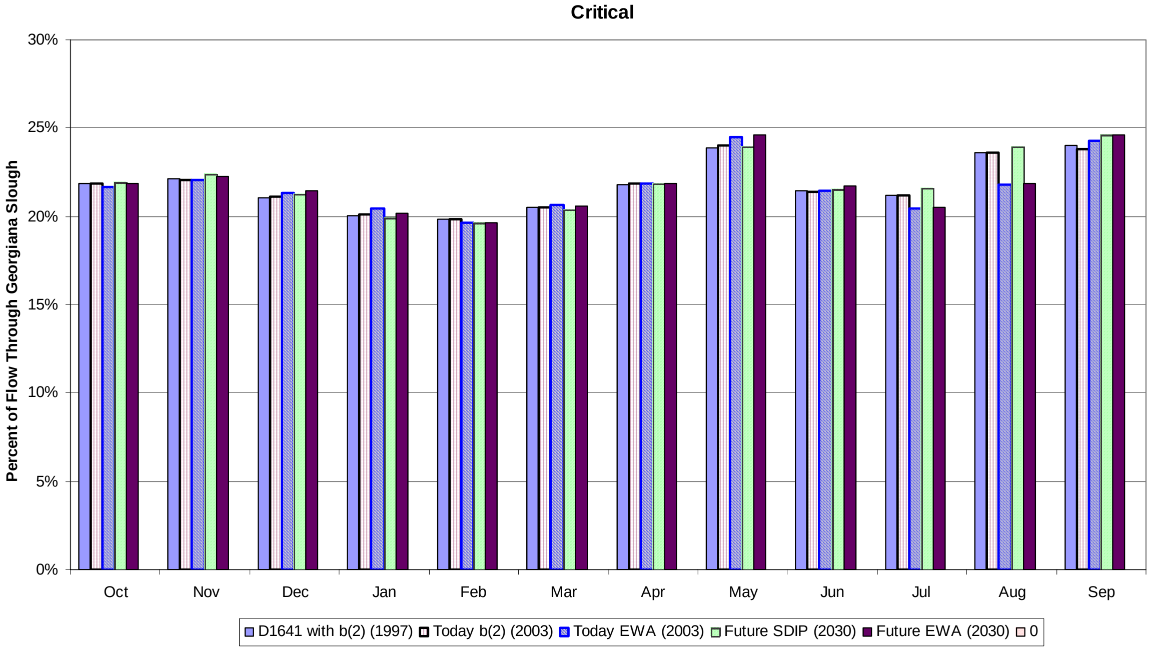


Figure 10–6 Percent of Sacramento River flow passing through Georgiana Slough during critically dry years under the five scenarios.

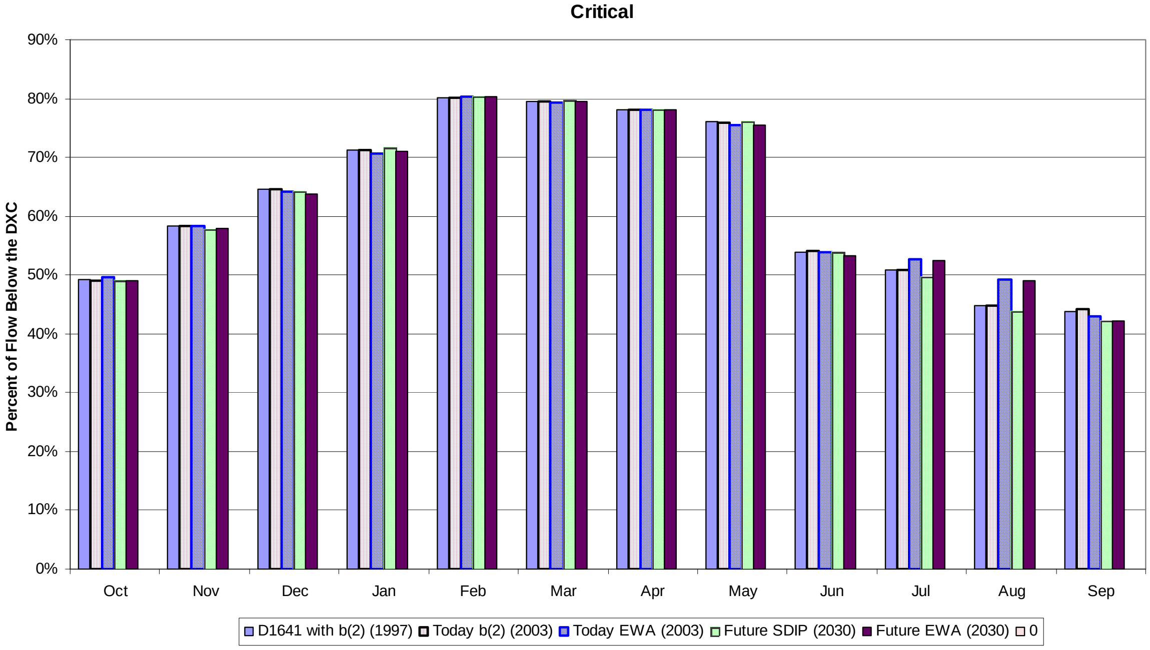


Figure 10–7 Percent of Sacramento River flow continuing down the main Sacramento River channel past the DCC and Georgiana Slough during critically dry years under the five scenarios.

Rock Slough Old River Intake

The Rock Slough diversion diverts water from Old River into the Contra Costa Canal. The historical diversion pattern varied between 50 to 250 cfs (Jerry Morinaka 1998, 2003 pers. comm., Table 10–4), with the higher pumping rates typical of the late spring through late fall period. The diversion is presently unscreened and construction of a fish screen is not currently planned. The extrapolated numbers of steelhead entrained by the facility between 1994 and 1996 were low, ranging from 52 to 96 per year (Morinaka 1998). Additional losses (8 percent to 30 percent) were recorded from the remains of fish killed during passage through the intake. Further losses could have occurred through predation due to the facility's location at the end of a dead-end slough, but this was not assessed for steelhead.

The following is a summary of fisheries monitoring conducted at Rock Slough since 1994. Numbers of listed fish species captured during monitoring is shown in Table 10–3.

Fish Monitoring Program at Pumping Plant #1

1994 to beginning of 1997

- Sample with a sieve-net in the Contra Costa Canal
- Sampled approximately 90–100 percent of the flow of water
- Sampled for an 8-hour period each sampling effort
- Year round monitoring program:

February through May = every other day
June and July = every 4th day
August and September = once a week
October through January = every 4th day

- Rock Slough was the primary source to meet the water demands in the Contra Costa Canal throughout this monitoring program

Fish Monitoring Program at the Headworks Location (Rock Slough Intake)

1998 to present

- Sampled with a sieve-net at the headworks structure of the Contra Costa Canal intake channel (4 miles upstream of Pumping Plant #1)
- Sampled approximately 10 – 15 percent of the flow of water
- Sampled for periods of 3 to 5 hours
- Year round monitoring program (once a week throughout the year)
- Rock Slough intake was used less after 1998 when Los Vaqueros Reservoir and the Old River Pumping Plant were operating

Table 10–3 Numbers of listed fish species captured at Pumping Plant # 1 of the Contra Costa Canal and the headworks at the Rock Slough Intake during fisheries monitoring, 1994-2002.

	1994	1995	1996	1997	1998	1999	2000	2001	2002
Chinook Salmon (All Races)	101	95	40	0	1	0	3	0	0
Winter–run Sized Chinook Salmon	2	6	4	0	1	0	0	0	0
Spring–run Sized Chinook Salmon	29	54	25	0	0	0	0	0	0
Steelhead	10	14	12	0	0	0	0	0	0
Delta Smelt	2	0	2	0	0	0	0	0	0

Table 10–4 Average monthly diversion rate at the Rock Slough intake, 1998-2002.

Contract	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs
1998	35	28	38	69	102	115	132	159	171	139	107	88
1999	40	38	28	64	8	147	218	140	18	3	2	21
2000	8	15	28	73	20	149	100	149	155	54	35	13
2001	40	37	31	68	48	166	29	32	9	10	13	13
2002	6	6	38	60	31	165	146	22	18	10	11	17

The extrapolated numbers of juvenile Chinook salmon (all races) entrained by the facility between 1994 and 1996 ranged from 262 to 642 per year (Morinaka 1998). Additional losses due to predation and fish being killed passing through the intake were estimated using juvenile marked hatchery fall–run Chinook salmon in 28 release groups. Survival estimates (estimated from recaptures in a sieve net 60 feet downstream of Pumping Plant #1) ranged from 0 percent to 51 percent and averaged about 18 percent. The large variation in survival rates may have resulted from releases done at different times of day and with different numbers of fish (see Morinaka 1998 for details). If we assume that only about 20 percent of salmon passing through the pumping plant survive, then the estimated numbers of juvenile salmon (all races) entrained between 1994 and 1996 would be about 1,695, 3,210 and 1,310 respectively.

Because most diversions occur during the summer months when salmon and steelhead are not present in the vicinity of the diversion and very few listed fish species (one winter–run and one splittail) have been captured during monitoring since 1997, the Rock Slough diversion is not believed to be a significant source of mortality for any of the listed species. Take of salmon and steelhead will likely continue to occur at levels similar to the past, which were estimated to be up to 3,200 juvenile Chinook (all races) per year assuming 20% survival from the diversion to the sampling site. No listed runs have been captured in sampling since 1996 so take of listed runs is expected to be very low, probably fewer than 50 spring–run, 50 winter–run and 15 steelhead.

Suisun Marsh Salinity Control Gates

The SMSCG could be operated as needed to meet State salinity standards in the marsh September through May, overlapping with an expected January through May peak emigration of steelhead through the Delta. However, young steelhead are rare in Suisun Marsh and are therefore unlikely to be substantially affected by gate operations. Examination of the UC Davis Suisun Marsh Monitoring databases revealed six steelhead were captured from 1979 through 1997. Only two of the six were sub-adult sized fish. The very low number of steelhead in the samples is partly due to poor capture efficiencies of the beach seines and otter trawl used in the UC Davis survey. However, 1,505 splittail greater than 200 mm, were collected by UC Davis sampling during the same period. Both adult splittail and yearling steelhead are excellent swimmers and are inefficiently sampled by the gear types used in this program. The much higher incidence of adult splittail in the samples suggests steelhead are relatively rare in the marsh. Furthermore, the marsh sampling collected more adult steelhead (4) than yearlings (2). The adults are larger and faster and therefore sampled less efficiently, providing additional evidence that yearling steelhead seldom occur in Suisun Marsh. The very infrequent occurrence of steelhead in the marsh suggests predation associated with migration delays is unlikely to significantly affect the steelhead population. As support for this hypothesis, steelhead were not listed as a prey item of striped bass or Sacramento pikeminnow captured near this facility between 1987 and 1993 (DWR 1997).

The Suisun Marsh Salinity Control Gates could potentially be operated September through May, overlapping with an expected November through May spring–run emigration. However, juvenile Chinook salmon of all races are rare in Suisun Marsh and are therefore unlikely to be substantially affected by gate operations. Examination of the UC Davis Suisun Marsh Monitoring databases showed only 257 juvenile Chinook salmon were captured from 1979 through 1997.

The infrequent occurrence of young Chinook in the marsh suggests that predation associated with migration delays is unlikely to significantly affect the spring–run or winter–run population. As support for this hypothesis, only three Chinook salmon were found in the stomachs of striped bass and pikeminnow captured near this facility between 1987 and 1993 (Heidi Rooks, pers. comm.).

Although young Chinook salmon will probably not be significantly affected by gate operations, it is possible upstream passage of adults could be influenced. Adult winter–run and spring–run may pass through the marsh channels from December through May when their migration could potentially be delayed. The SMSCG Steering Group decided based on preliminary results from the modified SMSCG tests that the slots resulted in less adult passage than the original flashboards. The modification made for the 2001-02 control season was to leave the boat lock at the SMSCG open at all times. This modification is currently being tested. It is hoped that this continuous opening at the structure will facilitate increased adult salmon passage. See "Suisun Marsh Salinity Control Gates" in Chapter 5 for more information.

