CHAPTER 4. PLAN FORMULATION

This chapter describes the plan formulation process during Phase 1 of the feasibility study. It includes a description of the planning approach, initial screening of surface storage options, evaluation of surface storage options retained for further study, and an approach for developing conjunctive management options. Plan formulation is an ongoing process that evolves as results of technical studies become available and stakeholder input is received. Throughout Phase 1, the Investigation was supported by input from CALFED agencies and stakeholders. Public outreach included a series of workshops that provided periodic updates to stakeholders on the progress of the Investigation and provided opportunities to receive comments and suggestions on completed and planned work.

The Phase 1 planning approach was designed to identify opportunities for water storage development, estimate the extent to which water resources problems could be addressed with new storage, and identify potential participants for the development of a storage project or program. As shown in Figure 4-1, the Investigation is a multitrack effort that includes the planning process, operations studies, assessment of potential surface storage options, and identification of groundwater storage options.

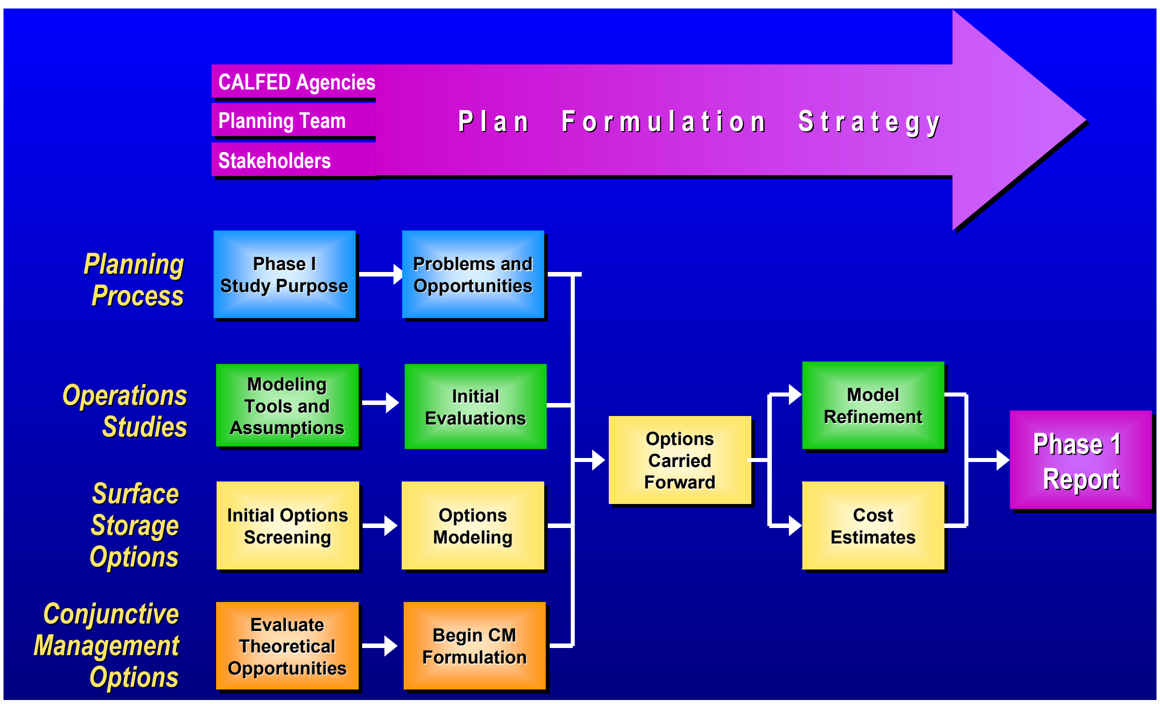


FIGURE 4-1. PHASE 1 INVESTIGATION PLANNING APPROACH

The planning process began with defining the purpose for Phase 1 of the feasibility study. In general, the purpose is to identify and investigate methods that could provide additional storage of San Joaquin River water. From that purpose, a set of goals to be addressed was defined based on the problems described in Chapter 3. The goals are general in nature and provide direction for the Investigation, but do not detail specific desired outputs. Study goals and objectives will continue to be refined as the feasibility study proceeds.

PHASE 1 INVESTIGATION PURPOSE

The CALFED ROD provided guidance for considering initial problems to be addressed by the feasibility study and an initial range of potential storage capacity to be considered. The ROD did not, however, provide quantitative objectives to be achieved or guidance on how to identify a functionally equivalent storage program.

The purpose of Phase 1 was to complete technical studies sufficient to determine whether a potentially viable project exists and to provide focus for more detailed evaluation in the feasibility study. The study was developed to convey relevant information to Reclamation, DWR, CALFED management, and stakeholders who ultimately could be involved in implementing study recommendations. The strategy described below focuses on common information that would likely be needed to support decision-making by all interested parties.

POTENTIAL EFFECTS OF ADDITIONAL WATER SUPPLY AT FRIANT DAM

Many water resource problems to be addressed by the Investigation relate to water supply availability. The overall goal of the Investigation is to develop additional water supplies that could be released from Friant Dam to address these problems. New water supplies could be used specifically for one or more of the primary purposes of the Investigation. Table 4-1 identifies the types of benefits that could be addressed under various operational scenarios.

TABLE 4-1 POTENTIAL EFFECTS OF ADDITIONAL WATER SUPPLY AT FRIANT DAM

Potential Effect	Operational Purpose[1]		
	San Joaquin River Restoration	San Joaquin River Water Quality	Water Supply Reliability
Total Friant Division water deliveries	0	0	+
Class 2 Friant Division water deliveries	+	+	+
Delivery of unstorable water (Section 215)	-	-	-
Reduction in regional groundwater overdraft	+	+	+
Water supply at Mendota Pool	+	+	-
Water quality at Mendota Pool	+	+	-
South-of-Delta supplies and/or Delta inflow	+	+	-
Year-round river releases from Friant Dam	+	+	0
Seasonal river releases from Friant Dam	+	+	0

Key:
\+ positive effect
\- negative effect
0 no change

Notes:
1. Anticipated effects are based on operations focused on a single purpose. Phase 2 evaluations will include multiple-purpose operational scenarios.

OPPORTUNITIES TO STORE SAN JOAQUIN RIVER WATER

In general terms, San Joaquin River water could be stored either in surface water reservoirs or in groundwater and a variety of approaches are available for either of these two methods. For example, San Joaquin River water could be directly stored in reservoirs on the San Joaquin River, as would be accomplished by raising Friant Dam, in potential off-stream reservoirs in the San Joaquin River basin, or in potential off-canal reservoirs served by the Madera or Friant-Kern canals.

Storage of San Joaquin River water could also be achieved through exchanges with stored water from other watersheds. In this case, water from another watershed could be captured and held so that water from Millerton Lake could be released earlier for delivery to areas otherwise served by other watersheds, thereby lowering storage levels and allowing the capture of more San Joaquin River water. The water captured in the other watersheds would then be used for later delivery.

Groundwater storage could be accomplished by several methods: increasing deliveries to existing water users in the Friant Division in lieu of groundwater pumping; increasing the rate of groundwater recharge; and developing groundwater banks that would accept water during wet years and make it available during dry years.

The following sections describe the approaches used to identify and evaluate surface water storage and groundwater storage options. Surface water storage options were identified and screened based on construction and permitting-related issues. Options retained for further consideration were evaluated to identify potential benefits and costs. To date, specific groundwater storage options that could be evaluated at a similar level of detail have not been identified. Work is continuing to identify specific groundwater storage actions that could be considered in Phase 2.

INITIAL SCREENING OF SURFACE STORAGE OPTIONS

Several surface storage options were considered during Phase 1 of the feasibility study. These options were passed through an initial screening process that was intended to identify options that would be dropped from the study and those to be considered further. This section describes the approach for identifying and selecting potential surface storage sites for consideration.

Surface Storage Options Dropped from Further Consideration

A review of previous regional water resources studies identified 17 potential surface storage options for initial consideration (Figure 4-1). This list included enlarging two existing reservoirs (Lake Kaweah and Lake Success), which were dropped from further consideration because they have already been authorized for construction. The remaining sites include enlarging existing reservoirs and constructing new reservoirs. Some options are located in the upper San Joaquin River basin; others are located in watersheds that are served by the Friant Division or would be operated as off-canal storage. Information considered was obtained from multiple sources, including previous studies, field observations by study team members, and from stakeholders. In some cases, the configuration of a storage option was modified from that project described in previous studies, and information was updated as appropriate.

Initial screening focused on potential construction-related issues that could preclude constructing required facilities, create environmental impacts that could not be mitigated, or create conditions under which permits issued by regulatory agencies or approved by decision-makers would be unlikely. Initial screening did not consider reservoir operations modeling or construction cost estimates.

A Technical Memorandum (TM) was prepared for each surface storage option considered. As indicated in Table 4-2, six surface storage sites were retained for further analysis in Phase 2 of the feasibility study and one option will be further evaluated by others.

Although cost was not a criterion for initial screening, cost information is provided in all of the TMs, which are included as appendices to this report. The following sections describe eight surface storage options that were reviewed and dropped from further consideration.

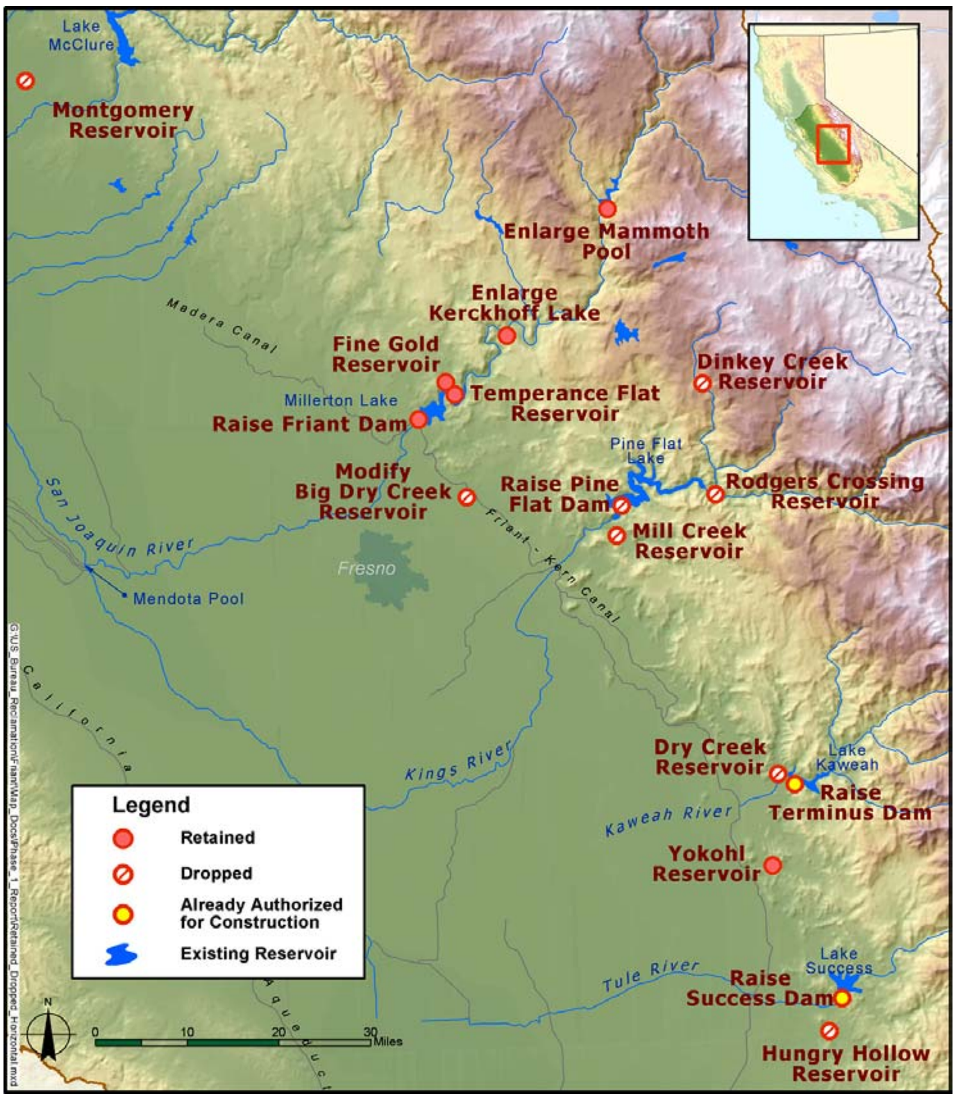


FIGURE 4-2. SURFACE STORAGE OPTIONS CONSIDERED

TABLE 4-2
INITIAL SCREENING OF SURFACE STORAGE OPTIONS

Watershed / Reservoir Site	Max Cap[1] (TAF)	Engineering Issues			Environmental Issues					Result of Initial Screening
		DS	SG	WQ	Bot	WL	AB	Rec	LU	
Merced River Watershed										
Montgomery Reservoir	241									Dropped
San Joaquin River Watershed										
Raise Friant Dam	870									Retained
Fine Gold Creek	800									Retained
Temperance Flat RM 274	2,100									Retained
Temperance Flat RM 279	2,750									Retained
Temperance Flat RM 286 (Enlarge Kerckhoff Lake)	1,400									Retained
Enlarge Mammoth Pool	35									Retained[2]
Big Dry Creek Watershed										
Big Dry Creek Dam	30									Dropped
Kings River Watershed										
Raise Pine Flat Dam	124									Dropped[3]
Mill Creek	200									Dropped
Rodgers Crossing	295									Dropped
Dinkey Creek	90									Dropped
Kaweah River Watershed										
Enlarge Lake Kaweah	n/a									Dropped[4]
Dry Creek	70									Dropped
Yokohl Valley	800									Retained
Tule River Watershed										
Enlarge Lake Success	n/a									Dropped[4]
Hungry Hollow	800									Dropped

Key to Engineering Issues		Key to Assessments	
DS	Safety of existing dam		Unfavorable engineering or operational condition
SG	Soils and geology		Potential environmental effects not determined
WQ	Quality of developed water		Low or no likely adverse environmental effects
			Potential adverse effects; mitigation to be determined
Key to Environmental Issues			Potential unmitigable adverse environmental effects
AB	Aquatic biology & water quality	**Notes**	
Bot	Botany	1.	Maximum new storage capacity (thousand acre-feet).
LU	Land use	2.	Under review by others; will not be considered in Phase 2.
Rec	Recreation	3.	Potential partner not interested in pursuing project.
WL	Wildlife	4.	Authorized for construction by U.S. Army Corps of Engineers.

Merced River Watershed - Montgomery Reservoir

A new reservoir was considered on Dry Creek, a northern tributary to the Merced River. Montgomery Reservoir would be an off-stream reservoir that would store flood flows released or spilled from Lake McClure at New Exchequer Dam and diverted from the Merced River at Merced Falls. Water stored in Montgomery Reservoir would be used to meet water needs in Merced Irrigation District (MID), allowing water stored in Lake McClure to be used in exchange for other purposes.

Montgomery Reservoir would store up to 241 TAF of water. This option would entail construction of a 101-foot-high zoned earthfill dam and eight saddle dams, with a combined crest length of 14,300 feet. Conveyance of water to and from Montgomery Reservoir would require modifications to the North Side Canal.

MID expressed concern regarding the quality of the water that would be developed in Montgomery Reservoir. With a surface area of nearly 8,000 acres, the average reservoir depth would be roughly 30 feet when filled. High water temperature, the likelihood of algal growth, and relatively high evaporative losses would make the developed water undesirable to MID and its customers. This reservoir option was dropped from further consideration.

San Joaquin River Dry Creek Watershed - Big Dry Creek Reservoir

Big Dry Creek Dam is an existing flood control structure in Fresno County, near Clovis, operated by the Fresno Metropolitan Flood Control District. The reservoir area spans Big Dry Creek and associated smaller drainages to the north. The zoned earthfill embankment dam could accommodate a reservoir with approximately 30 TAF of storage. Due to seepage concerns and insufficient inflow, however, the total storage capacity has not been exploited.