Delta Smelt

This analysis is based on two CALSIM II case comparisons: model case #1 v model case #4 and model case #1 v model case #5 (see detailed explanation of model scenarios in Chapter 8). We have focused on these comparisons in order to characterize the future conditions with and without EWA against the baseline condition. The CALSIM II model scenarios represent the only available data simulating the movement of water through the delta under the various future scenarios considered in this document. The model results provide a (crude) basis to make these model case comparisons. The analysis is crude, because the monthly timestep of the CALSIM II model forces us to draw inferences from only a few data representing the critical seasons of each year.

In each model case comparison, we have considered (1) changes in expected direct entrainment loss at the CVP and SWP export facilities, (2) changes in X2, and (3) changes in the Export-Inflow ratio (E/I). Potential changes in entrainment are important indices of the effects of facility operations because entrainment directly reduces the pool of delta smelt available to replenish the population. Changes in X2 may not in themselves increase mortality, but may modify the proportion of the delta smelt population at risk of becoming entrained into the export facilities. The export-inflow ratio can index the extent to which export operations influence the pattern of flow through the delta, and may be useful where comparisons can be made at constant inflow. The index does not, however, tell us which areas of the delta are influenced by the pumps, nor is it reliable when comparisons cannot be made at constant inflow.

Direct losses to entrainment by CVP and SWP export facilities.

Some delta smelt are entrained by the south delta export facilities and lost to the estuarine population. Because the species is migratory, entrainment is seasonal. Adult delta smelt may be present in the south delta and vulnerable to entrainment from December through April; larvae and juveniles are likely to be present and vulnerable during late March through early July.

Entrainment is actually estimated by extrapolating salvage from periodic salvage measurements, which are assumed to index entrainment, and then applying assumptions. To make prediction of the difference in salvage between model scenarios possible, we assumed that salvage density (fishes per volume) is independent of the pumping rate. Because salvage density is not independent of delta outflow and varies seasonally, we estimated salvage density for wet and dry water year types from historical data representing the period 1993–2002. There were too few years of most water-year types to reasonably estimate salvage density for each type, so data from wet (Wet and Above Normal) and dry (Below Normal, Dry, and Critically Dry) types were pooled. The difference in salvage between two model cases was then computed simply by estimating the difference in pumping rate from the CALSIM II model output and multiplying by the corresponding salvage density estimate. We separately estimated changes in salvage for each (a) salvage facility and (b) Sacramento River water-year type. The monthly differences were computed as $(X_y–X_1)/X_1$ where the subscript y is either 4 or 5 (corresponding to those model cases), and X_1 represents the base case (#1).

We have focused on typical differences between the model cases, and have used the median rather than the mean to represent them. The median ordinarily divides a body of scalar data into two groups of equal size. The distributions of differences in the pumping data were skewed in some cases, with one tail of the distribution much longer than the other. This usually arose in cases where some of the base-case values X_1 were much smaller than other X_1 values within the case for reasons having to do with the CALSIM II model assumptions. Because X_1 appears in the denominator of the difference calculation, small values tend to telescope the distribution of differences. Use of the median avoids the mean's tendency to track the longer tail of the distribution, thus overstating the typical difference between the data being compared.

Results:

Salvage of adult delta smelt

All comparisons of model cases #4 and #5 are with model case #1. Unspent adult delta smelt of considerably more value to the population than juveniles, so salvage of individuals likely to fall into this class is important. In general, the results suggest modest increases in salvage in typical years at the CVP facility in model case #4, while there is either no change or a trivial decrease when EWA actions are included in case #5 (Table 10–5 – Table 10–14). At the SWP facility, there is a more consistent increase in model case #4, usually of 10% or less; the inclusion of EWA actions apparently has substantial effect in some cases, with the net result that there is little overall change in adult salvage in case #5 with respect to case #1. In typical wet years, there is a substantial 18% increase in adult December salvage at Banks in case #4 that is reduced to 13.7% under case #5. There are similar typical increases in both future cases in March. In critically dry years model case #5 produces a net decrease in adult entrainment at Banks. It is unclear what effect these changes might have on the smelt population in typical years. The increases in December and March in typical wet years under both case #4 and case #5 may be of concern in some years, depending on the abundance and distribution of adult delta smelt during those months.

Table 10–5 CVP salvage in Wet years

Month	Median model case 1 pumping (c.f.s.)	Median change in case 4	Median change in case 5	Density of delta smelt at Tracy[1]	Predicted median difference in salvage[2]	
					4 – 1	5 – 1
Adults						
December	4222	+8.9%	–0.7%	0.010	+3.8	–0.3
January	4226	+8.8%	–0.8%	0.095	+35.3	–3.2
February	4243	+8.3%	–2.2%	0.151	+53.2	–14.1
March	4273	–2.9%	+7.0%	0.159	–19.7	+47.6
Largely Juveniles						
April	2747	0	0	0.206	0	0
May	2274	0	0	7.430	0	0
June	3000	0	0	2.017	0	0
July	4588	+0.3%	0	0.036	+0.5	0
Net: December – March					+73	+29
Net: April – July					+1	0

[1] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Above Normal and Wet years 1995-2000.

[2] Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 10–6 CVP salvage in Above Normal years

Month	Median model case 1 pumping (c.f.s.)	Median change in case 4	Median change in case 5	Density of delta smelt at Tracy[1]	Predicted median difference in salvage[2]	
					4 – 1	5 – 1
Adults						
December	4221	+8.9%	–0.7%	0.010	+3.8	–0.3
January	4225	+8.9%	–0.8%	0.095	+35.7	–3.2
February	4242	+8.4%	–2.2%	0.151	+53.8	–14.1
March	4262	–14.3%	+0.3%	0.159	–96.9	+2.0
Largely Juveniles						
April	2742	0	0	0.206	0	0
May	1911	0	0	7.430	0	0
June	2920	0	0	2.017	0	0
July	4580	+0.1%	+0.2%	0.036	+0.2	+0.3
Net: December – March					–4	–16
Net: April – July					0	0

[1] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Above Normal and Wet years 1995-2000.

[2] Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 10–7 CVP salvage in Below Normal years

Month	Median model case 1 pumping (c.f.s.)	Median change in case 4	Median change in case 5	Density of delta smelt at Tracy[1]	Predicted median difference in salvage[2] 4 – 1	Predicted median difference in salvage[2] 5 – 1
Adults						
December	4221	+7.3%	–3.5%	0.067	+20.6	–9.9
January	4225	+8.9%	–0.7%	0.180	+67.7	–5.3
February	4241	+8.1%	+8.2%	0.235	+80.7	+81.7
March	4235	–3.8%	–4.8%	0.201	–32.3	–40.9
Largely Juveniles						
April	2321	0	–1.1%	0.259	0	–6.6
May	1911	0	–34.0%	11.93	0	–7751
June	3000	0	0	1.584	0	0
July	4554	+0.3%	+0.2%	0.005	+0.1	+0.1
Net: December – March					+137	+26
Net: April – July					0	–7758

[1] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2.

[2] Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 10–8 CVP salvage in Dry years

Month	Median model case 1 pumping (c.f.s.)	Median change in case 4	Median change in case 5	Density of delta smelt at Tracy[1]	Predicted median difference in salvage[2] 4 – 1	Predicted median difference in salvage[2] 5 – 1
Adults						
December	4220	+8.9%	–0.7%	0.067	+25.2	–2.0
January	4225	+8.8%	–0.8%	0.180	+66.9	–6.1
February	4235	+8.4%	+8.4%	0.235	+83.6	+83.6
March	4208	+1.4%	–0.8%	0.201	+11.8	–6.8
Largely Juveniles						
April	1808	+0.7%	+0.9%	0.259	+3.3	+4.2
May	1720	0	–38.1%	11.93	0	–7818
June	2874	0	–8.9%	1.584	0	–405
July	4421	–0.3%	–5.7%	0.005	–0.1	–1.3
Net: December – March					+188	+69
Net: April – July					+3	–8220

[1] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2.

[2] Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 10–9 CVP salvage in Critically Dry years

Month	Median model case 1 pumping (c.f.s.)	Median change in case 4	Median change in case 5	Density of delta smelt at Tracy[1]	Predicted median difference in salvage[2]	
					4 – 1	5 – 1
Adults						
December	2897	+4.8%	–19.1%	0.067	+9.3	–37.1
January	4218	+8.9%	–9.7%	0.180	+67.6	–73.6
February	3979	+1.9%	–0.1%	0.235	+17.8	–9.4
March	1247	+2.9%	0	0.201	+7.3	0
Largely Juveniles						
April	800	0	0	0.259	0	0
May	1189	0	–32.6%	11.93	0	–4624
June	953	–1.1%	0	1.584	–16.6	0
July	800	–1.5%	0	0.005	–0.1	0
Net: December – March					+102	–120
Net: April – July					–17	–4624

[1] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2.

[2] Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 10–10 SWP salvage in Wet years

Month	Median model case 1 pumping (c.f.s.)	Median change in case 4	Median change in case 5	Density of delta smelt at Banks[1]	Predicted median difference in salvage[2]	
					4 – 1	5 – 1
Adults						
December	7033	+18.0%	+13.7%	0.015	+19.0	+14.5
January	7408	+9.5%	+8.4%	0.214	+150.6	+133.2
February	5848	+2.4%	+4.1%	0.242	+34.0	+58.0
March	5653	+17.2%	+24.8%	0.069	+67.1	+96.7
Largely Juveniles						
April	4830	+8.7%	–19.2%	0.058	+24.4	–53.8
May	4660	+5.8%	–48.4%	12.52	+3384	–28238
June	5925	–0.1%	+7.0%	10.90	–64.6	+4521
July	6680	+12.7%	+17.4%	0.611	+518.3	+710
Net: December – March					+271	+302
Net: April – July					+3862	–23061

[1] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Above Normal and Wet years 1993 and 1995-2000.

[2] Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 10–11 SWP salvage in Above Normal years

Month	Median model case 1 pumping (c.f.s.)	Median change in case 4	Median change in case 5	Density of delta smelt at Banks[1]	Predicted median difference in salvage[2]	
					4 – 1	5 – 1
Adults						
December	6484	+9.3%	+4.8%	0.015	+9.0	+4.7
January	7548	0	–4.8%	0.214	0	–77.5
February	7451	+2.1%	–3.1%	0.242	+37.9	–55.9
March	5784	+14.3%	+26.6%	0.069	+57.1	+106.2
Largely Juveniles						
April	4508	+7.4%	–23.5%	0.058	+19.3	–61.4
May	3596	+2.3%	–58.3%	12.52	+1036	–26248
June	3942	+3.5%	+0.6%	10.90	+1504	+257.8
July	6157	+7.7%	+27.0%	0.611	+289.7	+1016
Net: December – March					+104	–23
Net: April – July					+2848	–25036

[1] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Above Normal and Wet years 1993 and 1995-2000.

[2] Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 10–12 SWP salvage in Below Normal years

Month	Median modelcase 1 pumping (c.f.s.)	Median change in case 4	Median change in case 5	Density of delta smelt at Banks[1]	Predicted median difference in salvage[2]	
					4 – 1	5 – 1
Adults						
December	5938	+11.2%	+6.0%	0.050	+33.3	+17.8
January	7172	+7.5%	–0.4%	0.209	+112.4	–6.0
February	5850	+2.1%	+5.7%	0.134	+16.5	+44.7
March	5713	+12.4%	+8.9%	0.178	+126.1	+90.5
Largely Juveniles						
April	3548	+1.0%	–25.2%	0.369	+13.1	–329.9
May	3235	+3.9%	–50.0%	29.97	+3781	–48477
June	3977	–0.2%	–2.6%	6.706	–53.3	–693.4
July	5320	+4.0%	+23.1%	0.446	+94.9	+548
Net: December – March					+288	+147
Net: April – July					+3836	–48952

[1] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2.