The study team considered a turnout from the Friant-Kern Canal, along with an energy dissipation structure, to divert water to Big Dry Creek Reservoir. DWR’s Division of Safety of Dams has indicated that no more than 10 TAF can be stored in the existing reservoir, and only if the dam demonstrates satisfactory performance when the reservoir is 50 percent filled. Due to insufficient inflows, the reservoir has yet to be tested at this level of storage. Consequently, uncertainty remains regarding the existing dam’s ability to store more than a few thousand acre-feet of water. In addition to these concerns, modifications to enable storage for longer than 90 days may require extensive reconstruction of the dam. Based on these concerns, enlarging the Big Creek Flood Control Basin for long-term water storage was dropped from further consideration.

Kings River Watershed - Raise Pine Flat Dam

Raising the gross pool elevation of Pine Flat Reservoir by 20 feet would result in 124 TAF of additional storage. This would be accomplished by raising the crest of Pine Flat Dam 12 feet and replacing 36-foot-high radial gates with 59-foot-high gates. Additional water stored in the enlarged Pine Flat Reservoir would be exchanged for Friant Division water. Early in the year, water from Millerton Lake could be delivered to Pine Flat water users, thereby creating additional storage space in Millerton Lake to capture San Joaquin River flows. Kings River water that otherwise would have been delivered would be retained in the enlarged Pine Flat Reservoir. Later in the year, water from Pine Flat would be delivered to the Friant-Kern Canal in lieu of releases from Millerton Lake.

Implementation of this option would require collaboration with the Corps and the Kings River Conservation District (KRCD), which represents the users of water stored in Pine Flat Reservoir. KRCD does not support this storage option. KRCD, which had previously studied enlarging Pine Flat Reservoir in coordination with the Corps, recommended that the Investigation not pursue the option further, citing inundation of recreation facilities, aquatic, and terrestrial habitat, and the need to modify PG&E's Kings River Powerhouse upstream of Pine Flat Reservoir. Consequently, this option was dropped from further consideration.

Kings River Watershed - Mill Creek Reservoir

A new dam on Mill Creek, which joins the Kings River approximately 1.7 miles downstream of Pine Flat Dam, was considered. A zoned embankment dam up to 250 feet high would create a reservoir with a storage capacity of up to 200 TAF. Excess flows in the Kings River would be diverted by gravity into Mill Creek Reservoir by means of a 5,000-foot-long, 10-foot-diameter, unlined tunnel. Stored water would be exchanged with Millerton Lake water.

An extensive a sycamore alluvial woodland is located in the lower reaches of Mill Creek near its confluence with the Kings River (Corps, 1994). This is a rare and sensitive habitat type that hosts a diverse assemblage of wildlife, particularly birds. It is anticipated that creation of Mill Creek Reservoir would result in unmitigable negative impacts to the sycamore alluvial woodland habitat. Consequently, this option was dropped from further consideration.

Kings River Watershed - Rodgers Crossing Reservoir

A dam at Rodgers Crossing would be located on the main stem of the Kings River, above Pine Flat Reservoir, and approximately one-half mile upstream of the confluence with the North Fork. Two options had been studied previously, a 400-foot-high concrete arch dam that would create a reservoir capacity of 295 TAF, and a roller-compacted concrete (RCC) gravity dam up to 660 feet high that would create a reservoir capacity of 950 TAF. Stored water would be exchanged with Millerton Lake water.

The Kings River is one of the least disturbed large rivers in California and its wild trout population is considered one of the best in the state. Upstream of Pine Flat Reservoir, the Kings River also supports whitewater recreation. Both options would inundate a portion of the Kings River Special Management Area, and the larger option would inundate a portion of the river that has been Federally designated as a Wild and Scenic River. Inundation of either the Special Management Area or the Wild and Scenic River would violate expressed Congressional intent. A reservoir at Rodgers Crossing would also affect a Wild Trout Fishery, as designated by the California Department of Fish and Game. For these reasons, Rodgers Crossing Reservoir was dropped from further consideration.

Kings River Watershed - Dinkey Creek Reservoir

Dinkey Creek is within the upper watershed of the North Fork of the Kings River. A dam on Dinkey Creek would be located within the Sierra National Forest at an elevation of over 5,400 feet above mean sea level (elevation 5,400). It would be a zoned rockfill dam, approximately 340 feet high and 1,600 feet long, creating a 90 TAF reservoir. Stored water would be exchanged with Millerton Lake water.

Developing a reservoir at Dinky Creek would result in adverse environmental impacts in all categories assessed – botany, wildlife, aquatic biology, recreation, and land use. In particular, a reservoir at Dinkey Creek would fundamentally alter the existing recreation-based community. Dinkey Creek is a popular recreation area and trout fishing destination. A flow reduction could reduce available habitat, particularly during spring and summer when rainbow trout are spawning and rearing. Changes in water temperature below the dam could adversely affect trout and the dam would impede migration. The potentially inundated area includes two organization camps, vacation residences, and roads that provide access on both sides of the stream to numerous recreational resources in the Sierra National Forest. Creation of the reservoir would adversely impact an established community and may be unmitigable. This option was dropped from further consideration.

Kaweah River Watershed - Dry Creek Reservoir

Dry Creek Reservoir would be a new impoundment on Dry Creek, which is a tributary to the Kaweah River, just downstream and northwest of Lake Kaweah at Terminus Dam. The dam would be a 200-foot-high RCC structure with a crest length of approximately 3,210 feet, which would create a 70 TAF reservoir. Water would be diverted from Lake Kaweah through a 7,600-foot-long gravity tunnel, 12 feet in diameter. The new reservoir would also capture natural runoff from Dry Creek. Stored water would be exchanged with Millerton Lake water.

A sycamore alluvial woodland exists near the confluence of Dry Creek and the Kaweah River. As with the Mill Creek Reservoir option, it is anticipated that adverse effects to the sycamore alluvial woodland could not be mitigated. Consequently, this option was dropped from further consideration.

Tule River Watershed - Hungry Hollow Reservoir

Hungry Hollow Dam and Reservoir would be constructed on Deer Creek, a tributary to the Tule River about 3 miles south and downstream of Lake Success and 6 miles east of Porterville. The dam would be a zoned earthfill structure 267 feet in height and 5,200 feet in length that would impound an off-stream reservoir with a storage capacity of up to 800 TAF. Additional features would include two saddle dams, a spillway, outlet works, and relief wells along the downstream toe of the dam. Two conveyance configurations were previously considered. One would divert water from the Friant-Kern Canal via a two-way canal and pump it into the reservoir. A second option involves diverting water from Lake Success and pumping it into Hungry Hollow Reservoir via a 10-foot-diameter tunnel nearly 3 miles in length. For both options, stored water would be exchanged for Millerton Lake water.

Extensive young alluvial deposits, over 300 feet thick, lie beneath the potential dam axis. The deposits are unconsolidated, loose, permeable, and subject to liquefaction during an earthquake. Although no significant faults passing through the site have been identified, the alluvium may not provide an adequate foundation for the dam. In addition, the reservoir would inundate up to 8 miles of Deer Creek, which supports well-developed sycamore alluvial woodland, a rare and regionally important wildlife habitat. It is anticipated that construction of a reservoir on Deer Creek would adversely affect the sycamore alluvial woodland habitat and that the damage could not be mitigated. Consequently, Hungry Hollow Reservoir was dropped from further consideration.

TECHNICAL ANALYSES OF RETAINED SURFACE STORAGE OPTIONS

The remaining surface storage sites retained for further analysis after the initial screening were evaluated to identify potential accomplishments, costs, and environmental effects. Each option was simulated in CALSIM to identify additional water that could be developed; potential power generation and use were estimated; and cost estimates were prepared for major components of each option.

This section describes methodology followed for technical evaluations of retained options. It includes a description of CALSIM model development to establish baseline operation of the Friant Division, methodology applied to estimate hydropower generation and energy use, and assumptions applied for cost estimates. Results of the evaluations are included in the descriptions of retained surface storage options in the next section of this chapter.

CALSIM Model Development and Validation

The CALSIM model simulates the operation of CVP, State Water Project (SWP), and some locally owned facilities throughout California. This model is widely used for water resources studies by Reclamation, DWR, and numerous water agencies in California to identify how potential projects and actions would affect system-wide operations. Prior to the Investigation, CALSIM included a highly generalized representation of the Friant Division that could not simulate changes in project operations in response to changes in demands or facility configurations. As part of this Investigation, the CALSIM model was modified to reflect the decision-making process used to allocate water supplies at Friant Dam. The revised model includes logic that determines the allocation of Class 1 and Class 2 water supplies and the availability of Section 215 water for diversion to the Friant-Kern and Madera canals based on hydrologic conditions.

Historical operations demonstrate that the timing and pattern of demands for Class 1 and Class 2 water depend on the availability of Section 215 water and the total quantity of water allocated on an annual basis. The CALSIM model logic applies water demand patterns for Class 1, Class 2, and Section 215 water supplies based on calculated allocations. Model results were compared to historical operations during validation to assure an accurate representation of Friant Dam operations. A description of CALSIM modifications and a comparison of the results to historical deliveries are presented in the Hydrology and Modeling Technical Appendix. The results from simulated operations compare closely with actual historical operations. The revised CALSIM that includes Friant operations is used as a benchmark for the Investigation

Surface Storage Options Modeling Methodology

Surface storage sites retained for further analysis from the initial screening were evaluated in the CALSIM model to estimate the water supply the option could provide. For each surface storage option, single-purpose evaluations were run for multiple reservoir sizes. Model simulations were done to identify the quantity of water that could be available for each Investigation purpose if the additional water supply created by new storage were operated solely to meet that purpose. The single-purpose analyses did not include any changes to the flood storage rules currently in place.

The single-purpose analyses address the three purposes of the Investigation – river restoration, water quality, and water supply reliability. Each single-purpose evaluation includes a generalized operation of the expanded reservoir to specifically address one project purpose. Operations for one purpose can also contribute to other purposes and address other opportunities. For example, releases to the San Joaquin River for river restoration would also contribute to improved water quality in the river.

Enlarging storage capacity would result in year-to-year changes in water storage conditions; changes would affect Class 1, Class 2, and Section 215 water amounts. A modeling constraint was established to identify how new storage could contribute to Investigation purposes without causing an unaccounted reallocation of existing supplies. The single-purpose evaluations for river restoration and water quality improvement used the iterative approach shown in Figure 4-3 to estimate the annual amount of water that would be available to each purpose without increasing or decreasing deliveries to current water users. Modeling iterations continued until resulting average annual deliveries by water year type were similar to the benchmark simulation. This approach did not result in the same distribution of water deliveries between the different classes of water as for the benchmark simulation, but it furnished information on the total amount of water that additional storage could provide.

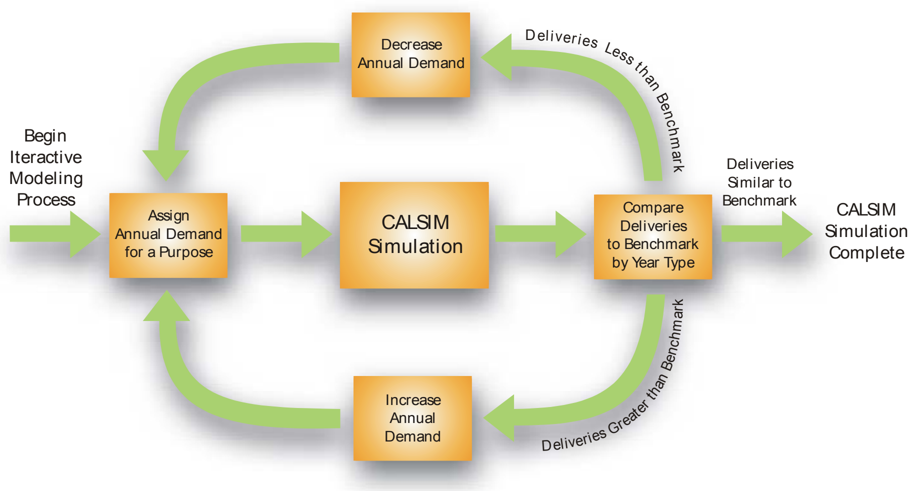


FIGURE 4-3. ITERATIVE MODELING APPROACH FOR SINGLE-PURPOSE RIVER RESTORATION AND WATER QUALITY IMPROVEMENT ANALYSES

Annual restoration and water quality demands for each year type were modified until a set of demands was established that would result in average deliveries for each year type similar to the benchmark. This approach resulted in a wide variation in the annual quantity of water that could be provided for river restoration or water quality improvement. It is important to note that initial modeling scenarios were based on the annual reservoir operations currently applied to Millerton Lake. In calculating annual water supply availability, the model assumes that minimum end-of-year storage would be 130 TAF, or the approximate level of the canal outlets. If the enlarged reservoir were operated with an objective to carry over water supply from one year to the next, the results presented in the following sections would differ. In particular, the wide variation in water quantities between different year types would be reduced and more water would likely be available during critically dry years.

San Joaquin River Restoration Single-Purpose Analysis

As described in Chapter 3, a flow requirement for restoration of the San Joaquin River has not been established. To determine how additional storage could provide water supplies to support restoration of the San Joaquin River, a range of ecosystem demands was placed on Millerton Lake. The model was run in an iterative manner until the constraints of maintaining long-term average annual water supply deliveries, as described above, was satisfied.

The monthly variation of flow (March through the following February) was based on the percentage distribution of monthly flows under an unimpaired condition. The variation of unimpaired flows for all year types was reviewed and found to be similar on a percentage basis. Therefore, the same percent distribution shown was used in all years. The percentage distribution pattern is shown in Figure 4-4.

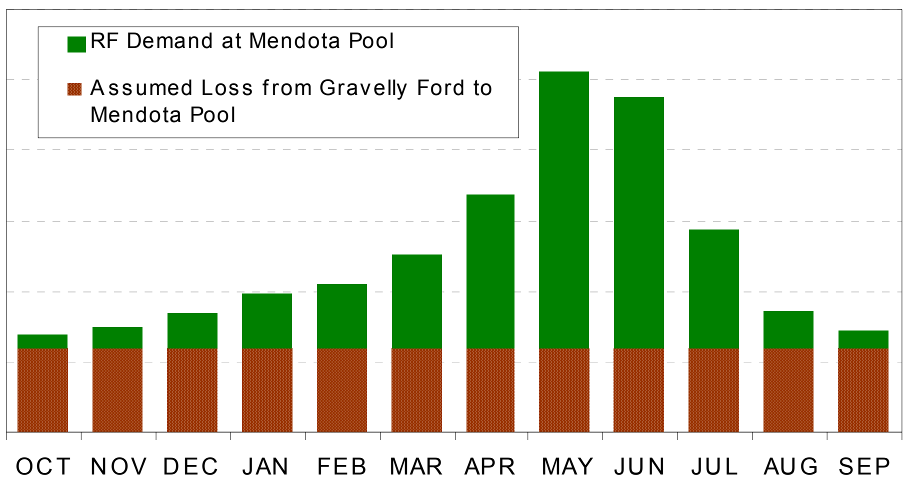


FIGURE 4-4. MONTHLY PERCENTAGE DISTRIBUTION OF RELEASES FOR RIVER RESTORATION FLOW SINGLE-PURPOSE ANALYSIS

Under the river restoration flow single-purpose analysis, the San Joaquin River Exchange Contractors could use Friant water reaching Mendota Pool, and the demand for Delta water at Mendota Pool could be similarly reduced. Provisions could be made to pass water by Mendota Pool and increase downstream flows and Delta inflow. This approach was not evaluated, however, because an assumption of water use at or below Mendota Pool would not have a direct affect on estimating how much new water supply could be available if additional surface water storage were developed. Operational scenarios at Mendota Pool will be evaluated in more detail during Phase 2.

San Joaquin River Water Quality Single-Purpose Analysis

Water quality in the San Joaquin River would improve if water releases from Friant Dam to the San Joaquin River were increased. Water quality improvements would result if released water were delivered to Mendota Pool in lieu of Delta water, or if the released water were allowed to flow downstream of Mendota Pool. In general, water released from Friant Dam is of better quality than water exported from the Delta. An increase in the quantity of better-quality water to Mendota Pool from Friant Dam, and a corresponding decrease of Delta water, would improve the quality of source water to agricultural and refuge areas. This in turn would result in improved quality of discharge to the San Joaquin River.

For the purposes of the Phase 1 studies, quantities of water available for improving San Joaquin River water quality from new storage were estimated on the basis that releases from Friant Dam would be delivered to Mendota Pool. The quantity of water that could be released from Friant Dam for San Joaquin River water quality improvement was estimated in a similar manner to the approach described above for San Joaquin River restoration. The monthly distribution of flows for San Joaquin River water quality improvement, however, differed from that used for river restoration single-purpose analysis. As shown in Figure 4-5, San Joaquin River water quality single-purpose analysis considered simulated releases from Friant Dam during the 3-month period of July through September, when water quality conditions in the San Joaquin River are most severe. Seepage to groundwater is based on an estimate from the San Joaquin River Habitat Restoration Plan of 12 TAF per month for intermittent flow conditions.

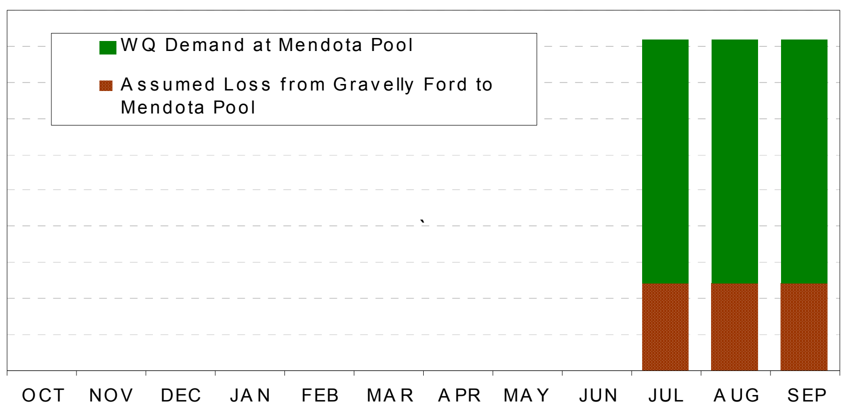


FIGURE 4-5. MONTHLY PERCENTAGE DISTRIBUTION OF RELEASES FOR WATER QUALITY SINGLE-PURPOSE ANALYSIS

For the initial analyses, it was assumed that the San Joaquin River Exchange Contractors would use Friant water reaching Mendota Pool and the demand for Delta water at Mendota Pool would be similarly reduced. Seepage to groundwater would help reduce groundwater overdraft in the area.

It is recognized that water management strategies other than deliveries to Mendota Pool could be developed that would improve San Joaquin River water quality by releasing water from Friant Dam. However, it is expected that other release patterns for water quality purposes in the San Joaquin River would produce generally similar estimates of the amount of water that could be developed from new storage. Operational scenarios at Mendota Pool will be evaluated in more detail during Phase 2.

Water Supply Reliability Single-Purpose Analysis

Single-purposes analyses for water supply reliability used the same logic as the benchmark simulation for diversion to the Madera and Friant-Kern canals based on Class 1, Class 2, and Section 215 demands. The reservoir would be operated as an annual reservoir, with no explicit carryover requirement. In effect, annual deliveries are based on the objective of delivering as much of the annual supply as possible. When annual supplies exceed annual demands, incidental carryover would provide additional water for the following year.

Modeling Retained Surface Storage Options

Storage sites retained for further consideration following the initial review were modeled to identify the extent to which they can contribute to Investigation purposes. Each retained option was represented in CALSIM and operated in combination with existing facilities to identify the amount of new water supply that would be available for the three primary purposes, as described previously. Preliminary results showed that the water supply reliability single-purpose analyses estimated less annual average new water supply than the river restoration or river water quality single-purpose analyses. Therefore, all sizes of the options were simulated using the water supply reliability single-purpose analysis, and some sizes were also evaluated using the river release purposes.

A schematic of CALSIM model modifications that were made to support the evaluation of surface storage options is shown in Figure 4-6. Reservoir nodes were added upstream of Millerton Lake to represent Temperance Flat Reservoir and Kerckhoff Lake. The simulation of Fine Gold Creek Reservoir includes a diversion facility for pump-back storage. Yokhol Valley Reservoir was represented as a generalized pump-back facility off the Friant-Kern Canal. The representation of Yokohl Valley reservoir in CALSIM could also be used to simulate the operation of other off-canal storage sites, including potential groundwater storage options. The capacity of the Friant-Kern Canal decreases south of the Kings River, before reaching Yokohl Valley Reservoir. For initial evaluations, assumed capacity was based on diversion capacity. No attempt was made to reflect reduced canal capacity or canal operating assumptions.

Model Refinement and Sensitivity Analyses

Following initial modeling work, stakeholders provided suggestions on additional model refinements, post-process evaluations, and sensitivity analyses. The additional model developments and application improved understanding of current project operations and will provide information for developing operational assumptions to be considered during Phase 2.

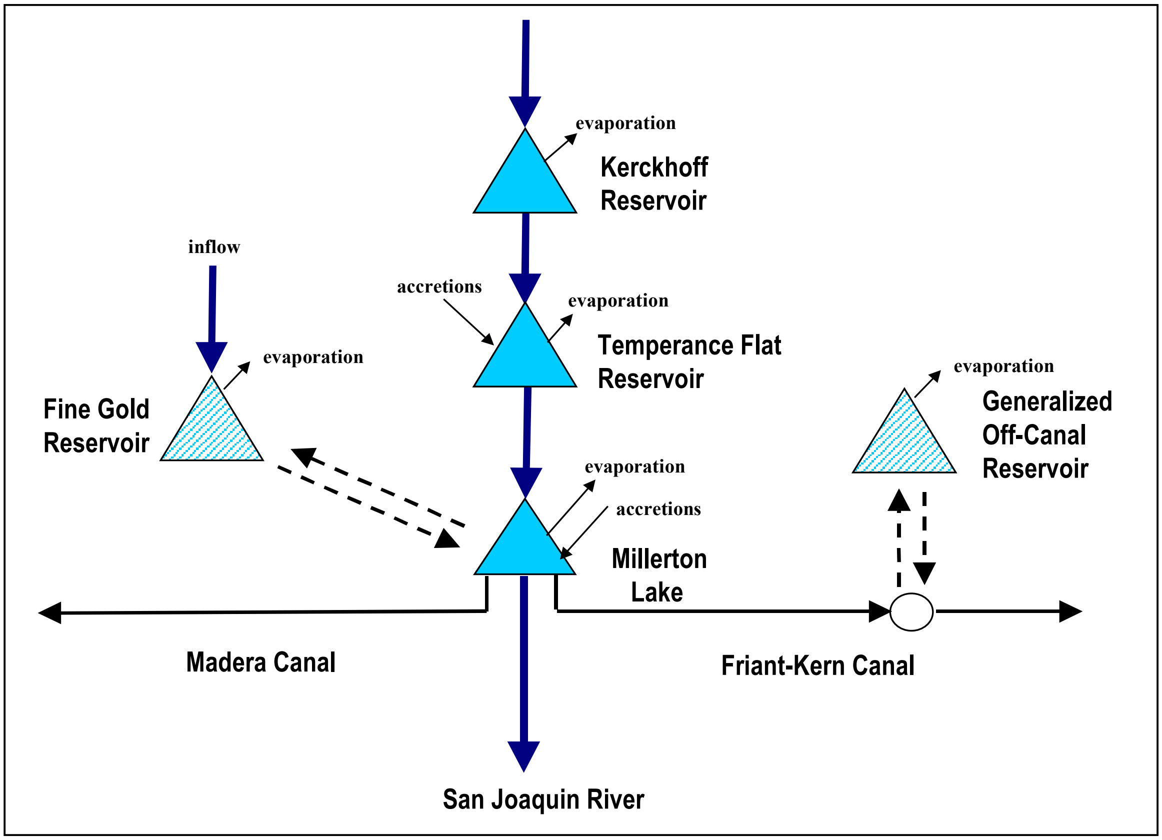


FIGURE 4-6. CALSIM SCHEMATIC FOR SIMULATION OF RETAINED SURFACE STORAGE SITE OPTIONS

Hydropower Generation and Energy Use Analytical Methodology

Preliminary energy estimates were made using a spreadsheet approach based on output from CALSIM. Estimates were made for the single-purpose analyses for restoration and water quality. These simulations were chosen because the restoration flow single-purpose analysis would release water to the San Joaquin River early in the year, whereas the single-purpose analysis for water quality would hold new water in storage until it is released to the San Joaquin River in the late irrigation season. The water supply reliability single-purpose analysis would fall within the range of these operations.

Figure 4-7 shows the relationship between a typical powerhouse configuration at the base of a dam and primary variables that affect energy generation, namely head and flow. These variables are important in determining the energy required to pump water into off-stream or off-canal reservoirs. Energy generation also depends on generating and pumping efficiencies, and equipment operational constraints. Assumptions were made regarding pumping and generating efficiencies, equipment submergence requirements, head and flow ranges within which pumping and generating equipment would operate, and head losses in water passages. Output from CALSIM accounted for flood storage and minimum storage assumptions.

Results are preliminary, due to the assumptions made in this level of study, and therefore give an indication only of possible pumping energy required and energy generation output. A major factor in selecting pump-turbine and motor-generator unit sizes is the relatively large variation in head and flows available for energy generation over the simulation period.

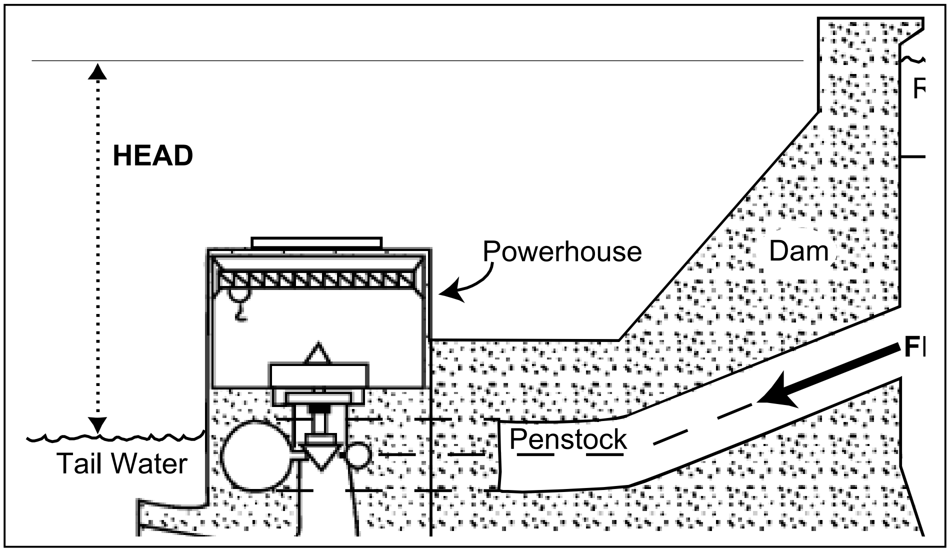


FIGURE 4-7. TYPICAL HYDROELECTRIC ENERGY GENERATION FACILITY

Methodology for Estimating Surface Storage Options Costs

Construction costs were estimated for retained surface storage options. In most cases, previous estimates either did not exist or were considered too old to be confidently updated. Costs were based on prefeasibility-level designs and contain provisions for uncertainties. For most options, costs were estimated for different dam types and reservoir sizes.

Field costs for construction were estimated at 2003 price levels. Field costs represent the estimated costs for identified features, plus allowances for mobilization (5 percent), unlisted items (15 percent), and contingencies (25 percent). Field costs were increased by 25 percent to account for investigations, designs, administration, and construction management to obtain total estimated construction costs.

Costs for road construction, relocations of existing facilities, environmental mitigation, land requirements, reservoir clearing, and finance interest during construction will be prepared during Phase 2.

SURFACE STORAGE OPTIONS RETAINED FOR FURTHER CONSIDERATION

This section describes the six surface storage options identified in Table 4-1 that will be carried forward for further consideration. These include Raise Friant Dam, Fine Gold Creek Reservoir, Temperance Flat Reservoir (three options), and Yokohl Valley Reservoir. The Enlarge Kerckhoff Lake option is represented by one of the three Temperance Flat options and the Enlarge Mammoth Pool option is under study by the FWUA. The Investigation will continue to coordinate with FWUA on the findings of that review.

Raise Friant Dam

Friant Dam is a 319-foot-high concrete gravity dam on the San Joaquin River about 20 miles northeast of Fresno. Potential modifications would include raising the dam up to 140 feet.

Options Considered

Three specific optional dam raise heights were considered, including 25-, 60- and 140-foot raises. Friant Dam would be raised by adding an overlay of RCC on the downstream face, as illustrated in Figure 4-8. In addition to the dam raise, up to three supplemental earthfill dams or dikes would be required. The most extensive would be a dike on the southwest rim of the reservoir (i.e., left side, looking downstream). Two additional, but considerably smaller, saddle dams would be required on the northwest side of Millerton Lake. The availability of materials from local sources does not appear to be a limiting factor.

A 25-foot raise, which would increase storage capacity by about 130 TAF, would involve raising the dam crest and modifying the spillway and spillway chute. It would also require construction of a dike, approximately 3,000 feet long, across a low saddle at the southwest shoreline of the existing reservoir. A 60-foot raise would increase capacity by 340 TAF and entail raising the dam crest, modifying the spillway and spillway chute, and constructing approximately 8,500 feet of new dike. A 140-foot raise would result in approximately 870 TAF of additional capacity, and would require new dikes of approximately 9,500 feet in total length. Figure 4-9 shows the extent of an enlarged Millerton Lake and facilities associated with a 140-foot raise of Friant Dam.