[2] Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 10–13 SWP salvage in Dry years

Month	Median model case 1 pumping (c.f.s.)	Median change in case 4	Median change in case 5	Density of delta smelt at Banks[1]	Predicted median difference in salvage[2]	
					4 – 1	5 – 1
Adults						
December	5358	+9.5%	+9.5%	0.050	+25.5	+25.5
January	5717	+10.0%	–8.6%	0.209	+119.5	–102.8
February	5303	+7.2%	+9.5%	0.134	+51.2	+67.5
March	4413	–0.1%	–0.1%	0.178	–0.8	–0.8
Largely Juveniles						
April	2168	+0.1%	–18.1%	0.369	+0.8	–144.8
May	2099	–1.8%	–58.1%	29.97	–1132	–36549
June	2952	–0.8%	–6.7%	6.706	–158.4	–1326
July	5217	+0.1%	+29.2%	0.446	+2.3	+679.4
Net: December – March					+195	–11
Net: April – July					–1288	–37341

[1] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2.

[2] Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 10–14 SWP salvage in Critically Dry years

Month	Median model case 1 pumping (c.f.s.)	Median change in case 4	Median change in case 5	Density of delta smelt at Banks[1]	Predicted median difference in salvage[2]	
					4 – 1	5 – 1
Adults						
December	4267	+6.0%	–5.9%	0.050	+12.8	–12.6
January	4891	+6.2%	–13.2%	0.209	+63.4	–134.9
February	3198	+13.4%	+14.4%	0.134	+57.4	+61.7
March	2030	+14.2%	+0.3%	0.178	+51.3	+1.1
Largely Juveniles						
April	1197	0	0	0.369	0	0
May	1189	0	–32.7%	29.97	0	–11652
June	300	0	0	6.706	0	0
July	553	–1.1%	+53.5%	0.446	–2.7	+132.0
Net: December – March					+185	–85
Net: April – July					–3	–11521

[1] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2.

[2] Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Salvage of Juvenile Delta Smelt

All comparisons of model cases #4 and #5 are with model case #1. There are only small changes in juvenile salvage at the CVP facility under both case #4 and case #5. Changes at Banks under case #4 are also small. There are substantial median reductions in Banks pumping in April and May when EWA actions are added in case #5. These would result in reductions in juvenile smelt salvage during those months that might benefit the species in some years, particularly those in which high entrainment episodes would otherwise occur during that period (particularly in May).

It should be noted that although it is used for the purpose, salvage does not particularly reliably index entrainment of delta smelt. Furthermore, delta smelt salvage is highly variable at all time scales, because fish are locally patchily distributed in the delta and may spawn at different times and in different regions in different years. Delta smelt also present no good stock-recruit relationship. Consequently, while this analysis credibly predicts what might happen in typical years, there will – even under the “baseline” model case 1 scenario – certainly be a small percentage of future years in which the confluence of natural and anthropogenic circumstances causes large delta smelt entrainment episodes. Delta smelt spend more time closer to the export facilities under low-flow conditions, making these episodes more likely in dry years; however, they might occur in any water-year type. Because an analysis of the likelihood of these events would require modeling delta smelt movement using detailed historical distributional data that are unavailable, we cannot determine whether the frequency of large entrainment events would be different from model case #1 under model cases #4 or #5. Better modeling and improved monitoring may provide a means to attack this question in the future.

There may have been a population-level export effect – i.e., depression of the delta smelt population in the fall following a spring with especially high entrainment -- in a few years during 1980–2002. If these effects are real, they will probably occur again when similar circumstances arise. New analytical approachs that employ estimates of the boundary of the zone of entrainment to predict the proportion of the delta smelt population that is subject to entrainment are under development. If these efforts succeed, they could provide a respectable basis for evaluating the population-level effects of export operations and proposed changes to operations.

Changes in Habitat Availability for Delta Smelt Based on X2 Movement

Average X2 during March–July of each year differed very little between model case #1 and either #4 or #5. However, a review of the monthly data revealed that there were isolated differences that were larger than most others during the March–July months. We are concerned about upstream movements of X2 during the spring and early summer primarily because smelt tend to aggregate in a region defined by low salinity, and movement of that region upstream moves those aggregations closer to the export pumps. Because there is no basis for identifying a particular value as the critical one that separates a dangerous X2 difference from an innocuous one, we arbitrarily selected one kilometer as the criterion for review.

The difference between X2 in CALSIM II model cases #4 and #5 and case #1 were plotted against X2 in case #1 for each of the months March through July (Figure 10–8 – Figure 10–12). In each figure, five panels representing each of the Sacramento River water-year types are presented. Positive differences represent movement of X2 upstream. In each figure, difference values larger than one kilometer in Below Normal, Dry, and Critically Dry years have been labeled with the years they represent.

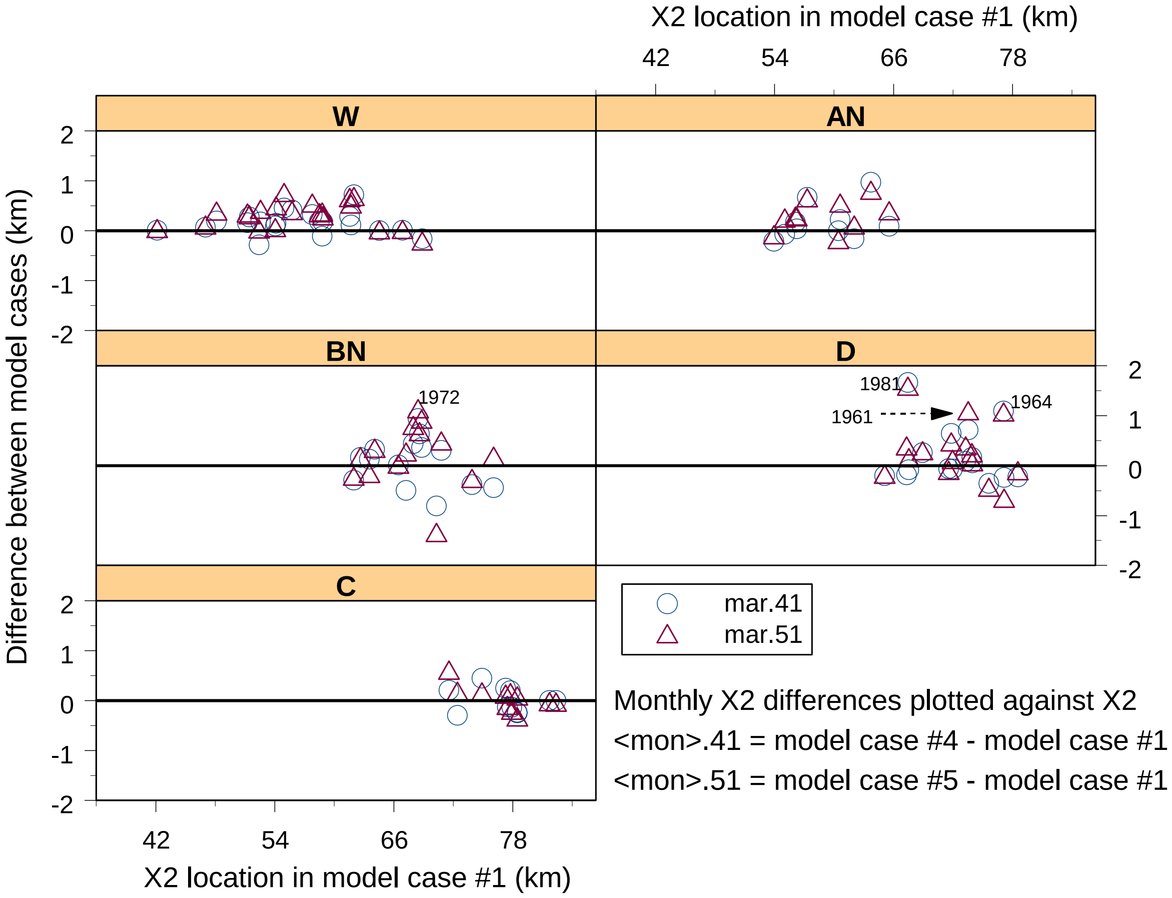


Figure 10–8 Differences in X2 under model cases #4 and #5 in March. Water year types: W=Wet, AN=Above Normal, BN=Below Normal, D=Dry, C=Critically Dry

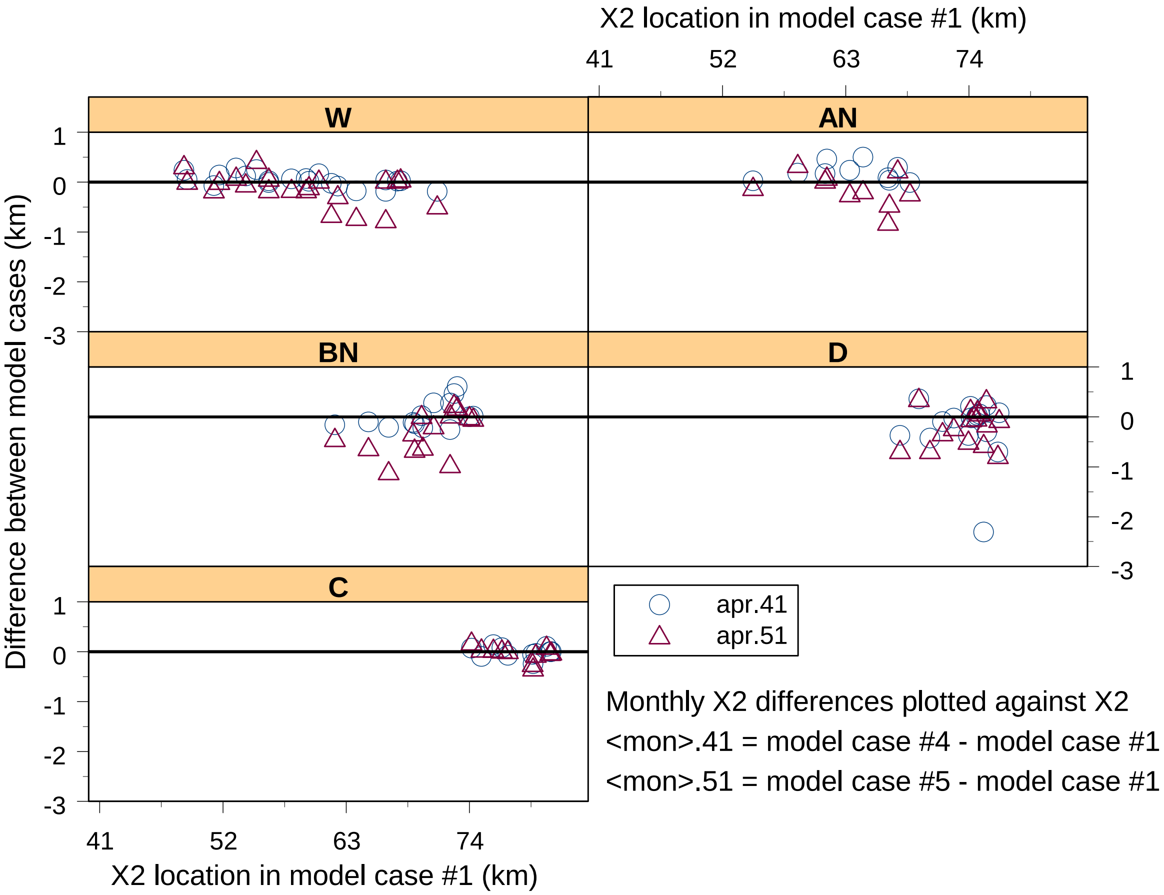


Figure 10–9 Differences in X2 under model cases #4 and #5 in April. Water year types: W=Wet, AN=Above Normal, BN=Below Normal, D=Dry, C=Critically Dry