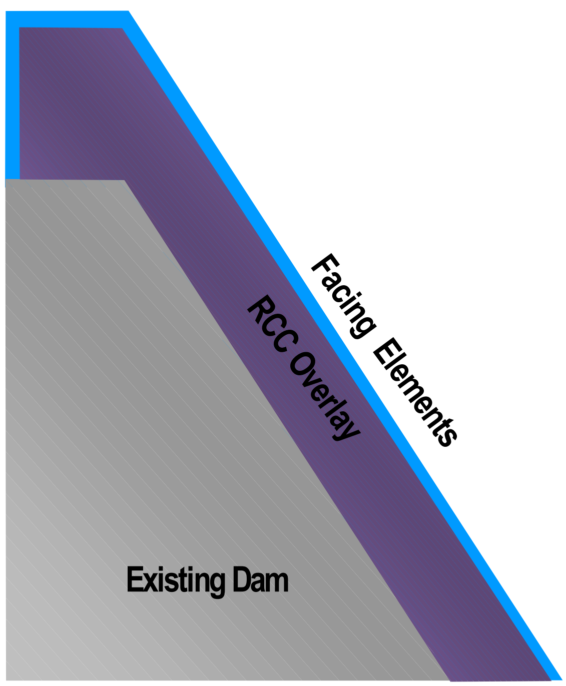


FIGURE 4-8. RAISE FRIANT DAM SIMPLIFIED CROSS SECTION

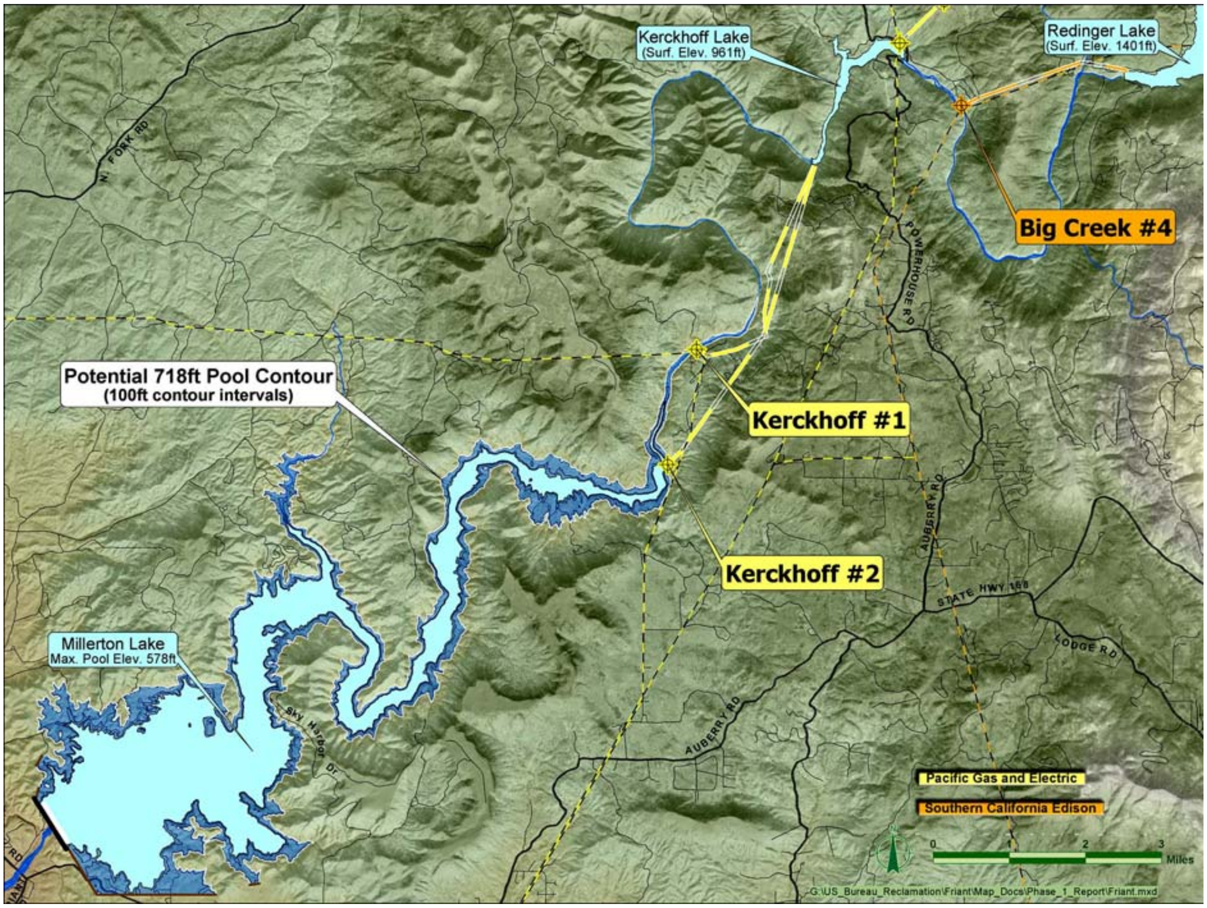


FIGURE 4-9. RAISE FRIANT DAM OPTION

Potential New Water Supply

An enlarged Friant Dam and Millerton Lake would continue to capture flow on the San Joaquin River. Additional storage capacity would provide opportunities to store larger flood volumes than with the current reservoir. Stored water would continue to be diverted to the Friant-Kern Canal, the Madera Canal, and/or released to the San Joaquin River.

CALSIM simulations show that the potential new water supply resulting from raising Friant Dam 140 feet could be as high as 150 TAF/year. The long-term average annual amount associated with each single-purpose analysis for various sizes of Friant Dam are listed in Table 4-3. The table shows that releasing water to the San Joaquin River would provide more water than the water supply reliability single-purpose analysis. This is because water deliveries are limited by contract amounts, whereas simulated releases to the river were maximized to the extent that they would not reduce water deliveries from benchmark levels. The new water supply for the restoration flow single-purpose analysis is higher than that for the water quality analysis because releases would be made earlier in the year, providing more opportunity to capture San Joaquin River inflow during late spring months.

TABLE 4-3
NEW WATER SUPPLY FROM FRIANT DAM RAISE OPTIONS

Friant Dam Raise Height (feet)	Water Surface Elevation (feet, above mean sea level)	Additional Storage Capacity (TAF)	New Water Supply Estimated in Single-Purpose Analysis (average TAF/year)		
			RF	WQ	WS
25	603	125	n/s	n/s	24
45	623	250	n/s	n/s	51
60	638	340	n/s	n/s	68
75	653	450	n/s	n/s	93
111	689	700	152	139	128
140	718	870	n/s	n/s	146

Key:
n/s not simulated
TAF – thousand acre-feet
RF – San Joaquin River restoration flow single-purpose analysis
WQ – San Joaquin River water quality single-purpose analysis
WS – water supply reliability single-purpose analysis

Hydropower Generation and Impacts

The Friant Power Authority owns and operates three power plants at Friant Dam: one each on the Friant-Kern and Madera canals and one at the river outlet, with a combined generation capacity of 2 megawatts (MW). The plants generate energy when flows exceed minimum levels and adequate head is available. Although an analysis of Friant power generation was not completed during Phase 1, additional storage capacity in Millerton Lake would allow more controlled releases through some or all of the power plants. These releases would be associated with higher lake levels and thus would increase energy production.

Raising the level of Millerton Lake would affect energy generation at the Kerckhoff Project. The Kerckhoff No. 2 Powerhouse, which has a capacity of 155 MW, discharges directly into Millerton Lake and would be affected by any increase in the lake level. The Kerckhoff Powerhouse is located at elevation 636 and would also be affected by a raise of Friant Dam of 60 feet or more. As listed in Table 2-4, average energy generation from these plants is about 579 gigawatt-hours per year (GWh/year). It is not likely that additional generation at the Friant power plants resulting from any raise of Friant Dam would replace lost energy generation from the Kerckhoff Project.

Estimated Costs

Cost estimates for raising Friant Dam listed in Table 4-4 include costs for dam modifications, saddle dams, dikes, and land acquisition. Several residential areas around Millerton Lake would be affected by raising the lake level. Based on a review of aerial photography, it is estimated that structures on approximately 165 properties would be within the inundation area associated with a 140-foot raise in lake level.

Preliminary estimates of land acquisition, based on typical costs per acre, are listed in Table 4-3, but are not included in estimated construction costs. Other costs, such as those associated with the Friant and Kerckhoff power plants, relocation of recreation facilities and roads, and reservoir clearing, require additional review.

TABLE 4-4
RAISE FRIANT DAM ESTIMATED CONSTRUCTION COSTS

Dam Raise Height (feet)	Additional Storage Capacity (TAF)	Construction Costs		Estimated Land Acquisition Cost ($Million)
		Field Cost ($Million)	Construction Cost ($Million)	
25	125	100	125	27
60	340	250	310	30
140	870	640	800	40

Key:
TAF – thousand acre-feet

Environmental Considerations

Raising Friant Dam and the level of Millerton Lake would cause environmental impacts to aquatic biology, wildlife, recreation, and land use. Impacts to wildlife and aquatic biology habitats may be difficult to mitigate due to the limited ability to create similar habitat conditions. Raising the level of Millerton Lake, however, would also create an opportunity to increase cold-water and warm-water fish habitat, and recreation opportunities associated with the reservoir.

Raising the level of Millerton Lake would result in relatively low impacts to special habitats and species. Six special status plant species occur in the region, including Hartweg's pseudobahia (a.k.a. San Joaquin adobe sunburst, *Pseudobahia peirsonii*), tree anemone; San Joaquin Valley Orcutt grass, Madera linanthus, succulent owl's-clover, and Bogg's Lake Hedge-hyssop.

Several special status wildlife species exist in the area that would be affected by raising the level of Millerton Lake, including California tiger salamander, and western spadefoot toad. Foothill yellow-legged frogs and tri-colored blackbirds are also likely to occur in the area. Southern bald eagles may use the area for nesting and foraging during winter months.

American shad, an anadromous Atlantic Ocean fish successfully introduced to the Sacramento and San Joaquin rivers, and accidentally planted in Millerton Lake in the mid 1950s, is present in Millerton Lake. This population is the only known landlocked population of the species. Spawning habitat in the upper portion of Millerton Lake and upstream in the San Joaquin River would be affected by raising the level of Millerton Lake. Other impacts to habitat and wildlife would vary relative to the extent of inundation.

Millerton Lake Recreation Area facilities, along the south side of the reservoir, include boat ramps, a marina, camping and day use facilities, and other structures. Any raise of Millerton Lake would affect recreation facilities on the current shoreline. It is anticipated that recreation facilities would be relocated and would remain accessible. Opportunities for additional recreational opportunities would result from higher or longer storage levels in Millerton Lake, which would increase the reservoir surface area during peak recreation months.

Forty-seven archaeological sites, mostly prehistoric, may be within, adjacent to, or outside but close to, the existing pool. Some or all of these sites would be adversely affected by raising the level of Millerton Lake up to 140 feet. In addition, the historic Fresno County Court House, which was relocated to the current shore of Millerton Lake during construction of Friant Dam in the 1940s, would be inundated by raising the lake level more than 20 feet. Inundation damage to archaeological sites can be mitigated with scientific data recovery programs. Reservoir projects also provide an opportunity for public interpretation of the past. Ancillary facilities, such as roads, power lines, or other structures, may provide an opportunity for avoiding impacts to archaeological sites through design or facility placement.

Raising the level of Millerton Lake would affect residential properties around the lake and upstream power generating facilities. A 60-foot raise would also inundate several mines associated with the abandoned Sullivan mine. Impacts to land use, structures, and facilities appear mitigable, but mitigation would likely be at significant cost.

Fine Gold Creek Reservoir

Fine Gold Creek is a tributary to the San Joaquin River that enters Millerton Lake from the north and drains a watershed area of approximately 91 square miles. Fine Gold Creek Reservoir would be designed and operated as a pump-back project. This option would increase water supply by allowing Millerton Lake to be drawn down to a lower level to capture additional San Joaquin River inflow. Water stored in Fine Gold Creek Reservoir water be released to Millerton Lake and then diverted to the Friant-Kern or Madera canals and/or released to the San Joaquin River.

Options Considered

Two potential dam heights and reservoir capacities were considered (Figure 4-10). A low option would include a dam crest at elevation of 900, which corresponds to a 380-foot-high dam and a reservoir with 132 TAF storage capacity. A higher option, at elevation 1,100, would require a 580-foot-high dam and would create a reservoir with 780 TAF storage. For each dam size, two potential dam types were considered; a RCC gravity structure and a concrete-face rockfill (CFRF) dam. The higher dam option would require constructing a saddle dam approximately 100 feet high and 3,200 feet long on the west rim of the reservoir.

Geologic conditions appear suitable for dam construction at this site. Raw materials could be obtained from within the proposed reservoir inundation area. During construction, a temporary coffer dam approximately 80 feet high would be required above the permanent dam site on Fine Gold Creek to divert flows, and a second coffer dam approximately 60 feet high would be required to keep water from Millerton Lake out of the construction zone. One or more diversion tunnels would be required; the number and placement of tunnels depends on the dam type selected.

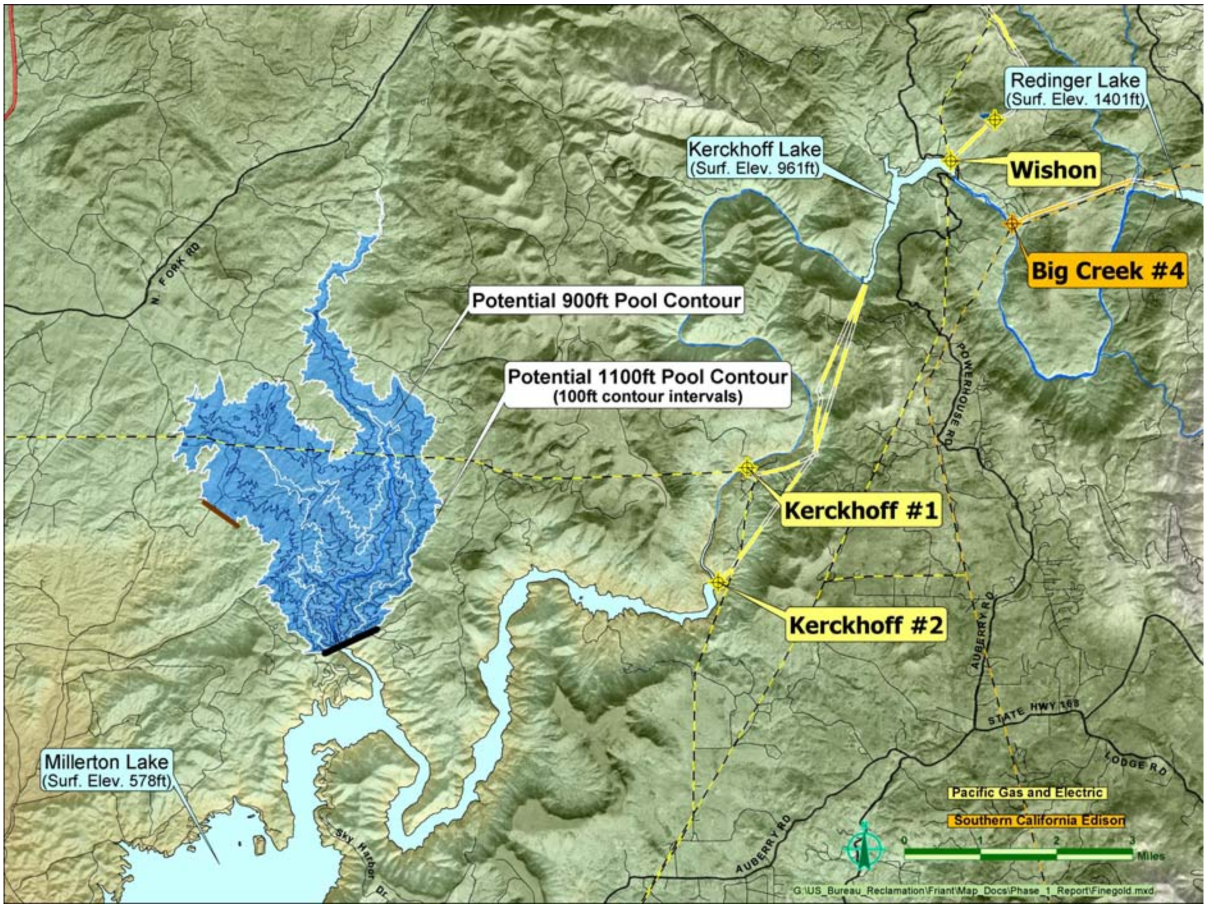


FIGURE 4-10. FINE GOLD CREEK RESERVOIR

Potential New Water Supply

CALSIM modeling results using single-purpose analyses indicate that the larger reservoir option considered at Fine Gold (crest at elevation 1,100) could produce a long-term annual average new water supply of approximately 110 TAF, if operated for water supply reliability. If operated for restoration or water quality purposes, the average new water supply would be slightly higher.

The small dam size considered (crest at elevation 900) with only a fifth of the storage capacity of the larger reservoir option (elevation 1,100), would not be expected to produce more than 20 TAF/year on average. Table 4-5 displays single-purpose analysis results for the storage volumes that were modeled.

TABLE 4-5
NEW WATER SUPPLY FROM FINE GOLD RESERVOIR

Dam Crest Elevation (feet above mean sea level)	Storage Capacity (TAF)	New Water Supply Estimated in Single-Purpose Analysis (average TAF/year)		
		RF	WQ	WS
900	400	n/s	n/s	65
1,100	800	136	124	113

Key:
n/s not simulated
TAF – thousand acre-feet
RF – San Joaquin River restoration flow single-purpose analysis
WQ – San Joaquin River water quality single-purpose analysis
WS – water supply reliability single-purpose analysis

Energy Use and Generation

For the evaluation of energy use and generation, the 800 TAF Fine Gold Creek Reservoir option was considered. CALSIM output included flows to be pumped into Fine Gold Creek Reservoir from Millerton Lake, releases from Fine Gold Creek Reservoir to Millerton Lake (available for generation), evaporation at Fine Gold Creek Reservoir, inflow from Fine Gold Creek and canal, and river releases from Friant Dam. Tables of reservoir areas and volumes relative to reservoir elevations for Fine Gold Creek Reservoir and Millerton Lake were used to estimate water pumping and available power generation heads.

As summarized in Table 4-6, pumping energy requirements for Fine Gold Creek Reservoir would exceed generation potential by nearly 80 percent. An analysis of the potential value of both pumping and generated energy has not yet been completed; thus, it is not possible to determine if the additional pumping energy requirement would also result in a net financial gain or loss. Additional controlled releases through the Friant power plants could increase the energy generation potential. An analysis of the power plants would also be needed to determine if net energy generation is increased or decreased.

New transmission line(s) would be required to serve the Fine Gold Creek pumping and generation plants. They would be connected to one or both of two major power lines, one located about 6 miles to the southeast and the other about 15 miles to the southwest. Additional study is needed to determine if existing lines have adequate capacity, alignments for new lines, and control, protection, interconnections, and protection requirements.

Estimated Costs

Table 4-7 lists estimated construction costs of the Fine Gold Reservoir options considered. Costs are shown for dam and power plant features, including a saddle dam for the elevation 1,100 option. Land acquisition costs are listed separately from construction costs. Additional review during Phase 2 will identify costs that would be associated with reservoir clearing, road construction or relocation, or any needed environmental mitigation.

TABLE 4-6
FINE GOLD ENERGY GENERATION AND USE

Storage Capacity (TAF)	Single-Purpose Analysis	Potential Average Annual Energy Generation (GWh/year)	Potential Average Annual Pumping Energy (GWh/year)
800	WQ	80 – 100	140 – 170
	RF	70 – 90	130 – 160

Key:
GWh/year – gigawatt-hours per year
TAF – thousand acre-feet
RF – San Joaquin River restoration flow single-purpose analysis
WQ – San Joaquin River water quality single-purpose analysis

TABLE 4-7
FINE GOLD RESERVOIR ESTIMATED CONSTRUCTION COSTS

Dam Height (feet)	Capacity (TAF)	RCC Dam		CFRF Dam		Land Cost ($Million)
		Field Cost ($ Million)	Construction Cost ($ Million)	Field Cost ($ Million)	Construction Cost ($ Million)	
380	120	160	200	160	200	3
580	745	430	540	400	500	9

Key:
RCC – roller-compacted concrete
CFRF - concrete-faced rock fill

Environmental Considerations

Creation of Fine Gold Creek Reservoir would result in adverse environmental impacts in a relatively pristine natural area that supports many biological resources. Extensive areas of pine and oak woodland habitat would be affected, as would pockets of riparian and wetland habitats. Vernal pools and special status species of plants, wildlife, and fish may be present in the inundation area. Western pond turtles, a Federally listed endangered species, are known to be present in Fine Gold Creek and its small tributaries. Abandoned mines and mine tailings in the inundation area create the potential for water quality impacts.

Pumped storage operations could affect water temperatures in Millerton Lake and cause fluctuations in water levels in both Millerton Lake and the new Fine Gold Creek reservoir. Lake level fluctuations could negatively affect habitat and spawning conditions for several species of fish, including American shad and largemouth bass.

Eight special status plant species occur in the region, including seven listed species: Hartweg's pseudobahia, tree anemone, San Joaquin Valley Orcutt grass, Madera linanthus, Mariposa pussypaws, succulent owl's-clover, and Bogg's Lake Hedge-hyssop. The greatest mitigation requirements would be associated with impacts to the tree anemone, Hartweg's pseudobahia, and wetland and riparian habitats.

Temperance Flat Reservoir

Temperance Flat is a wide, bowl-shaped area in the upper portion of Millerton Lake approximately 13 miles upstream of Friant Dam. For the purposes of Phase 1 of the feasibility study, all reservoir options between Millerton Lake and Kerckhoff Dam are addressed in this section. Temperance Flat Reservoir would capture the flow of the San Joaquin River downstream of Kerckhoff Lake and before it enters Millerton Lake. Water would be released from Temperance Flat Reservoir to Millerton Lake for canal diversion and/or release to the San Joaquin River. Operating criteria for the two reservoirs could be influenced by ecosystem needs in the reservoirs, recreation opportunities, and hydropower generation.

Options Considered

Initially, four potential Temperance Flat dam sites were identified on the basis of topographic characteristics and previous studies. Three of these sites, at river mile (RM) 274, RM 279, and RM 280, would result in the inundation of the Temperance Flat area. A fourth site, at RM 286, is upstream of the Temperance Flat area and could be considered a downstream enlargement of Kerckhoff Dam.

An initial comparison of site features showed that the RM 279 site is superior to the RM 280 site. These sites are close in proximity and would result in similar environmental effects for a reservoir at a given elevation. Both of these sites have similar geologic conditions, would be accessed in the same manner, would use a portion of the Temperance Flat area as a construction lay-down area, would have similar cofferdam and river diversion requirements, and would obtain dam materials from the same general borrow area.

However, a dam at RM 280 would require more material than a dam at RM 279 to create the same storage capacity at a higher cost. Therefore, RM 280 was dropped from further consideration. The remaining three Temperance Flat dam sites are shown in Figure 4-11, and are described in the following sections.

Foundation conditions at all of the dam sites considered for Temperance Flat options would be sound granitic rock. No special foundation considerations are known at this time, and foundation preparation would be typical for each option. Excavation for the concrete gravity dams was assumed to be 10 feet to remove overburden and weathered bedrock.

RM 274 Site

The RM 274 site is located in Millerton Lake approximately 1 mile upstream of the confluence of Fine Gold Creek and Millerton Lake. It was one of three sites in the original planning studies for Friant Dam in the 1930s, when it was referred to as the Temperance Flat site. From a water storage perspective, it was considered superior to both the Friant Dam site and a site at Fort Miller (just downstream of Fine Gold Creek). The Friant Dam site was selected, however, because construction of a dam at RM 274 would have required canals around the current Millerton Lake area or a diversion dam at Friant.

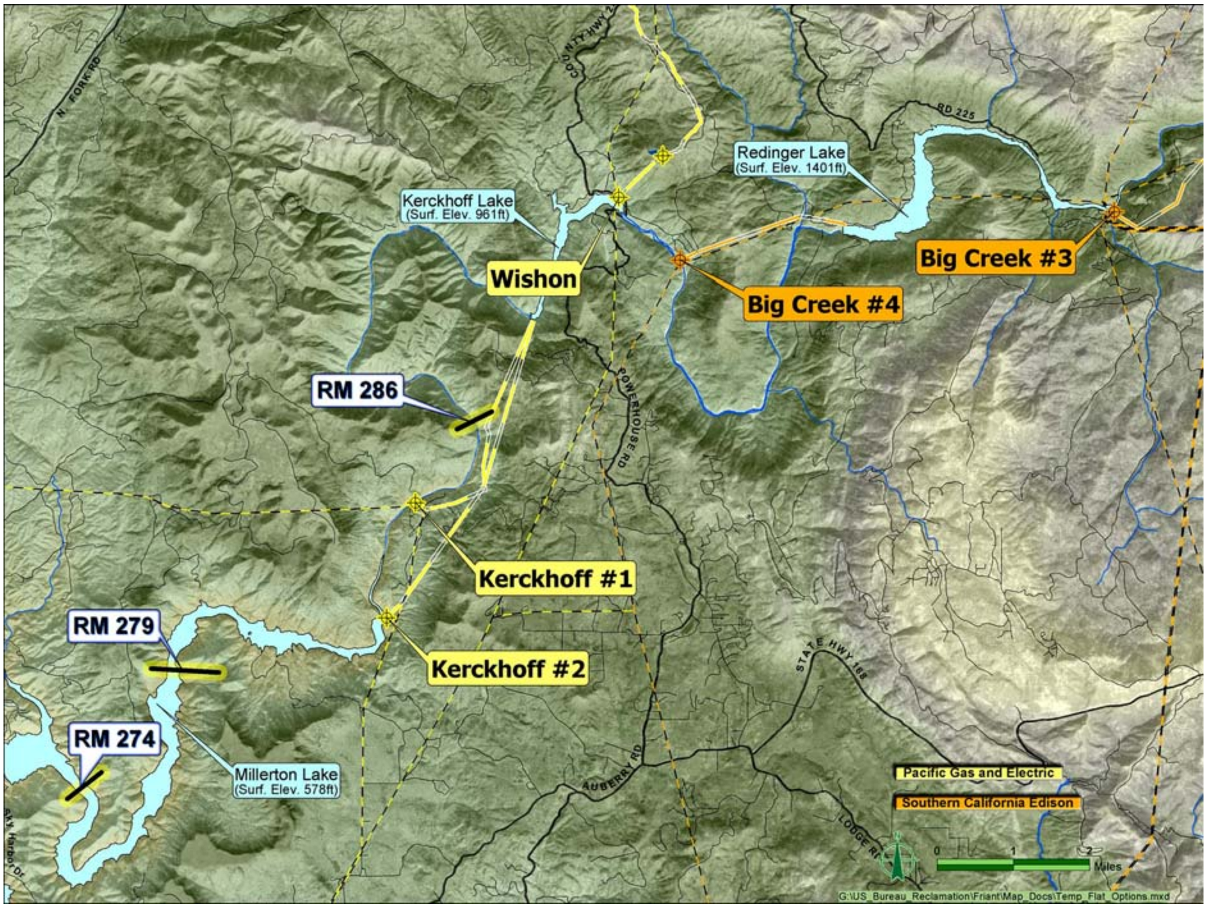


FIGURE 4-11. TEMPERANCE FLAT DAM SITE OPTIONS

The topography of the RM 274 site is fairly uniform on both the left and right abutments. The site rises from elevation 385 in the San Joaquin River channel, about 200 feet below water at the maximum water level. The left abutment rises uniformly to elevation 1,582 at Pincushion Mountain and the right abutment rises uniformly to elevation 1,473 at an unnamed peak. The maximum reservoir level at elevation 1,100 was considered due to a low spot along a ridge making up part of the left abutment adjacent to RM 275. This elevation would correspond to a dam height of about 715 feet and a reservoir capacity of about 2,100 TAF. The potential reservoir for the RM 274 site is shown in Figure 4-12.

The RM 274 site may be appropriate for concrete arch, concrete gravity, and CFRF dams. A concrete arch dam was not considered in the prefeasibility-level review because the relatively flat slopes would result in a wide canyon with potentially large volumes of concrete. However, this option should not be excluded from future consideration since further studies may show that an arch dam is economical. A design for an RCC type dam was not developed in detail for this site but would be similar to the structure considered for the RM 279 site. Preliminary designs and cost estimates were prepared for CFRF dams at two elevations at the RM 274 site, as described in a later section.

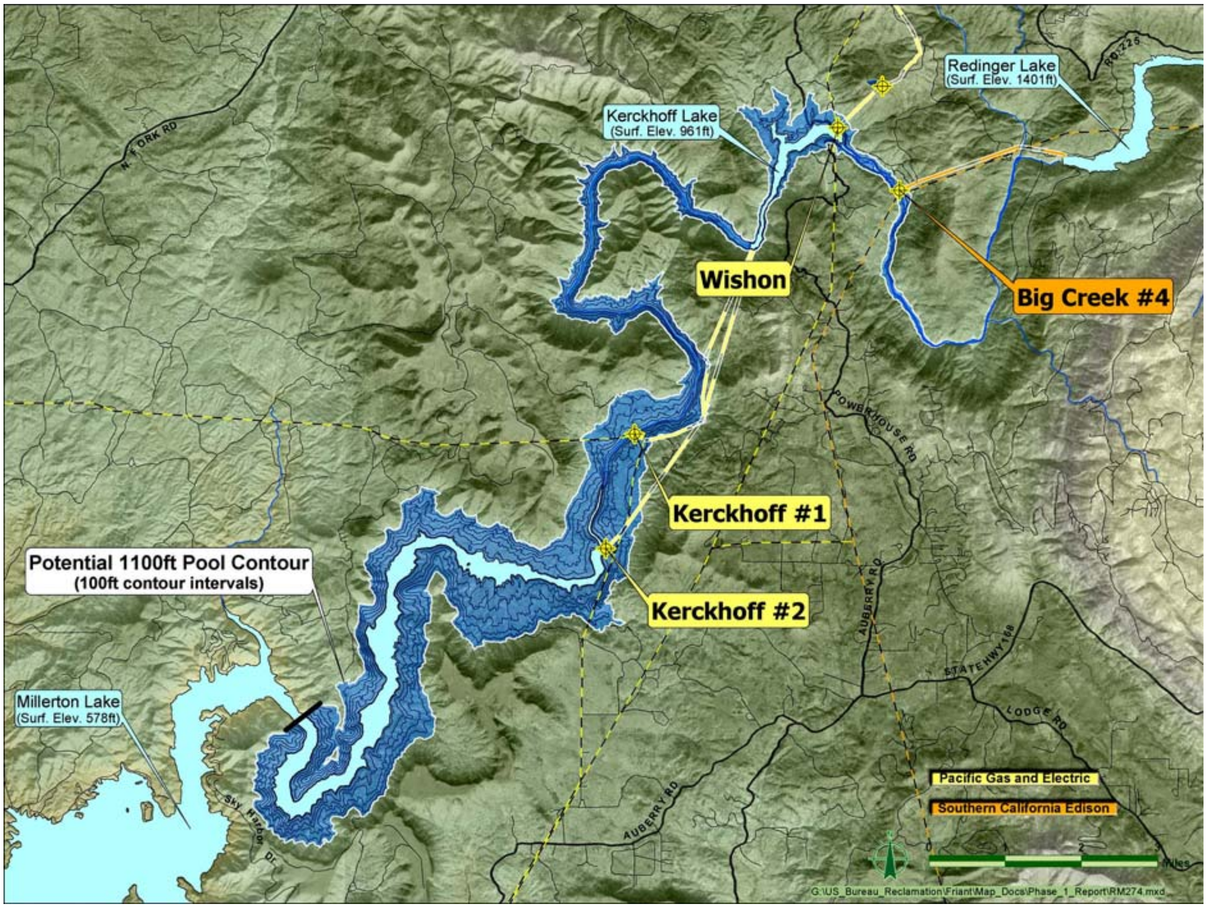


FIGURE 4-12. TEMPERANCE FLAT RM 274 RESERVOIR

Upstream and downstream cofferdams would be required for diverting stream flows during construction and to prevent inundation of the site from Millerton Lake. The cofferdams are sized for the estimated diversion flows, and to allow normal operation of Millerton Lake during construction. The upstream cofferdam would be at elevation 635 to provide sufficient head to pass the diversion flood. The downstream cofferdam would be at elevation 578 for all options, to accommodate normal reservoir operations for Millerton Lake. A significant portion of both cofferdams would be constructed within the existing reservoir pool a maximum depth of 175 feet.