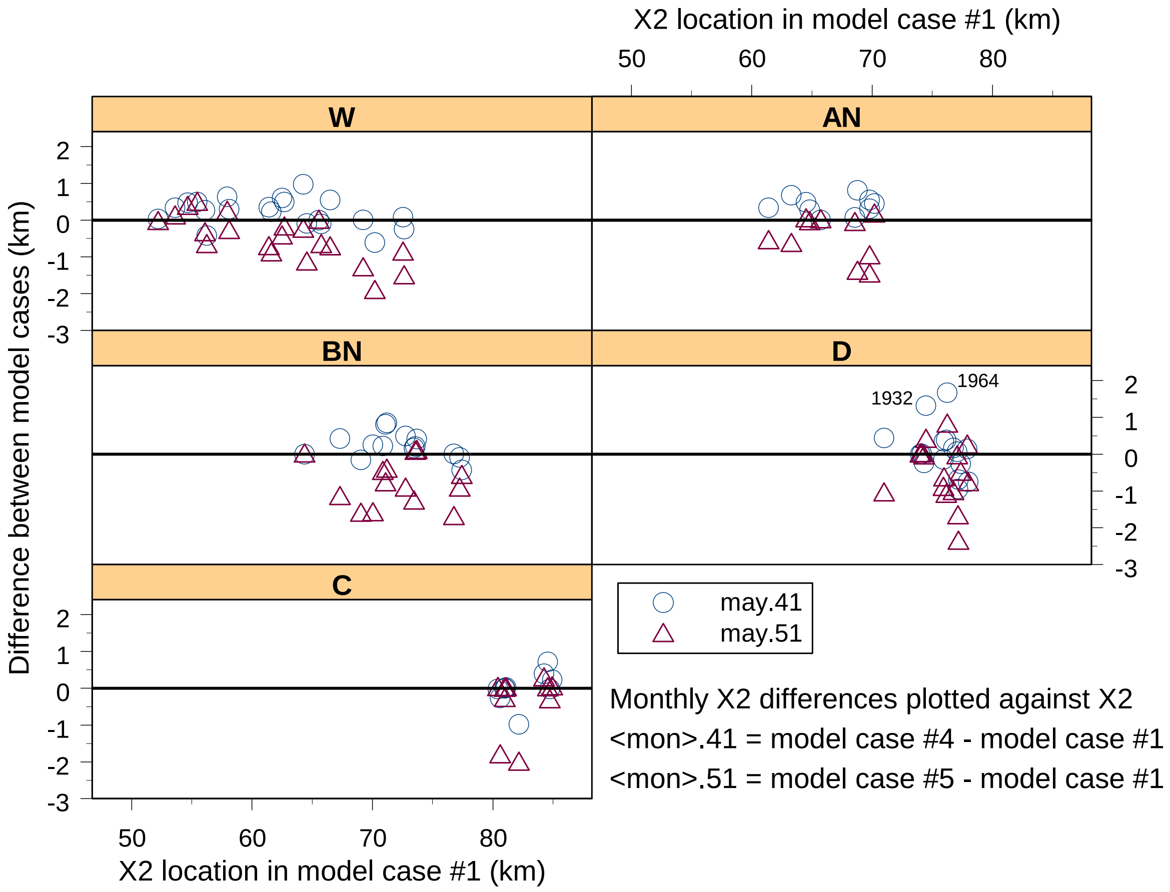


Figure 10–10 Differences in X2 under model cases #4 and #5 in May. Water year types: W=Wet, AN=Above Normal, BN=Below Normal, D=Dry, C=Critically Dry

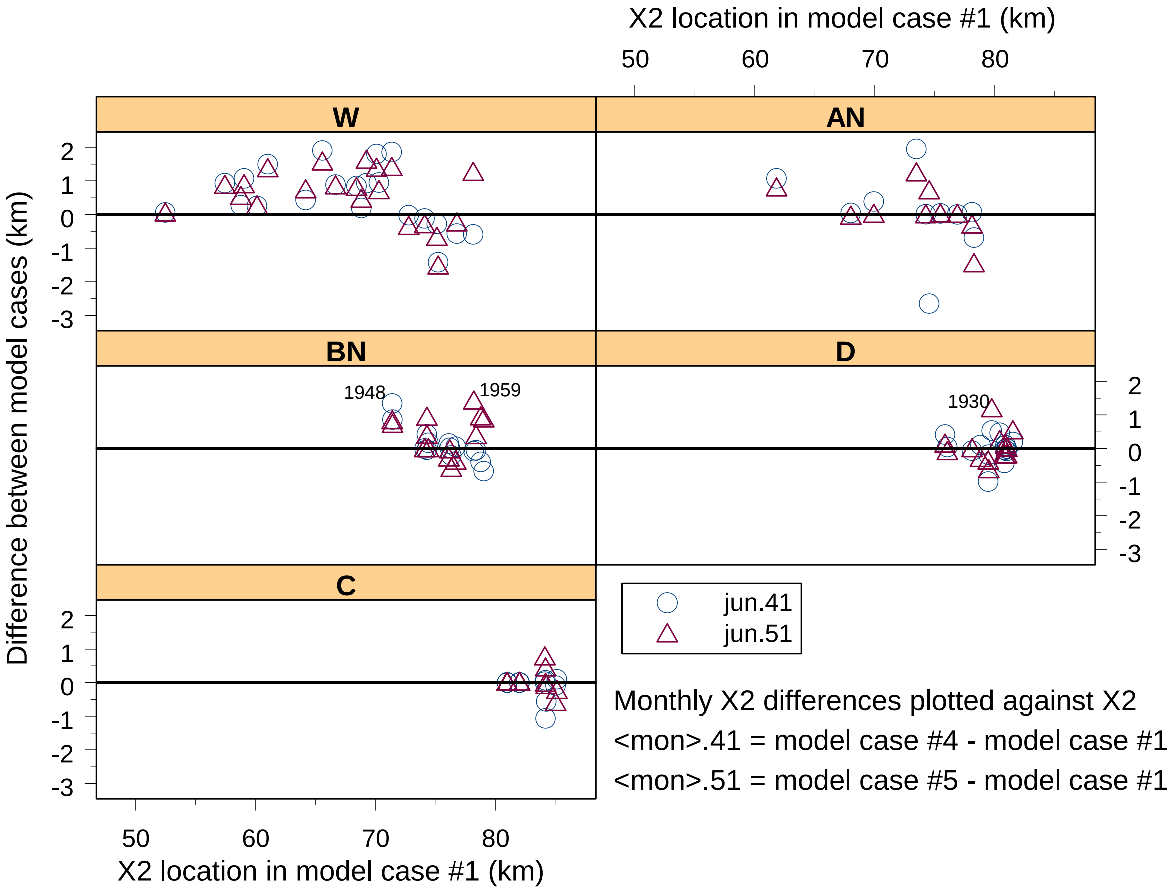


Figure 10–11 Differences in X2 under model cases #4 and #5 in June. Water year types: W=Wet, AN=Above Normal, BN=Below Normal, D=Dry, C=Critically Dry

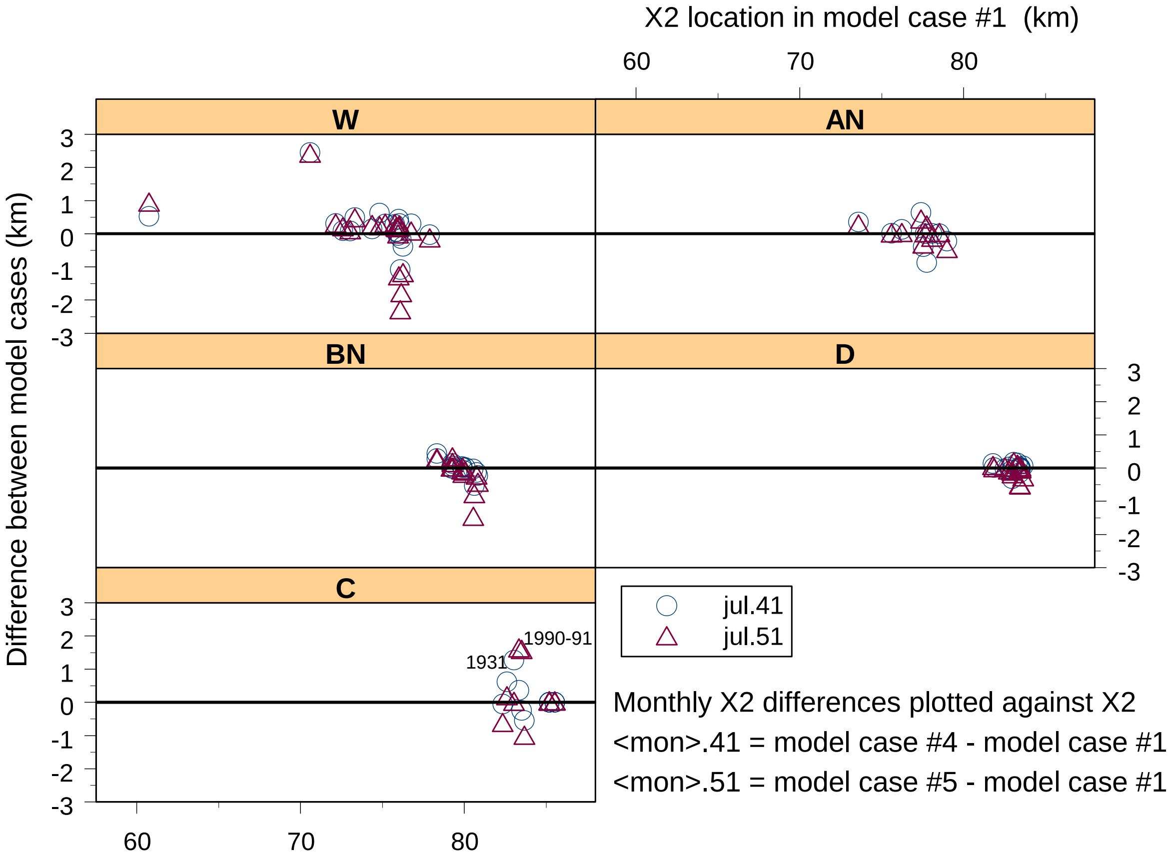


Figure 10–12 Differences in X2 under model cases #4 and #5 in July. Water year types: W=Wet, AN=Above Normal, BN=Below Normal, D=Dry, C=Critically Dry

Results:

March

There was one difference of at least one kilometer in a Below Normal year (1972) and three occurrences in Dry years (1961, 1964, 1981). In all four cases the base X2 value was similar (70–78 km). In 1961 and 1972, model case #4 yielded a lower X2 value than case #5 (0.71 vs. 1.08 in 1961 and 0.95 vs. 1.11 in 1972); in the other cases the model #4 and #5 values were similar. None of these larger differences was followed by an April X2 difference larger than 0.34 km; indeed, two of the April differences were negative and one was zero.

April

There were no differences larger than one kilometer in April.

May

There were two differences of at least one kilometer in model case #4 during May in Dry years. In both cases (1932 and 1964), the differences were greatly reduced (1.3 km vs. 0.4 km in 1932 and 1.67 vs. 0.8 km in 1964) by the addition of EWA actions in model case #5. In both cases, there were either negative differences or small upstream differences in adjacent months.

June

In June there were two Below Normal (1948, 1959) years and one Dry (1930) year which met the one-kilometer criterion for review. In 1948, a model case #4 value of 1.34 km was reduced to 0.82 km in case #5. Neither adjacent month in either future model case reached 0.5 km. In 1930 and 1959 the largest values occurred in case #5, with smaller values in case #4 (1.18 km in case #5 vs. 0.53 km in case #4 for 1930; 1.41 km in case #5 vs. –0.1 km in case #4 in 1959). None of these cases had an adjacent month in which the difference exceeded 0.5 km.