Diversion tunnels through both abutments of the new dam would be required to pass San Joaquin River flows around the construction site. The tunnels would be 30 feet and 40 feet in diameter. One of the diversion tunnels would be used for the outlet works, and the other would be plugged or could be used as part of the spillway depending on the dam height.

RM 279 Site

The RM 279 site is also located in Millerton Lake approximately 2 miles downstream of the Temperance Flat area. The RM 279 site rises uniformly from elevation 460 in the original San Joaquin River channel to elevation 1,080 on the left abutment, and then through a saddle at elevation 1,040 before continuing to elevation 1,416 at an unnamed peak. The right abutment rises uninterrupted to elevation 1,566 at an unnamed peak. A dam crest at elevation 1,300 was considered, which would result in a dam height of 840 feet and a reservoir capacity of over 2,750 TAF. The potential reservoir for the RM 279 site is shown in Figure 4-13.

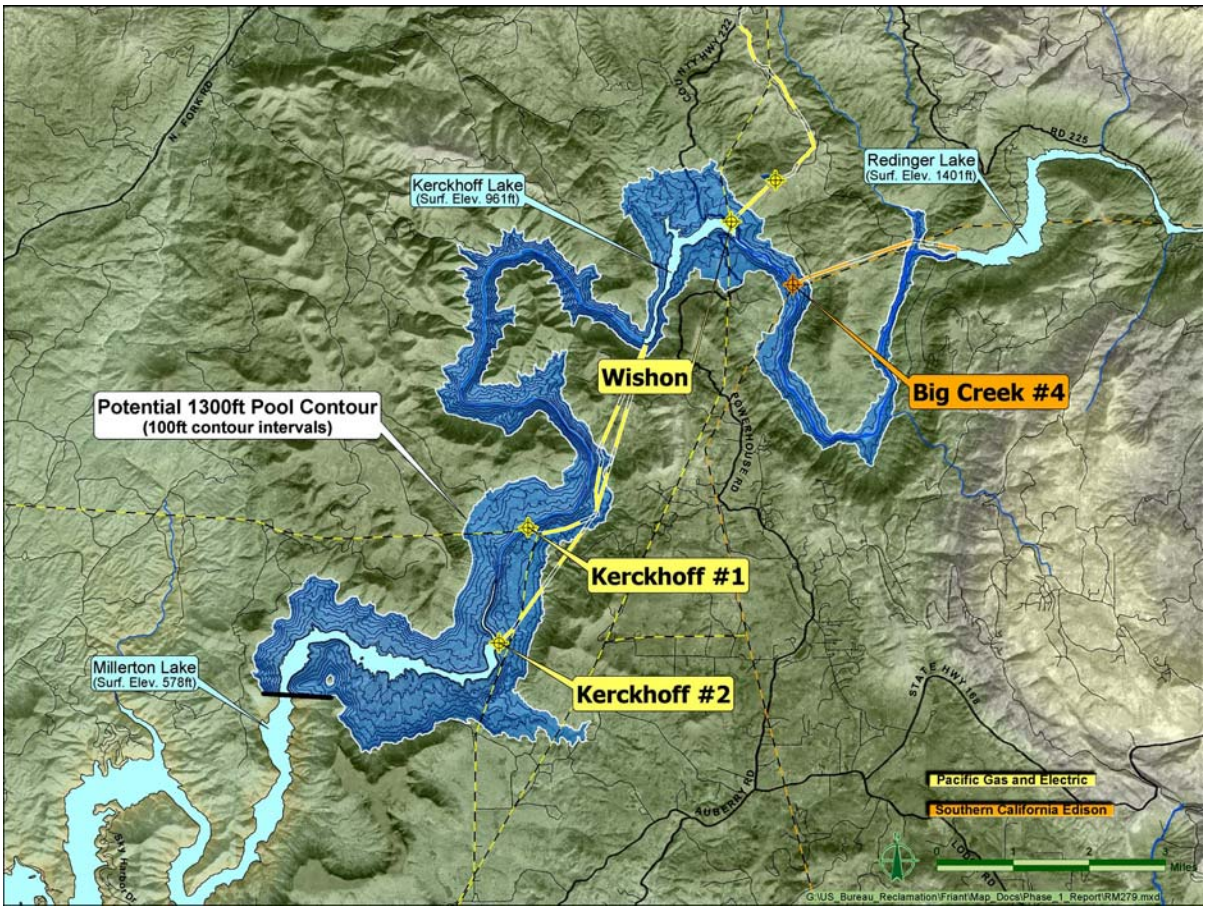


FIGURE 4-13. TEMPERANCE FLAT RM 279 RESERVOIR

The RM 279 site is appropriate for concrete arch, concrete gravity, and CFRF dams. A central-core earth fill dam is not considered economically viable, due to the limited availability of plastic, fine-grained materials for the core. A concrete arch dam was not considered for prefeasibility-level designs because the abutments have relatively flat slopes, which would result in a wide canyon requiring potentially large volumes of concrete. However, this design option was not evaluated sufficiently to exclude it from future consideration.

Upstream and downstream cofferdams would be required for diverting stream flows during construction and to prevent inundation of the site from Millerton Lake. The cofferdams are sized for the estimated diversion flows, and to allow normal operation of Millerton Lake during construction. The upstream cofferdam would have a crest at elevation 635, and a height of approximately 185 feet. The downstream cofferdam would have a crest at about elevation 578, and height of about 125 feet.

Diversion tunnels through both abutments of the new dam would be required to pass San Joaquin River flows around the construction site. The tunnels would be 30 feet and 40 feet in diameter. The smaller diversion tunnel would be converted to the outlet works; thus, a low-level outlet was not considered.

Access to the RM 279 site would require constructing new roads on the Fresno County side of the river. Construction staging and lay-down would be located in the reservoir area. Prefeasibility-level cost estimates were made for RCC and CFRF dams at two elevations.

RM 286 Site

Unlike the RM 274 and RM 279 sites, the RM 286 site is not located in Millerton Lake, but is approximately 6 miles downstream of Kerckhoff Dam, between the dam and the Kerckhoff powerhouses. The RM 286 site rises uniformly from elevation 740 in the San Joaquin River channel to elevation 1,450 on the left abutment, and then through a flatter slope at elevation 1,450 to 1,650 before continuing to elevation 2,100. The right abutment rises uninterrupted and uniformly to beyond elevation 1,850 at an unnamed peak.

A dam crest at elevation 1,400 was considered, which would result in a dam height of 660 feet and a reservoir capacity of 1,400 TAF. A larger reservoir size could be created by constructing a higher dam at the RM 286 site, but it would inundate the Big Creek No. 3 Powerhouse. The cost of power generation loss from Big Creek No. 3 may not be justified by the limited additional new water supply associated with larger sizes. The potential reservoir for the RM 286 site at elevation 1,400 is shown in Figure 4-14.

Upstream and downstream cofferdams would be required for diverting stream flows during construction. The downstream cofferdam would have a crest at about elevation 770, and height of about 30 feet. The upstream cofferdam would have a crest at about elevation 850, and a height of approximately 110 feet.

Diversion tunnels through both abutments of the new dam would be required to pass San Joaquin River flows around the construction site. The tunnels would be 30 feet and 40 feet in diameter. One of the diversion tunnels would be used for the outlet works, and the other would be plugged or could be used as part of the spillway depending on the dam height.

Prefeasibility-level designs and cost estimates were prepared for concrete arch, RCC, and CFRF dam types at two elevations at the RM 286 site, as described in a later section.

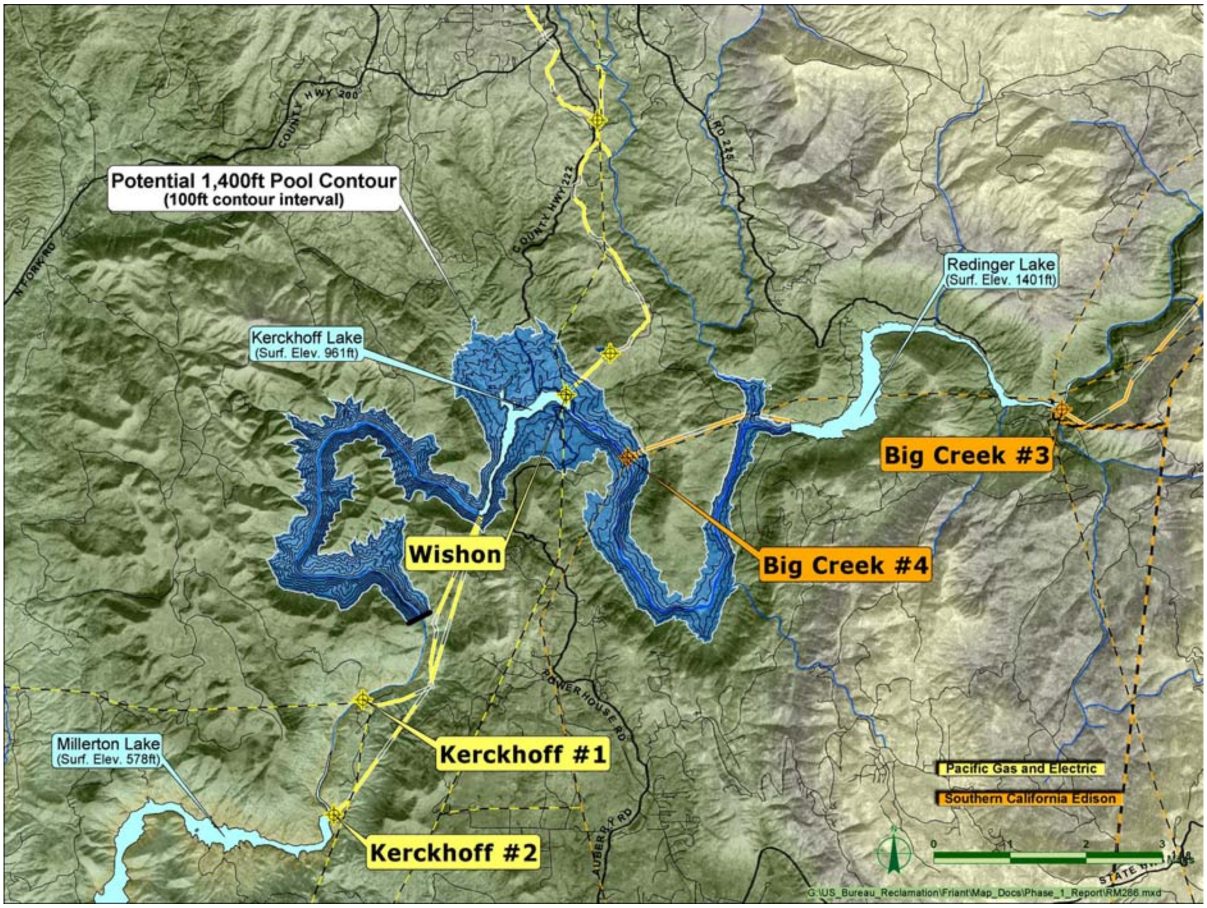


FIGURE 4-14. TEMPERANCE FLAT RM 286 RESERVOIR

Potential New Water Supplies

Constructing a dam at any of the three Temperance Flat locations could create a reservoir of up to 2,000 TAF or greater in storage capacity, depending on the height of the dam. As mentioned previously, the upper limit storage capacity for reservoirs created by the three Temperance Flat dam sites ranges from 1,400 TAF to 2,100 TAF.

Modeling the three options was accomplished using a single representation of Temperance Flat reservoir because the relationship of storage volume to surface area is similar for all three sites. Therefore, estimated losses to evaporation would be similar for all three options.

Results of initial model runs are listed in Table 4-8 and shown graphically in Figure 4-15. As indicated, preliminary results show that the average annual new water supply, measured as additional water available for delivery or controlled releases to the river, would approach 200 TAF/year for a reservoir in excess of 2,000 TAF storage capacity. Figure 4-15 shows a trend of increasing amounts of new water supplies as reservoir size increases. Results from the restoration flow, water quality, and water supply reliability single-purpose analyses are displayed.

TABLE 4-8
NEW WATER SUPPLY FROM TEMPERANCE FLAT OPTIONS

Additional Storage Capacity (TAF)	New Water Supply Estimated in Single-Purpose Analysis (average TAF/year)		
	WS	WQ	RF
725	122	123	146
1,350	168	187	185
2,100	197	n/s	n/s

Key:
n/s not simulated
TAF – thousand acre-feet
RF – San Joaquin River restoration flow single-purpose analysis
WQ – San Joaquin River water quality single-purpose analysis
WS – water supply reliability single-purpose analysis

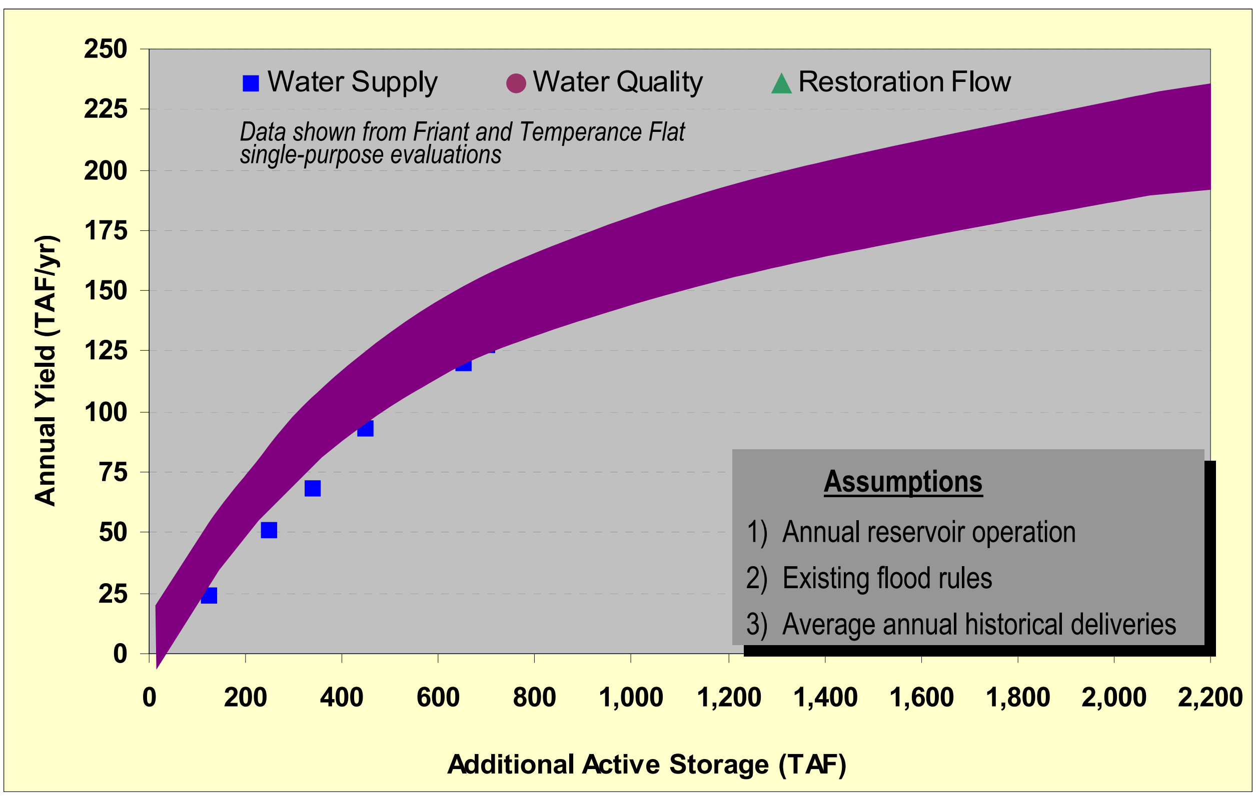


FIGURE 4-15. AVERAGE ANNUAL NEW WATER SUPPLY FOR RAISE FRIANT DAM AND TEMPERANCE FLAT OPTIONS

Hydropower Generation and Impacts

Any of the Temperance Flat options and raising the level of Millerton Lake would affect the operations of existing hydropower project facilities. Depending on the location and height of the dam, Temperance Flat reservoir has the potential to affect up to five powerhouses and two diversion dams upstream of Millerton Lake. The elevations and corresponding storage capacity at which power facilities would be affected are shown in Figure 4-16.

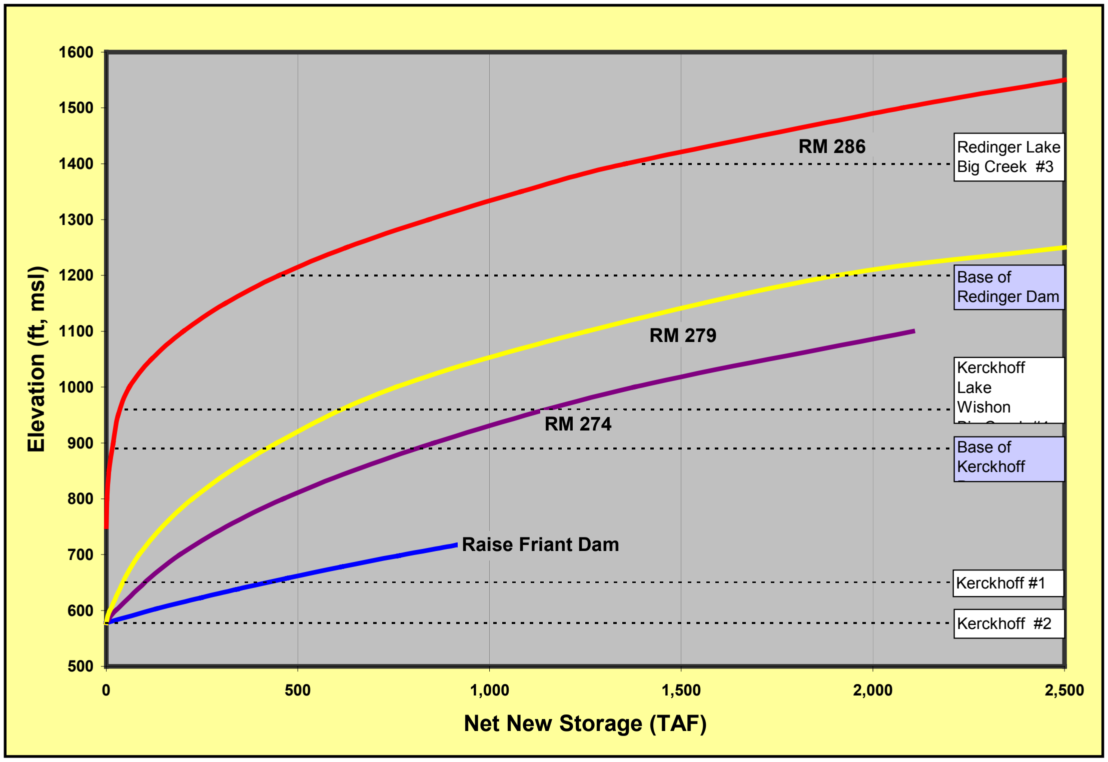


FIGURE 4-16. HYDROPOWER FACILITIES POTENTIALLY AFFECTED BY RAISE FRIANT DAM AND TEMPERANCE FLAT OPTIONS

Each of the potentially affected powerhouses has unique characteristics related to installed generation capacity, head, flow rates, equipment type, equipment age, and efficiency. A summary of generation capacity and recent annual energy generation for each facility is listed in Table 2-4. Figure 4-17 shows the amount of installed generation capacity that would be affected for raising Friant Dam and each Temperance Flat option. As shown, impacts to installed generation capacity increase as storage capacity increases at each site. In all cases, a step increase in generation capacity occurs when additional facilities would be impacted. For the RM 286 site, two curves are shown.

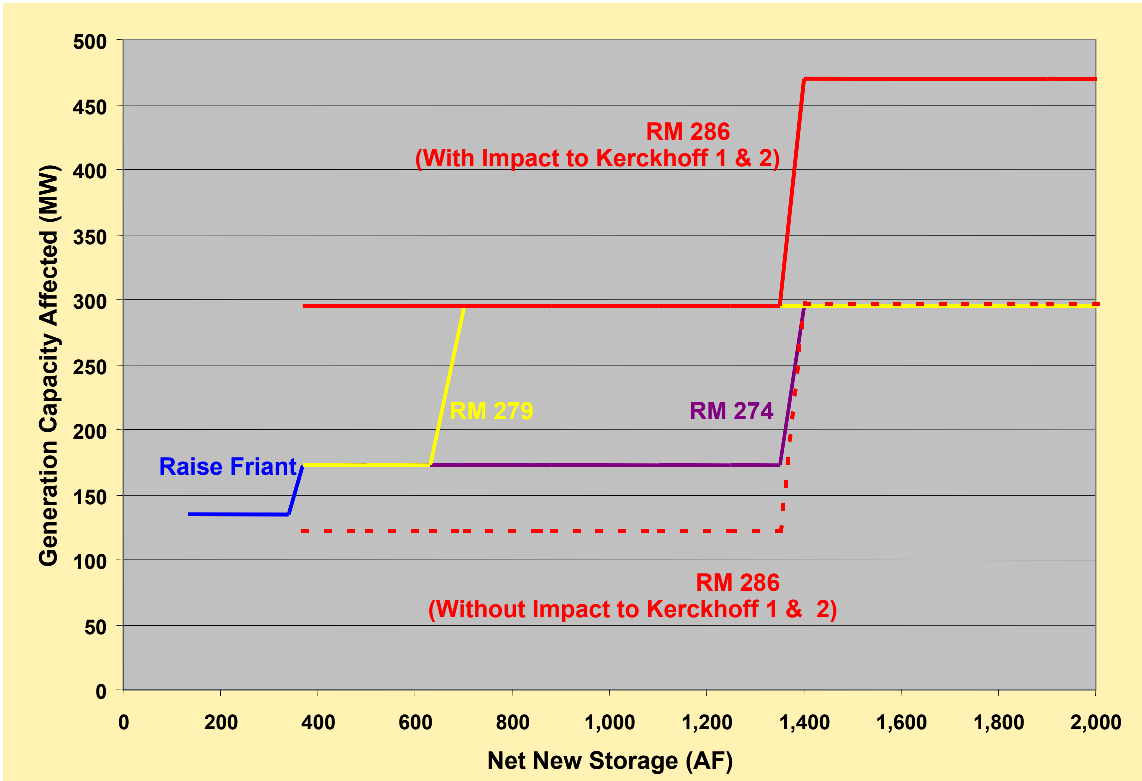


FIGURE 4-17. HYDROPOWER GENERATION CAPACITY POTENTIALLY AFFECTED BY TEMPERANCE FLAT OPTIONS

The RM 286 site is between Kerckhoff Dam and the Kerckhoff Powerhouse. The reservoir would not inundate either Kerckhoff powerhouses, but would affect generation because of the higher head above Kerckhoff Lake. The upper curve would apply if power generation at the Kerckhoff Powerhouse is not possible with a higher reservoir. This would correspond to a minimum of 300 MW installed generation capacity, and as great as 475 MW. If the plants could be operated, however, the impacts on power generation would be less, with 125 MW to about 300 MW of installed capacity affected.

To simplify the analysis, reservoir storage volumes of 725 TAF and 1,350 TAF were considered for each case. These volumes were chosen to generally correspond with storage volumes associated with impacts to power generation facilities. A storage volume of 725 TAF generally corresponds to the volume at which the reservoir at RM 279 would begin to affect generation at the Wishon and Big Creek No. 4 powerhouses. A storage volume of 1,350 TAF approximates the volume at which a reservoir at RM 274 would affect generation at the Wishon and Big Creek No. 4 powerhouses, and a reservoir at RM 286 would affect generation at the Big Creek No. 3 Powerhouse.

CALSIM output included monthly inflows to Temperance Flat Reservoir, water volumes and evaporation at Temperance Flat Reservoir and at Millerton Lake, inflow to Millerton Lake from Fine Gold Creek, and canal and river releases from Friant Dam. Tables of reservoir area and volume in relation to reservoir elevations for Temperance Flat Reservoir and for Millerton Lake were used to calculate head available for power generation.

Assumptions were made regarding turbine and generator efficiencies, minimum and maximum heads and flows for generation, and head losses in water passages. From these data and assumptions, preliminary estimates were made of installed capacity and energy generated on an annual basis.

For either the RM 274 and RM 279 sites, a powerhouse would be located at or near the dam with an installed generation capacity of approximately 100 MW to120 MW. For the 725 TAF option, both Kerckhoff powerhouses would be submerged, although it might be possible to extend the Kerckhoff tunnels to RM 274. The 1,350 TAF option would affect the Kerckhoff and Kerckhoff No. 2 powerhouses, Kerckhoff Dam, Wishon Powerhouse, and the Big Creek No. 4 Powerhouse.

For the RM 286 site, the powerhouse would be located downstream at about RM 283, the location of the Kerckhoff No. 2 Powerhouse. It would be supplied with water from an intake at the dam by means of a tunnel, surge chamber ,and penstocks. For both the 725 TAF and 1,350 TAF options, Kerckhoff Dam would be inundated. The Kerckhoff and Kerckhoff No. 2 powerhouses would not be inundated. It may be possible to use the existing Kerckhoff facilities, with modified gate arrangements, existing tunnels with upgraded or new turbine and generator equipment, and modifications to power station structures. The potential to build new powerhouses at Wishon and Big Creek No. 3 to make use of available, but reduced, head was not evaluated.

Estimates of annual energy generation for all Temperance Flat options are summarized in Table 4-9. In all cases, flow through the powerhouses would be the same, with the primary differences related to available head. More energy generation would be possible from the RM 286 site due to the greater head associated with this reservoir configuration. Estimates also do not include potential generation from pumped storage. It would be possible to construct a pumped storage arrangement at the 274 and 279 sites, because of the close proximity of the Temperance Flat Reservoir to Millerton Lake. The evaluation of a pumped storage project would require additional study of the flow regime and consideration of water supply operation requirements, and was not included in Phase 1 studies. The rather long distance from Millerton Lake to the RM 286 site would likely preclude the use of the RM 286 site for pumped storage purposes. At RM 286, the water conveyance length to available head ratio is considerably greater than 10, which is generally considered an upper limit for economic pumped storage.

TABLE 4-9
TEMPERANCE FLAT POTENTIAL ENERGY GENERATION

Dam Site	Water Storage Capacity (TAF)	Average Annual Energy Generation Potentially Affected[1] (GWh/year)	Potential Average Annual Energy Generation From Temperance Flat[2] (GWh/year)
RM 274	725	579	160 – 210
	1,350	1,125	210 – 270
RM 279	725	1,125	330 – 380
	1,350	1,125	400 – 450
RM 286	725	546 – 1,125[3]	630 – 680
	1,350	546 – 1,125[3]	690 – 740

Key:
GWh/year – gigawatt-hour per year
RM – river mile
TAF – thousand acre-feet
RF – San Joaquin River restoration flow single-purpose analysis
WQ – San Joaquin River water quality single-purpose analysis

Notes:
1. Average annual energy generation as reported in Table 2-4.
2. Range of estimated annual energy generation from restoration flow and water quality single-purpose analyses.
3. Potential impacts to power generation depend on the degree of impact to the Kerckhoff and Kerckhoff No. 2 powerhouses. The lower estimate does not include Kerckhoff power losses; the upper estimate includes the loss of all Kerckhoff power generation.

Due to the proximity of the Temperance Flat sites to existing facilities, it is expected that new power generation facilities would connect to existing transmission systems. Existing transmission line capacity to the Wishon Powerhouse is 70 kilovolts (kV), to the Kerckhoff and Kerckhoff No. 2 powerhouses is 115 kV, and to Big Creek No. 3 and No. 4 powerhouses is 220 kV. Additional study in Phase 2 will consider the adequacy of existing lines to serve new power facilities, and to ascertain the requirements for electrical control and protection.

The control center for the SCE Big Creek Hydroelectric Project is located at the Big Creek No. 3 Powerhouse. This control center would need relocated for any option that included inundation of the Big Creek No. 3 Powerhouse. Costs for relocation have not been estimated but are assumed to be included in the contingency provisions previously described.

Estimated Costs

Table 4-10 lists estimated construction costs for the Temperance Flat Reservoir options considered. As shown, cost estimates have been prepared at each dam site for the range of dam design and elevations that have been identified. Costs include dam and power plant features, including a saddle dam for the 1,300 ft elevation option at RM 279. Additional review is needed to identify costs that would be associated with reservoir clearing, road construction or relocation, and any needed environmental mitigation.

TABLE 4-10
ESTIMATED COSTS OF TEMPERANCE FLAT RESERVOIR OPTIONS

Gross Pool Elevation (feet above mean sea level)	Gross Storage Capacity[1] (TAF)	Net Additional Storage Capacity[2] (TAF)	Dam Type	Construction Costs	
				Field Cost ($Millions)	Construction Cost ($Millions)
RM 274 Dam Site					
800	531	462	CFRF	490	610
1,100	2,187	2,114	CFRF	800	1,000
RM 279 Dam Site					
900	460	444	RCC	410	510
			CFRF	430	540
1,100	1,263	1,243	RCC	750	940
			CFRF	730	910
1,300	2,775	2,736	RCC	1,400	1,750
			CFRF	1,200	1,500
RM 286 Dam Site					
1,200	465	457	Arch	330	410
			RCC	340	430
			CFRF	430	540
1,400	1,403	1,364	Arch	630	790
			RCC	560	700
			CFRF	590	740

Key:
TAF – thousand acre-feet
CFRF – concrete-faced rock fill dam
RCC – roller-compacted concrete dam

Notes:
1. Total storage capacity of new reservoir.
2. Accounts for lost storage capacity in Millerton Lake and Kerckhoff Lake.

Land costs estimates are preliminary and not considered complete.

Environmental Considerations

Developing a reservoir at Temperance Flat would cause adverse environmental effects to aquatic biology, botany, wildlife, and recreation resources, and could affect land uses in the reservoir vicinity. Aquatic species that would be affected by the RM 274 and RM 279 options include Kern brook lamprey, hardhead, American shad, and black bass. These species would be affected because they reside in the upper portion of Millerton Lake, which would be within the reservoir for these options. The RM 286 option would affect reservoir fisheries in the reaches above and below Kerckhoff Lake and in Kerckhoff Lake.

Regional botany is dominated by foothill woodlands of pine and blue oak, with open perennial grasslands. A considerable amount of such habitat would be inundated by a reservoir. Several plant species of special concern are documented as occurring in the project area and could be affected by a Temperance Flat reservoir. Quantitative estimates of potentially affected areas, and the frequency of inundation, will be made in Phase 2. Species for which mitigation may be required include carpenteria, Mariposa pussypaws, and Madera linanthus.

Wildlife species potentially affected by the Temperance Flat options include the southwestern willow flycatcher, the valley elderberry longhorn beetle, the California tiger salamander, and the western pond turtle. Field surveys will be made during Phase 2 to identify the potential presence and extent of habitats that support these species and mitigation approaches will be developed.

The RM 274 and RM 279 options would inundate portions of the Millerton Lake State Recreation Area and portions of the San Joaquin River Gorge Management Area, which is managed by the U.S. Bureau of Land Management (BLM). The larger reservoir option would also inundate Sierra National Forest lands above Kerckhoff Dam. The RM 286 options would not affect the recreation area, but could affect the BLM lands. The Patterson Bend whitewater boating run, a Class V rapid below Kerckhoff Dam, would be completely inundated by any of the Temperance Flat reservoir options considered. Depending on the elevation of the reservoir pool and operations, some or all of the Horseshoe Bend run above Kerckhoff Lake would be inundated by the Temperance Flat options. The RM 274 option would have the smallest effect on this run, whereas the RM 286 option at a storage capacity of about 750 TAF would completely inundate the run.