July

In July there were three Critically Dry years (1931, 1990, 1991) where the criterion was reached. In 1931 a difference of 1.28 km in case #4 was erased in case #5, while in both 1990 and 1991 negligible values in case #4 were replaced by positive values (1.6 km and 1.56 km, respectively) in case #5. Upstream movements of X2 in July are unlikely to be of significant concern except in unusual circumstances.

Summary

In the drier years, upstream movements of X2 predicted in model cases #4 and #5 reach one kilometer only in isolated months. In some cases upstream movements observed in case #4 are erased or reduced in case #5. In a few cases the upstream movement is larger in case #5. The seasonal average difference between both future cases and the base case is close to zero, and is sometimes negative. We are skeptical that a change as small as one kilometer – about an order of magnitude smaller than the typical tidal excursion at, for example, Chipps Island – in a single month would ordinarily affect the vulnerability of the smelt population near X2, even in critically dry years when X2 is far upstream during the spring. We conclude that X2 differences in the future cases are by themselves unlikely to affect delta smelt in most years. This conclusion is tentative, and might be modified in the future as our understanding of the circumstances that impose delta smelt vulnerability increases.

Export-Inflow ratio

Exceedence plots of the Export-Inflow ratio (E/I) reveal that in both cases #4 and #5 E/I is similar to or lower than case #1 in the months December–July. We do not expect changes to E/I predicted by cases #4 or #5 to create delta smelt protective concerns.

Water Transfers

Water transfers would increase Delta exports from 200,000 – 600,000 af in about 80% of years and potentially up to 1,000,000 af in some Dry and Critical years. Most of the transfers would occur during July through September. Juvenile salmonids are rarely present in the Delta in these months so no increase in salvage due to water transfers during these months is anticipated. Water transfers could be beneficial if they shift the time of year that water is pumped from the Delta from the winter and spring period to the summer, avoiding periods of higher salmonid abundance in the vicinity of the pumps. Some adult salmon and steelhead are immigrating upstream through the Delta during July through September. Increased pumping is not likely to affect immigrating adults because they are moving in a general upstream direction against the current. For transfers that occur outside of the July through September period all current water quality and pumping restrictions would still be in place to limit effects that could occur.

Post-processing of model data for Transfers

This sections shows results from post-processed available pumping capacity at Banks and Tracy for the Future SDIP (Study 4) the assumptions for the calculations are:

- Capacities are for the Late-Summer period July through September total.
- The pumping capacity calculated is up to the export-to-inflow ratio and is limited by either the total physical or permitted capacity and do not include restrictions due to ANN salinity requirements with consideration of carriage water costs.
- The calculations do assume a reserve of 90 TAF for EWA pumping total for the July to September months at Banks.

Figure 10-15 and Figure 10-16 show the total available export capacity from highest to lowest for Banks and Tracy in the Future SDIP study with the 40-30-30 water year type on the x-axis and the water year labeled on the bars. Figure 10-13 and Figure 10-14 show the available export capacity for the Today b(2) study at Banks and Tracy respectively. The SWP allocation or the CVP south or Delta allocation is the allocation from CALSIM II output from the water year.

From Figure 10-13 and Figure 10-15 the years with the most capacity at Banks are generally the Dry and Critical years with the lowest allocations and reflect years when transfers maybe higher to augment water supply to export contractors. For the Today b(2) study in approximately 80% of the years the available capacity at Banks for transfer ranges from about 60 to 460 TAF in the (if the 90 TAF dedicated for EWA is included). In most years (approximately 80%) the available capacity at Banks for transfer ranges from about 200 to 600 TAF in the Future SDIP study (if the 90 TAF dedicated for EWA is included). Transfers at Tracy (Figure 10-14 and Figure 10-16) are probably most likely to occur in the Critical years when there is available capacity and low allocations.

The transfer results just show the capacity at the export pumps and do not reflect the amount of water available from willing sellers or the ability to move through the Delta.

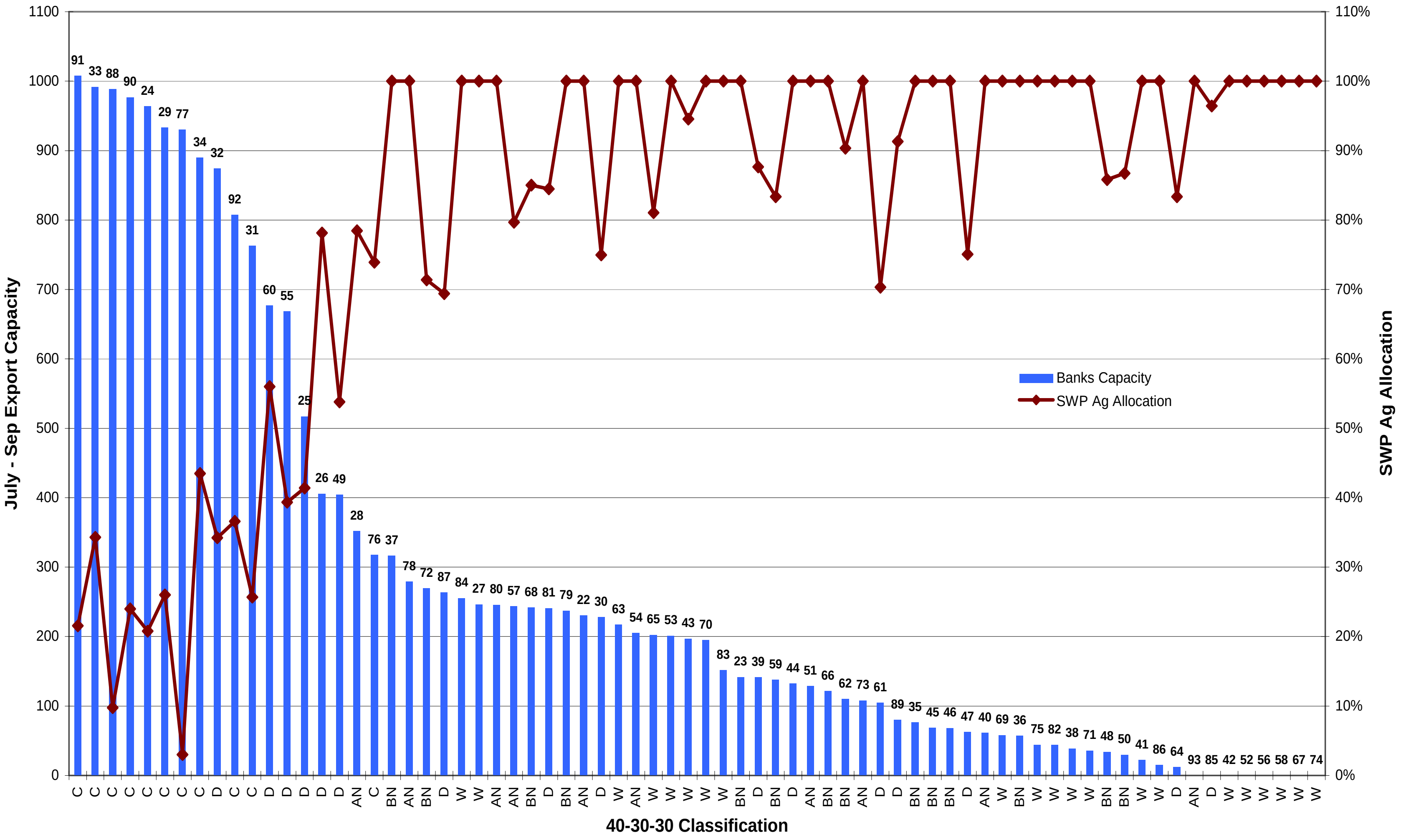


Figure 10-13 Total Banks pumping for July – September capacity in the Today b(2) Study sorted from highest to lowest with the corresponding SWP Allocation

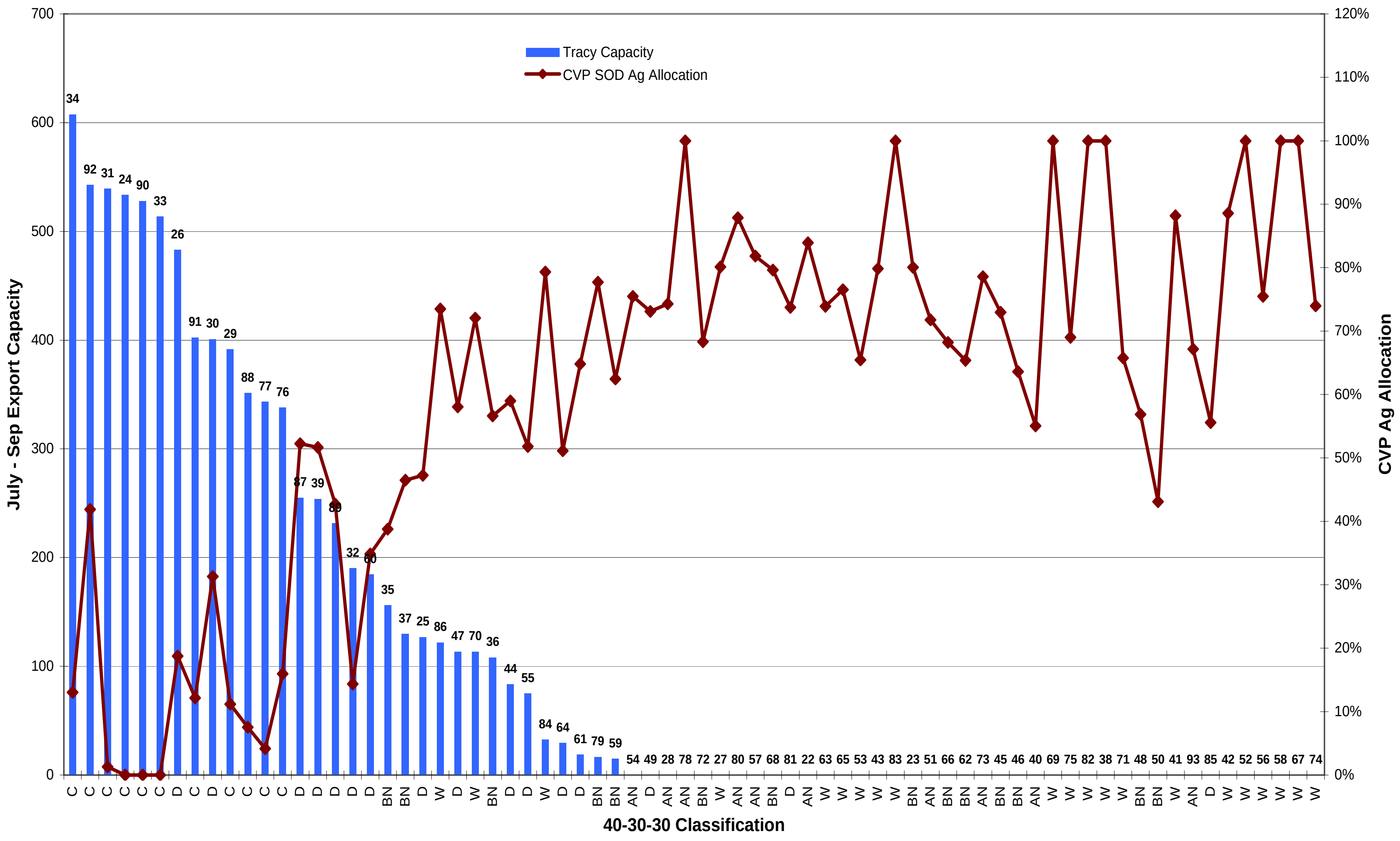


Figure 10-14 Total Tracy pumping for July – September capacity in the Today b(2) Study sorted from highest to lowest with the corresponding CVP south of Delta Ag Allocation

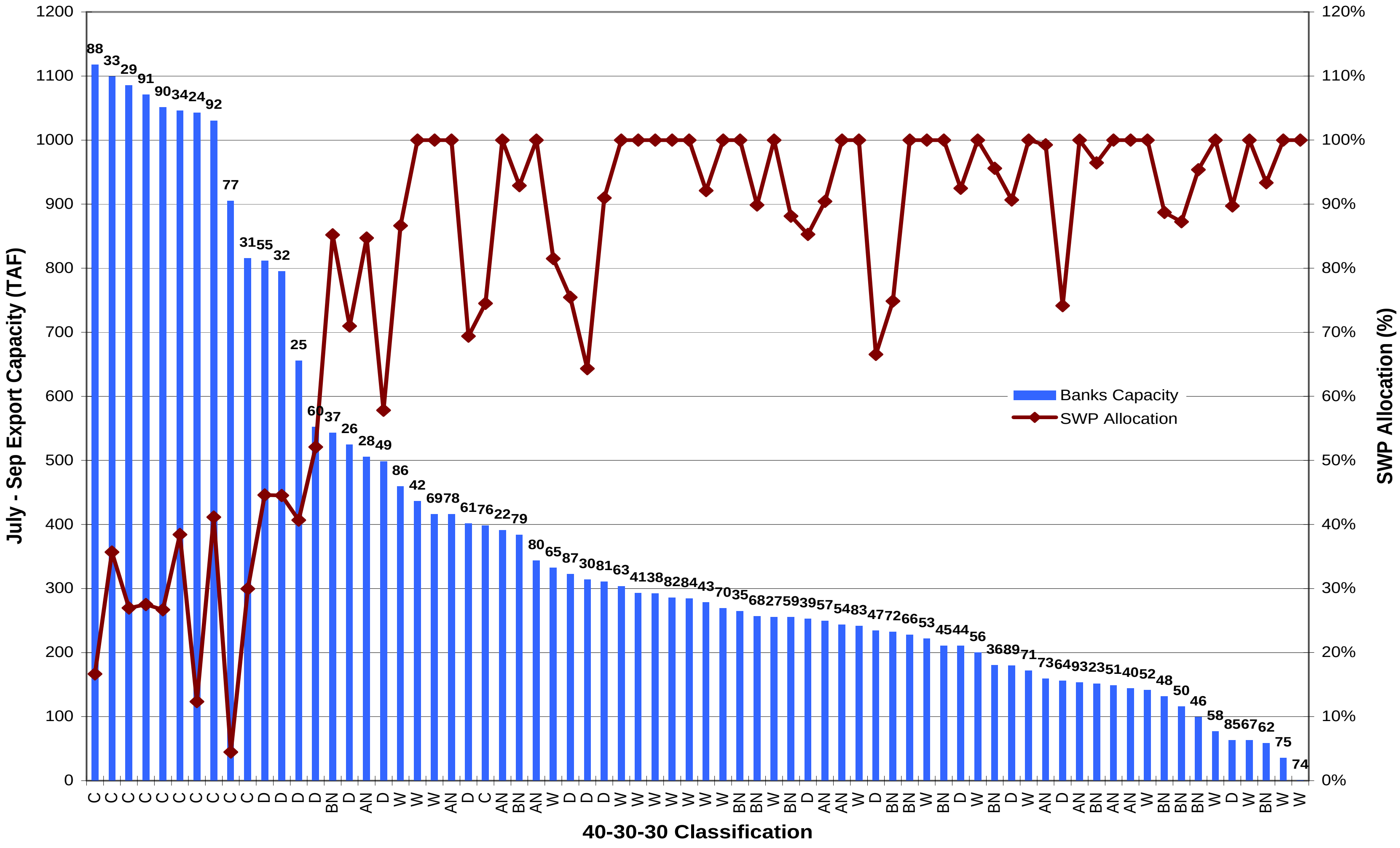


Figure 10-15. Total Banks pumping for July – September capacity in the Future SDIP Study sorted from highest to lowest with the corresponding SWP Allocation

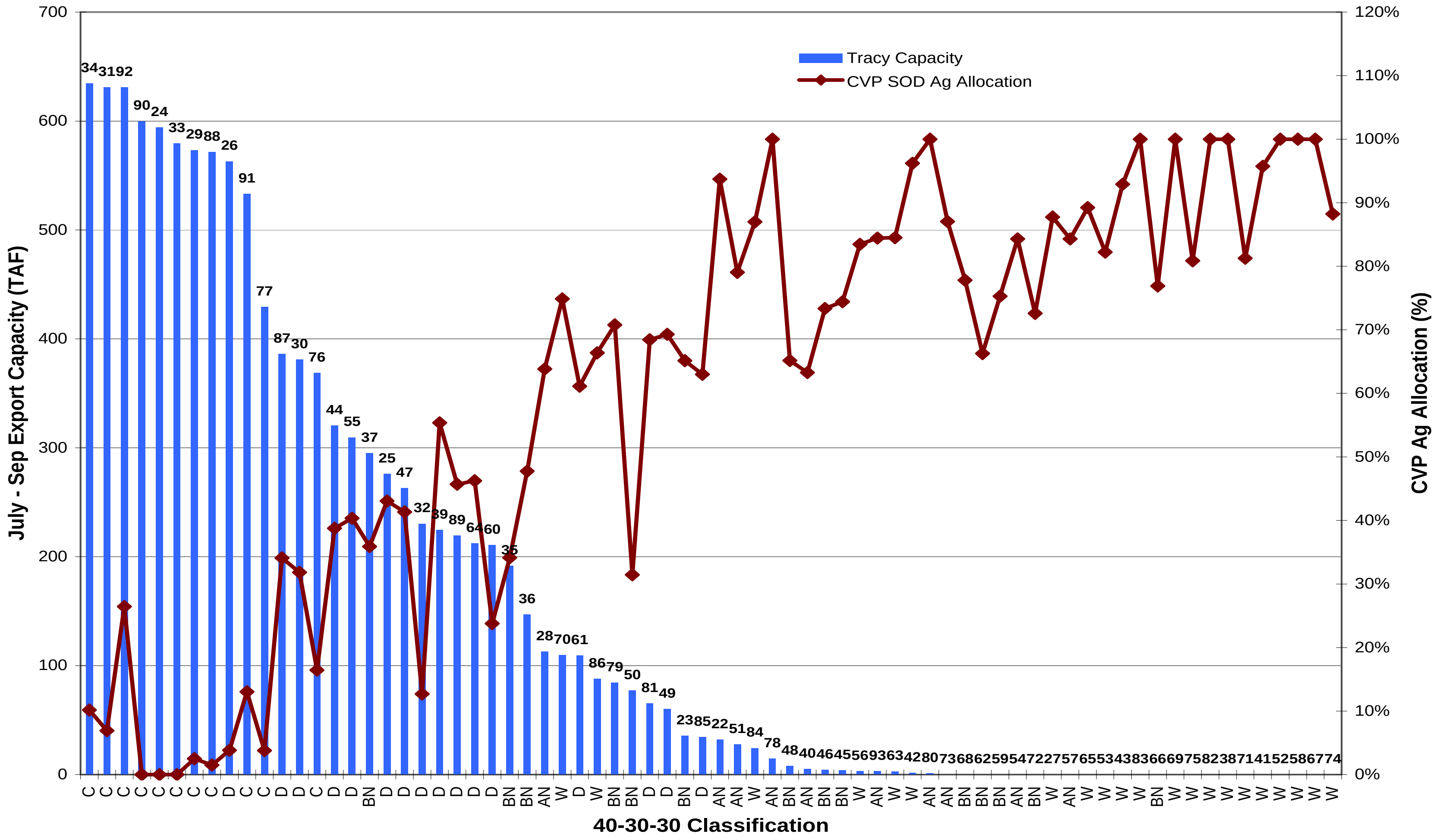


Figure 10-16 Total Tracy pumping for July – September capacity in the Future SDIP Study sorted from highest to lowest with the corresponding CVP south of Delta Ag Allocation

Delta CALSIM Modeling Results

Inflow

Total delta inflow in the model is treated as the sum of Yolo Bypass, Sacramento River, Mokelumne River, Calaveras River, Consumnes River, and the San Joaquin River. Table 10-15 lists average annual inflow into the delta on a long-term average and 1928 to 1934 average bases. The total annual inflow decreases in all comparisons on average between studies with the exception of the long-term drought period when comparing the Today runs to the Future runs. The increases in delta inflow in the dry period are generally for increased pumping at Banks.

Table 10-15 Differences in annual Delta Inflow for Long-term average and the 28-34 Drought

Differences (TAF)	Study 2 - Study 1	Study 3 - Study 1	Study 5 - Study 1	Study 4 - Study 2	Study 5 - Study 3
Total Delta Inflow Long-term Average	-76	-75	-229	-148	-154
Total Delta Inflow 28-34	-64	-58	-20	48	37

Figure 10-17 shows the chronology of total inflow for all 5 of the studies. The highest inflows occur January through April due to flood flows and July when pumping is increased though the late summer with the 50th percentiles being greater than 20,000 cfs Figure 10-18 in the other months the inflow tends to be less than 20,000 cfs. Considering the monthly averages by 40-30-30 water year classification, Figure 10-19 toFigure 10-24, the results show little difference on average with the exception of months when (b)(2) or EWA are taking actions and the inflow decreases in response to the reservoirs release reductions coincident with pumping restrictions. Delta inflow is also being affected by the decrease in Keswick and Nimbus releases due to decreasing storage conditions that either casue the minimum flows to be less of the magnitude of flood flows to decrease when comparing Studies 4 and 5 to Studies 1, 2, and 3.

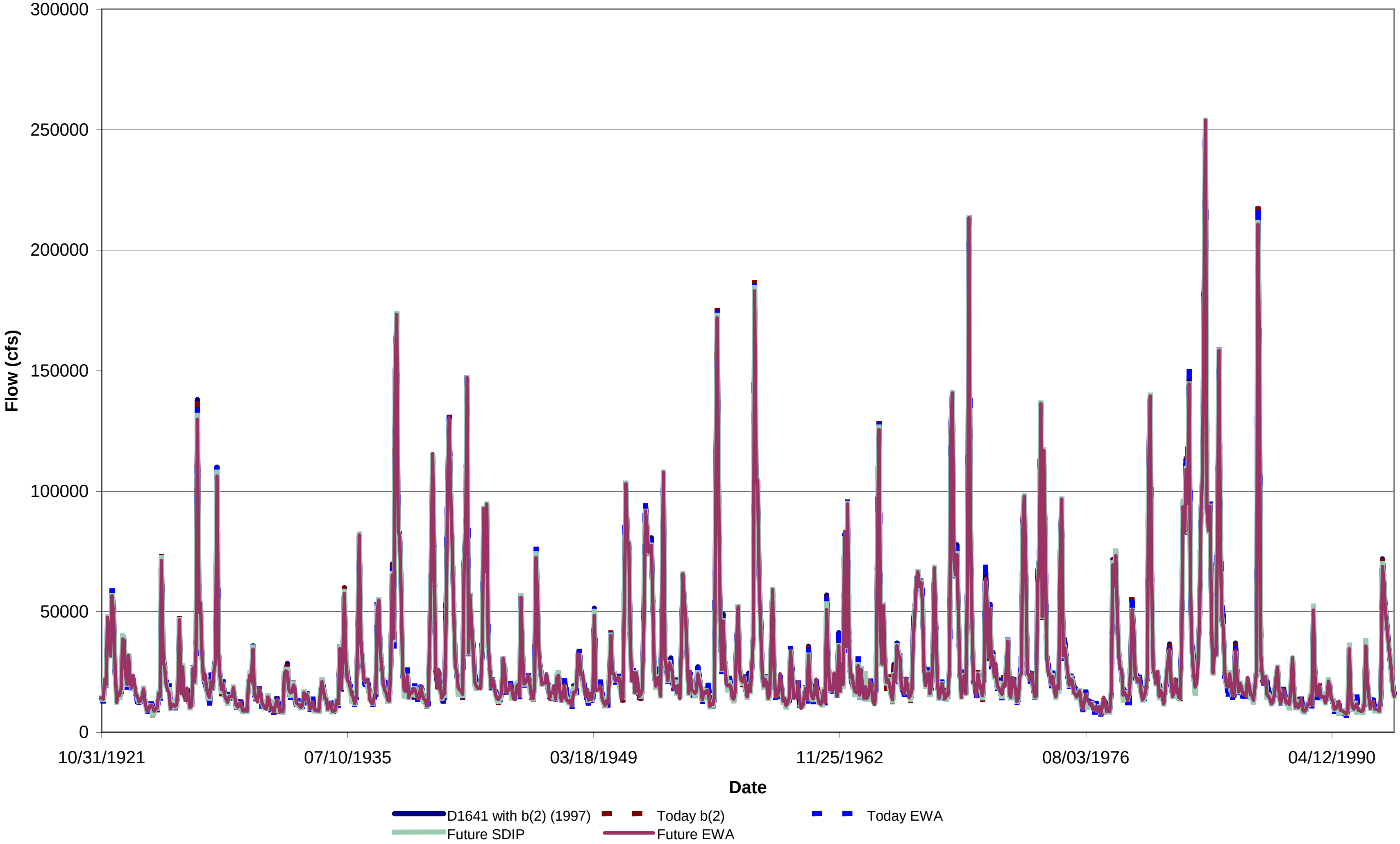


Figure 10-17 Chronology of Total Delta Inflow

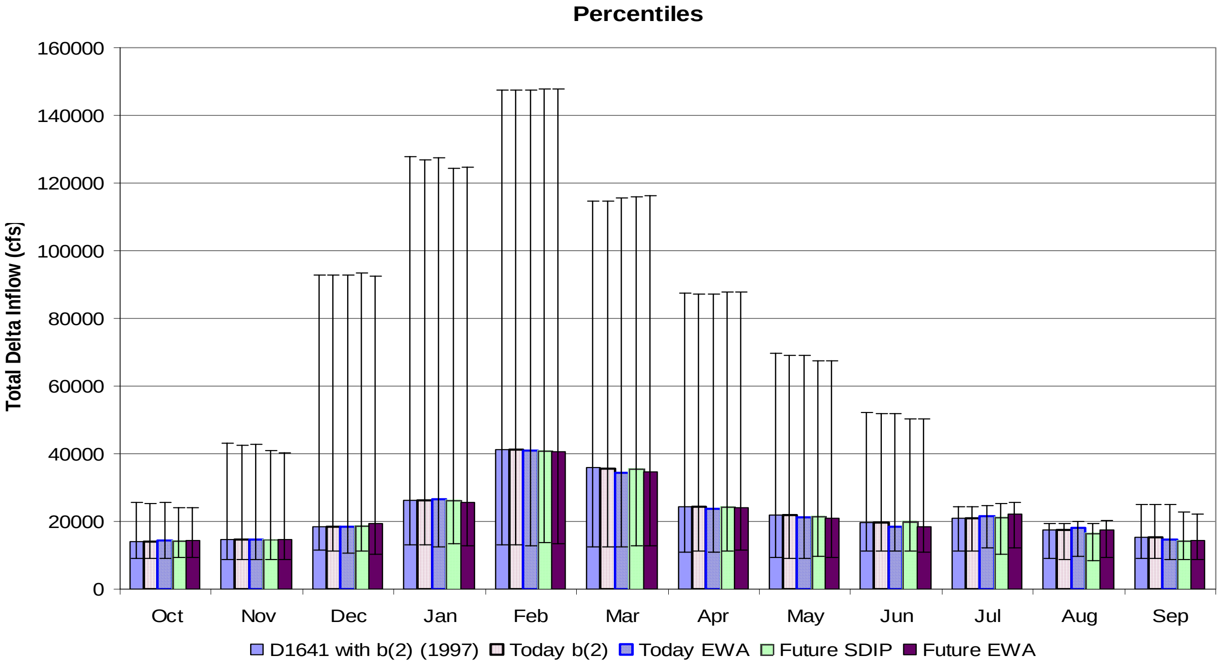


Figure 10-18 Total Delta Inflow 50th Percentile Monthly Releases with the 5th and 95th as the bars

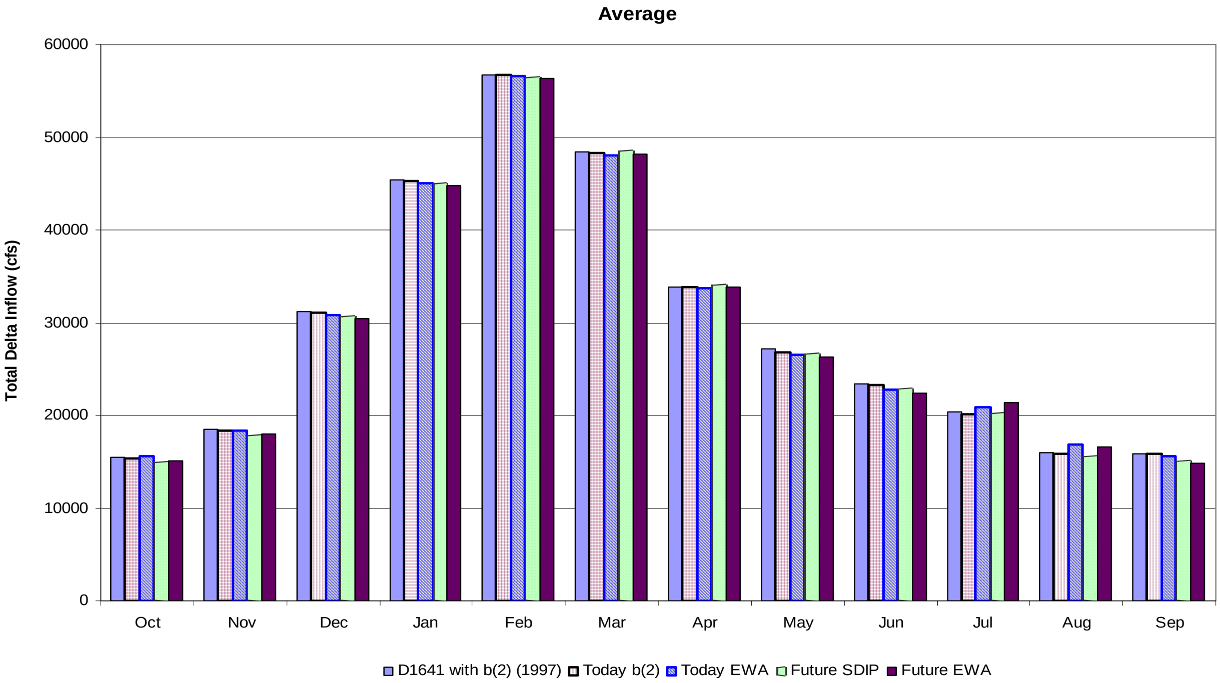


Figure 10-19 Average Monthly Total Delta Inflow

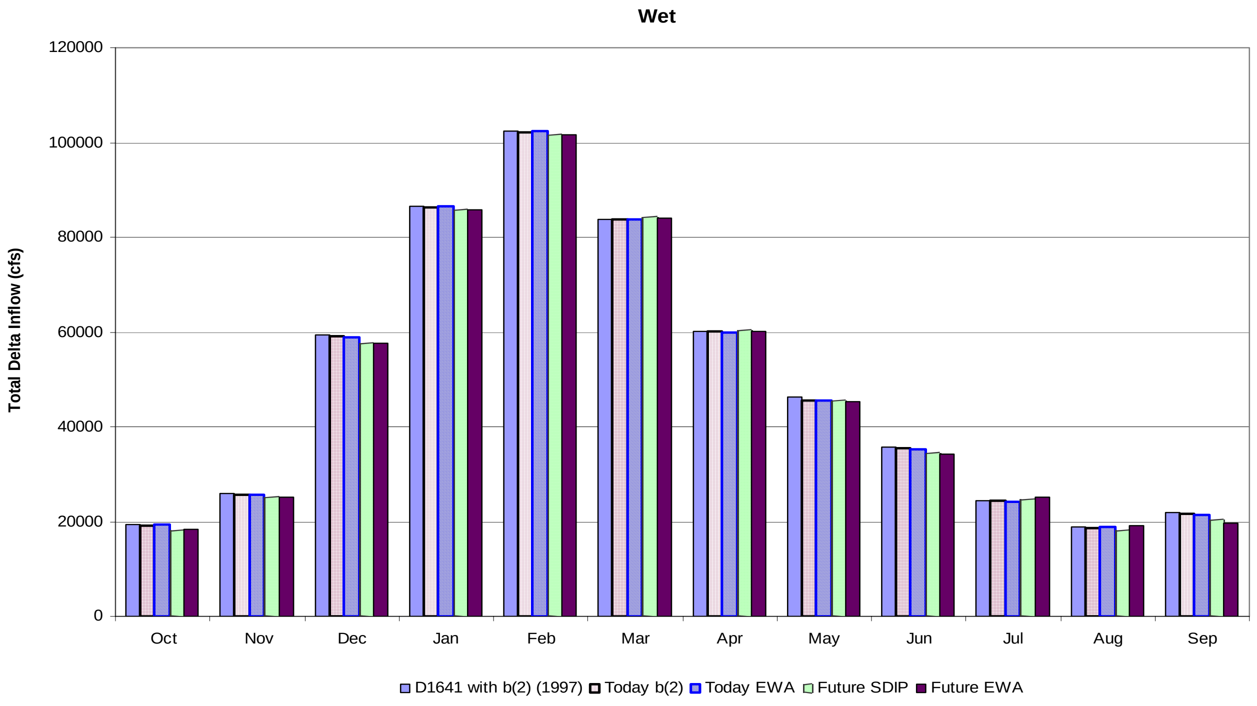


Figure 10-20 Average wet year (40-30-30 Classification) monthly Outflow Delta Inflow

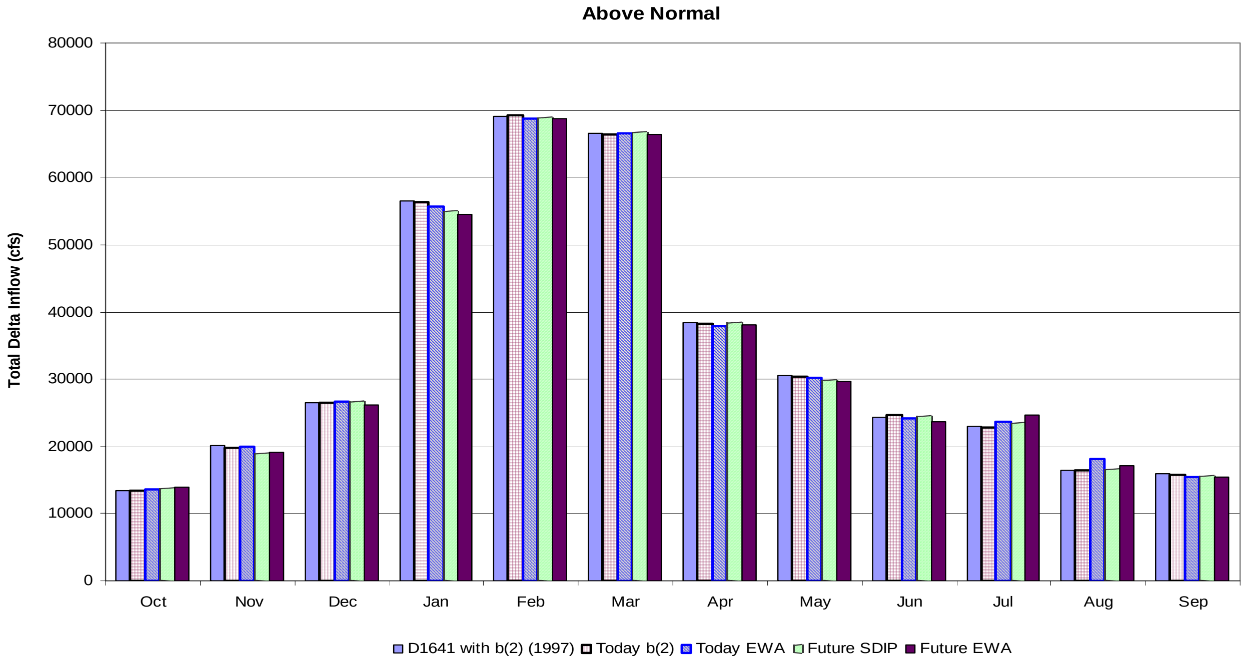


Figure 10-21 Average above normal year (40-30-30 Classification) monthly Outflow Delta Inflow

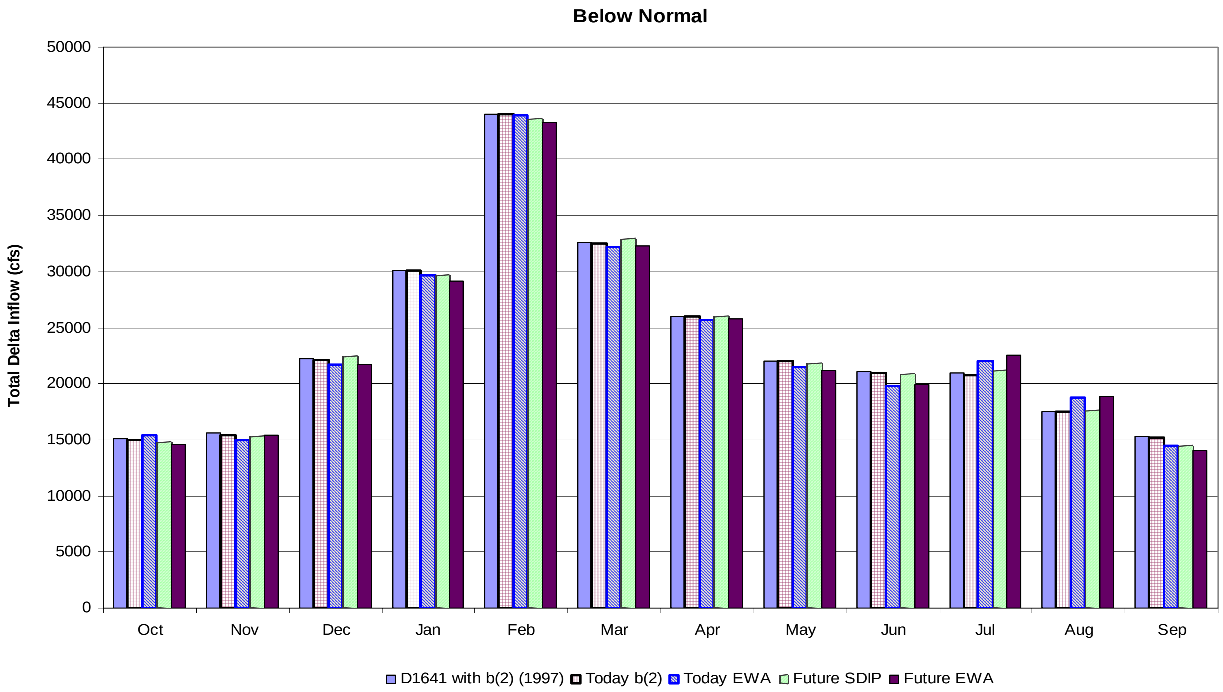


Figure 10-22 Average below normal year (40-30-30 Classification) monthly Outflow Delta Inflow

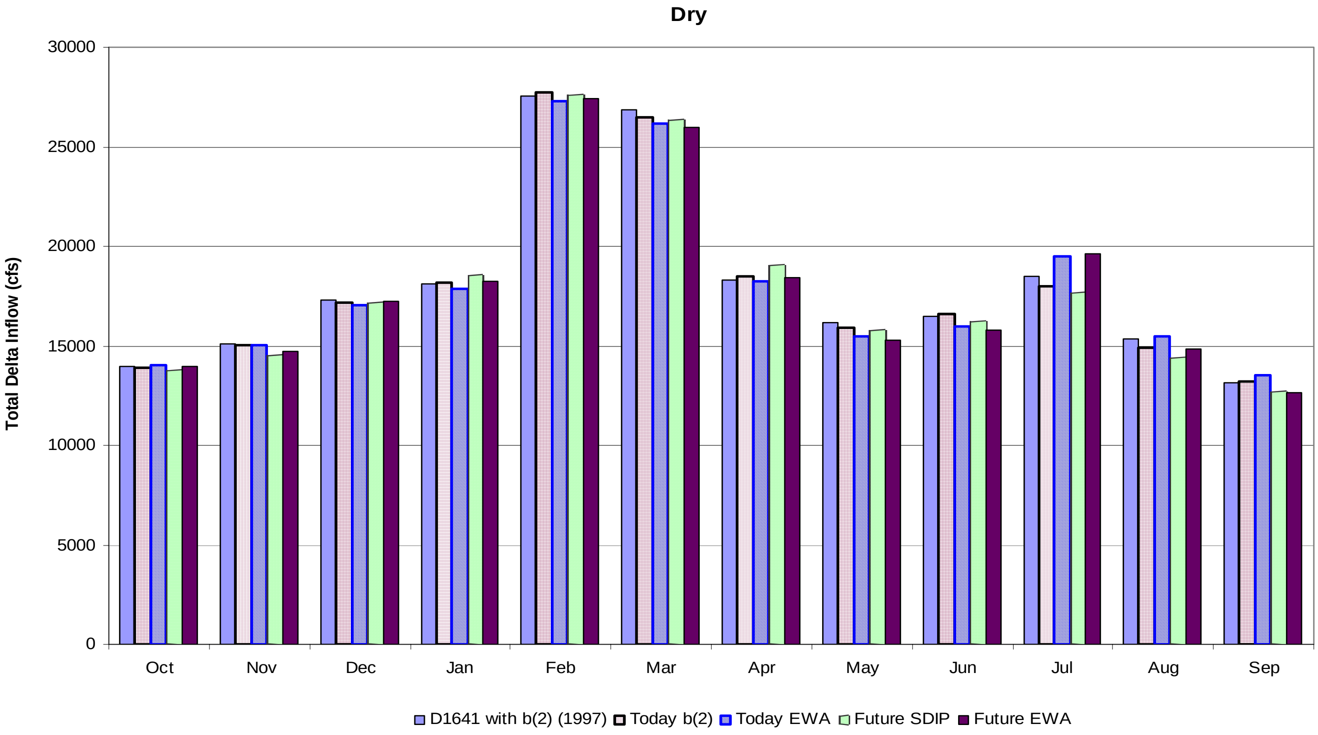


Figure 10-23 Average dry year (40-30-30 Classification) monthly Outflow Delta Inflow

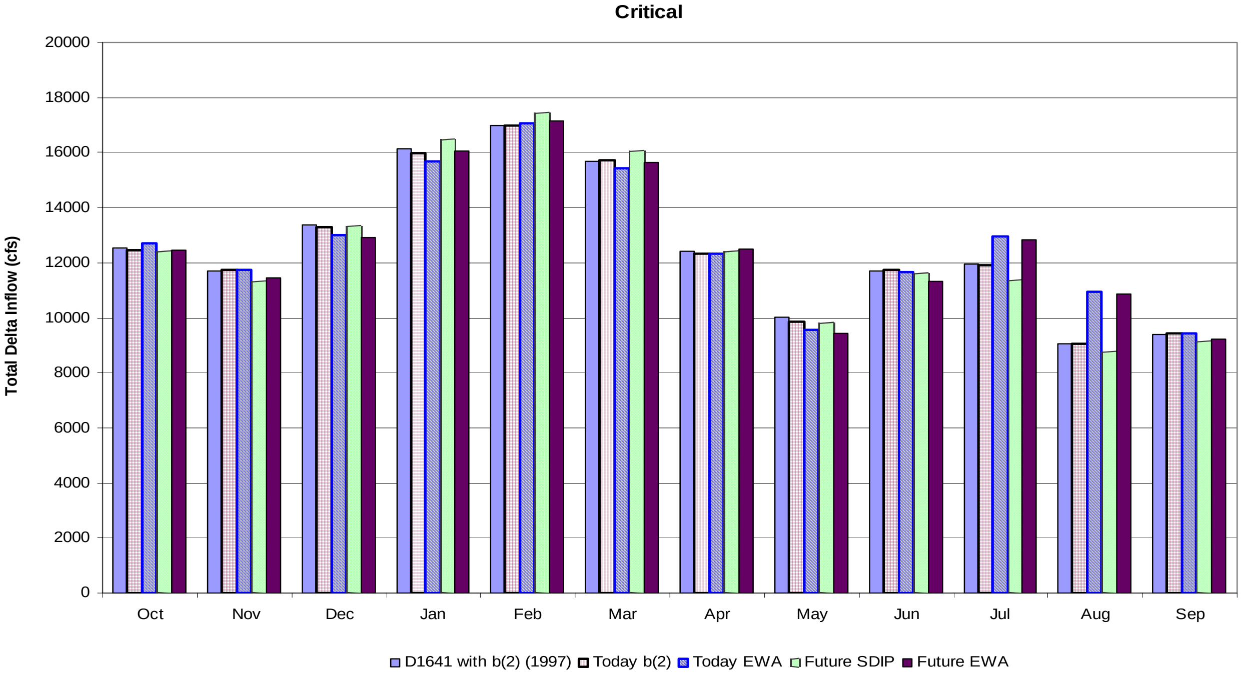


Figure 10-24 Average critical year (40-30-30 Classification) monthly Outflow Delta Inflow

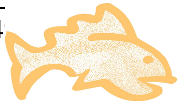
Outflow

The chronology of delta outflow is shown in Figure 10-25 and indicates that peaks in outflow can be seen due to EWA actions. Table 10-16 shows the differences in total and excess outflow for the five studies. On Study-to-Study comparisons (Table 10-16) with the exception of comparing Study 3 to 1, the average annual outflow decreases. Comparing of Study 5 to 1 increases outflow during the long-term drought period which appears to be due to delivery reductions and EWA actions during this period. The delivery reductions do not violate the "No Harm Principal" of EWA since delivery reductions are from lower storages relating to increased Trinity flows and increased demands in the American River system. The excess outflow numbers in this analysis do not reflect the salinity requirements from ANN calculations.

Figure 10-26 displays that the model always meets the required monthly required outflow for all five of the studies. Both average and percentiles outflow values increase in April, and May due to the actions taken under the 3406 (b)(2) and EWA programs, see Figure 10-27 and Figure 10-28 toFigure 10-33. Reductions in Delta outflow can be seen for the Future Studies from increased pumping activities taking more of the excess outflow than in the Today Studies.

Table 10-16 Differences in annual Delta Outflow and Excess Outflow for Long-term average and the 28-34 Drought

Differences (TAF)	Study 2 - Study 1	Study 3 - Study 1	Study 5 - Study 1	Study 4 - Study 2	Study 5 - Study 3
Total Delta Outflow Long-term Average	-48	103	-239	-341	-343
Total Delta Outflow 28-34	-20	128	111	-17	-17
Total Excess Outflow Long-term Average	-52	79	-316	-378	-394
Total Excess Outflow 28-34	-14	56	16	-26	-40



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