Prehistoric archaeological sites exist within the potentially inundated area associated with all Temperance Flat options, as do sites where mining occurred historically. Past mining sites have been identified but need to be assessed for their potential historic significance and their potential to affect water quality.

Land use effects associated with Temperance Flat options include impacts to roads, bridges, and trails. The RM 274 and RM 286 options would inundate both the San Joaquin River Trail footbridge at the Kerckhoff Powerhouse and the Road 222 bridge that crosses the San Joaquin River at Kerckhoff Lake. The RM 286 option would not affect the footbridge, but would also inundate the Road 222 bridge. Further evaluation is needed to identify mitigation approaches for these impacts.

Yokohl Valley Reservoir

Yokohl Valley Reservoir would be located approximately 15 miles east of Visalia and 8 miles south of Lake Kaweah. A 260-foot-high earthfill dam, with a crest length of nearly 3,000 feet, would create a 450 TAF reservoir. Two small saddle dams in the hills west of the main dam site would be required.

Options Considered

Yokohl Valley Reservoir would operate as a pump-back storage reservoir served by the Friant-Kern Canal, as shown in Figure 4-18. This is a variation of an option that was described initially in a study of the Mid-Valley Canal by Reclamation. Supplementary flows would come from natural runoff in Yokohl Creek. Stored water would be released to Yokohl Creek and directed to the Friant-Kern Canal to supplement CVP deliveries or to offset releases from Millerton Lake to the San Joaquin River. Only the first option, off-canal storage from the Friant-Kern Canal, is considered in this Investigation.

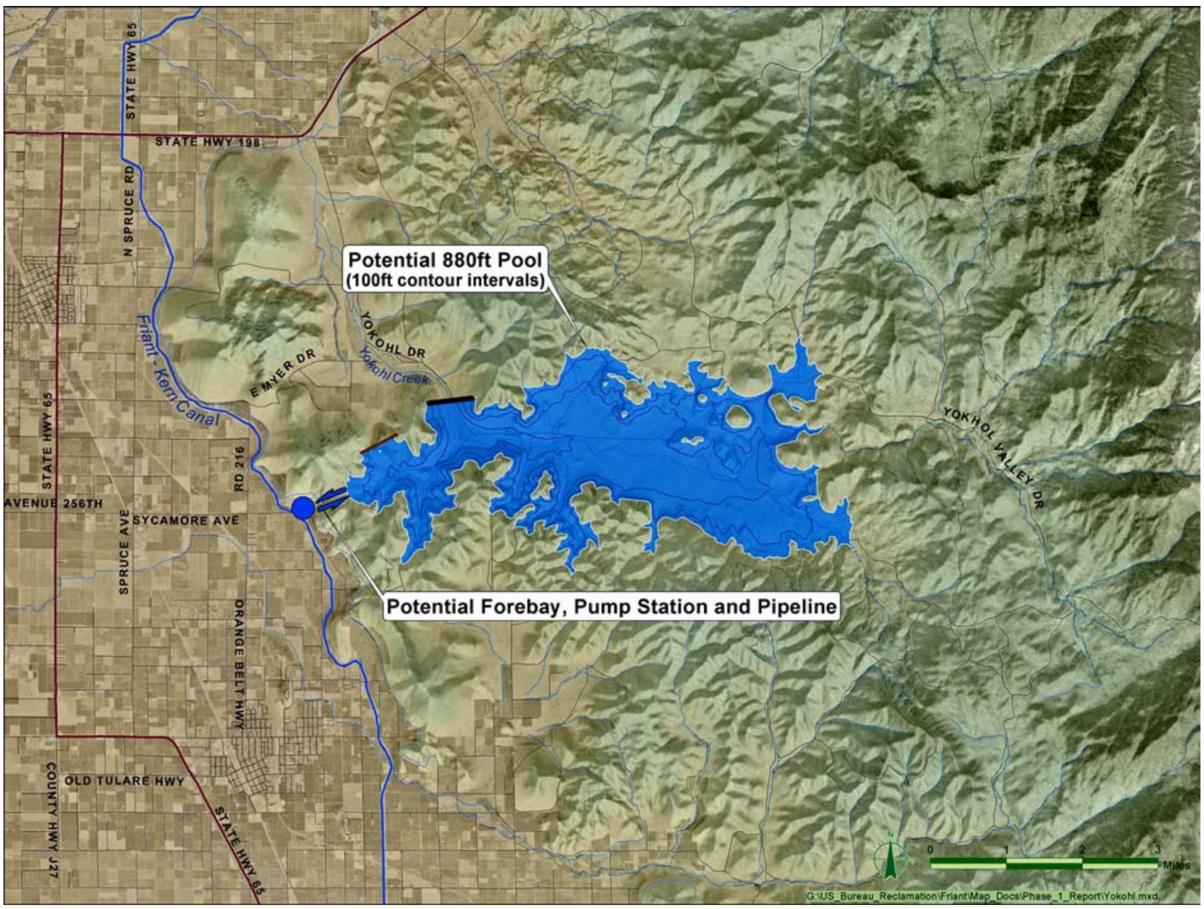


FIGURE 4-18. YOKOHL VALLEY RESERVOIR

Site characteristics at the Yokohl Valley dam site appear to pose no barriers to construction. Underlying rock conditions would be adequate for a dam foundation, sufficient impervious, pervious, and riprap materials exist within 2 miles of the proposed dam site, and potential staging and lay-down areas are located immediately upstream and downstream of the project site. An improved road provides access directly to the dam site and electrical power would likely be available from sources in Exeter or along Highway 198.

Potential New Water Supply

This off-stream and off-basin storage would rely on Friant-Kern Canal diversion as the only water source for the pump-storage operation. In wet months, any water that exceeds demand would be diverted to the Friant-Kern Canal and stored in Yokohl Valley Reservoir to free up Millerton Lake for capture of floodwater. During irrigation season, water released from Yokohl Valley Reservoir can supplement Millerton Lake diversion to satisfy demand along the Friant-Kern Canal. To avoid significant fluctuation in Friant-Kern Canal water levels, pumping and releasing would be through a forebay off the canal. The forebay would be relatively small, compared to surface water storage facilities under consideration, and therefore was not modeled in CALSIM.

Two Yokohl Valley Reservoir sizes were modeled in CALSIM. Two key assumptions were made to address hydrologic and operational issues. First, local inflow to Yokohl Valley Reservoir was not simulated. No river gage has been established to measure Yokohl Creek flow at any location. A synthetic Yokohl Creek inflow, created by regression, suggests a long-term annual average inflow of 9 TAF. This amount was considered minor and within the margin of accuracy of the analysis. Second, the capacity of the Friant-Kern Canal was assumed at 5,000 cfs and all demands were assumed to be located downstream of the forebay. While it is recognized that Friant-Kern Canal capacity downstream of Kings River, upstream of the Yokohl Valley forebay, decreases from approximately 5,000 cfs to about 3,000 cfs, and that demands vary along the canal, the CALSIM model does not include this resolution. It is not known if Friant-Kern Canal capacity between Kings River and the forebay would limit the pump-storage operation; therefore, the results presented below should be considered in the upper range of potential new water supplies. If Friant-Kern Canal capacity would affect pump-back storage operations, the revised estimates would be lower. Pumping capacity to Yokohl Valley Reservoir was assumed at 2,000 cfs.

The new water supply from Yokohl Valley Reservoir would be similar, but generally lower, than similar reservoir sizes at Fine Gold Creek because of conveyance constraints in the Friant-Kern Canal and because the evaporation losses from Yokohl Valley Reservoir are higher. As indicated in Table 4-11, annual average new water supply from the 800 TAF option would approach 100 TAF/year, if Friant-Kern Canal restrictions associated with up-stream demands and conveyance capacity below the Kings River have no additional effect on the simulated operations.

TABLE 4-11
NEW WATER SUPPLY FROM YOKOHL VALLEY RESERVOIR

Storage (TAF)	New Water Supply Estimated in Single-Purpose Analysis (average TAF/year)		
	RF	WQ	WS
400	n/s	n/s	60
800	88	82	97

Key:
n/s not simulated
TAF – thousand acre-feet
RF – San Joaquin River restoration flow single-purpose analysis
WQ – San Joaquin River water quality single-purpose analysis
WS – water supply reliability single-purpose analysis

Energy Use and Generation

Preliminary energy estimates were made using CALSIM output for the restoration flow and water quality single-purpose analyses. In each case, a Yokohl Valley Reservoir with storage volume of 800 TAF was considered. CALSIM output included monthly diversions to the Friant-Kern Canal. For purposes of the energy analysis, Friant-Kern Canal demands downstream of the pump-back plant location were assumed equal to total diversions.

The analysis considered flows to be pumped into Yokohl Valley Reservoir from the Friant-Kern Canal, releases to be made from the Yokohl Valley Reservoir to the Friant-Kern Canal (available for generation), and water volumes and evaporation at the Yokohl Valley Reservoir. The water surface level at the Friant-Kern Canal was assumed to be constant at elevation 410. Water levels in Yokohl Valley Reservoir were calculated and heads required for pumping and those available for power generation were determined.

Assumptions were also made regarding pump-turbine and motor-generator efficiencies, submergence, minimum and maximum heads and flows for pumping and generating, and head losses in water passages. Preliminary estimates of the energy required for pumping and energy generated on an annual basis were made. No existing power generation facilities would be impacted. Energy generation and pumping requirements are summarized in Table 4-12.

New transmission line(s) would be required to serve the Yokohl Valley pumping and generation plants. These transmission lines would be connected to one or both of two major power lines, one located about 3 miles to the west and the other about 5 miles to the east. Additional study during Phase 2 will determine if existing lines have adequate capacity to serve new power facilities, and to ascertain the requirements for electrical control and protection. Additional study is needed to determine if existing lines have adequate capacity, alignments for new lines, and control, protection, interconnections, and protection requirements.

TABLE 4-12
YOKOHL VALLEY RESERVOIR POTENTIALENERGY GENERATION AND USE

Storage (TAF)	Operating Scenario	Potential Average Annual Energy Generation (GWh/year)	Potential Average Annual Pumping Energy (GWh/year)
800	WQ	80– 110	180– 220
	RF	80– 110	180– 220

Key:
GWh/year – gigawatt-hour per year
TAF – thousand acre-feet
RF – San Joaquin River restoration flow single-purpose analysis
WQ – San Joaquin River water quality single-purpose analysis

Estimated Costs

Costs for a 260-foot-high zoned earthfill dam and appurtenant facilities were updated from a study completed in 1975. Total costs were indexed to 2003 price levels, although unit prices were not revised. This approach was considered sufficient for initial review of storage options, but would not be adequate to support detailed comparison with other options under consideration. Following this approach, and applying provisions for mobilization, contingencies, and oversight, total costs are estimated at $350 million. This estimate does not include land acquisition costs or specific costs that would be associated with reservoir clearing, road construction or relocation, or any needed environmental mitigation.

Environmental Considerations

Most of the potentially inundated area in Yokohl Valley would be common grassland. With the exception of botanical and cultural resources, few adverse environmental impacts are anticipated to resources known at the site. Four special status plant species occur in the vicinity of the area, including *Tulare pseudobahia*, a State-listed endangered and Federally listed threatened species, and *Kaweah brodiaea*. Vernal pool spiny-sepaled button-celery grows in Yokohl Creek downstream from the contemplated dam site. The presence of ultrabasic and metagabbro rock makes serpentine-specific plants possible, although none are listed in the CNDDB. Impacts to wildlife would be likely low. No fish were observed in Yokohl Creek during a May 2002 field visit. No recreational resources would be affected.

Numerous cultural resources, including pictographs, native gathering and processing sites, trails, and homesteads, are known to be present and additional sites that have not yet recorded may be present. Inundation of archaeological sites (prehistoric or historic) can result in the loss of important scientific data. Construction of the Yokohl Creek Dam could potentially affect as many as 35 archaeological sites and possibly more. Two Traditional Cultural Places have been identified within the potential reservoir vicinity ("Paint Place" on Rocky Hill, and the steatite quarry near Lindsay Peak), and impacts to these may be of concern to Yokod Yokuts people. Further site investigations and research would be needed to evaluate the significance of environmental impacts and associated mitigation requirements for biological and cultural resources. Land use impacts would be relatively low, and would be associated with relocation of scattered residences.

GROUNDWATER STORAGE OPTIONS

The Friant Division supports conjunctive management of surface water and groundwater supplies in the Eastern San Joaquin Valley. Water deliveries under Class 2 contracts and Section 215 during wetter years reduce groundwater pumping and, in many locations, are used for groundwater recharge. In this manner, the eastern San Joaquin Valley groundwater basins are used for water storage.

During Phase 1, many stakeholders suggested that the potential to develop and operate additional groundwater storage facilities to meet the purposes of the feasibility study be considered. In response, an approach to identify potential groundwater storage and conjunctive management components of the Investigation was developed in coordination with the CALFED Integrated Storage Investigation (ISI) Conjunctive Management Program and with stakeholder input.

The approach began with identifying the theoretical potential for groundwater recharge to determine if groundwater storage was a measure that should be further considered. Analysis focused on estimating the amount of water that could be made available at Friant Dam for groundwater recharge if adequate recharge facilities were in place. The outcome of this evaluation suggested that groundwater storage may be possible to support Investigation purposes, but that specific actions and facilities had not been identified. The following sections describe the theoretical analysis of groundwater recharge potential and a process currently underway to identify projects and actions for consideration in the feasibility study.

Theoretical Analysis of Groundwater Recharge Opportunities

A series of theoretical analyses were conducted using data from the CALSIM benchmark simulation to identify the potential opportunity to recharge San Joaquin River water. Evaluations quantified the amount of water that could be recharged under a variety of assumed operational conditions. No specific facilities were assumed in this analysis.

The theoretical analyses were based on the assumption that flood releases from Millerton Lake in the benchmark simulation could be available for recharge if conveyance and recharge capacity were available. The analyses applied a series of assumptions that addressed varying levels of assumed recharge capacity and the ability of water users to accept additional water during wet periods. The analyses assumed two different approaches for operating Millerton Lake. The first assumed the continued application of existing rules for managing storage in Millerton Lake. A second analysis assumed a reoperation of Millerton Lake that would evacuate storage levels to the minimum canal outlet every year.

Assumed Water Available for Recharge

Water assumed available for recharge in the theoretical analyses was identified as releases to the San Joaquin River in excess of operational requirements (i.e., flood spills). These releases in the CALSIM benchmark model result after maximizing deliveries to Class 1 and Class 2 contracts, and Section 215 water.

Assumed Recharge Capacity

As mentioned previously, no specific new groundwater recharge or extraction facilities that would enable storage of San Joaquin River water have been identified for evaluation in the feasibility study. Therefore, the theoretical analyses considered a range of potentially available additional recharge capacities (expressed as flow rates) that could accept excess water when it is available. Analyses were performed over a wide range of potential instantaneous recharge rates, from zero to 7,000 cfs in increments of 1,000 cfs. It was assumed that recharge could occur through any combination of direct or in-lieu recharge.

Assumed Delivery Constraints

Two constraints related to the delivery of water for recharge were applied in the theoretical analyses. The first constraint relates to the available capacity at the headworks of the Friant-Kern and Madera canals. In the theoretical analysis, capacities of up to 5,000 cfs for the Friant-Kern Canal and 1,250 cfs for the Madera Canal were assumed. In cases where canal capacity constraints were applied, water would be available for recharge to the extent that headworks capacity is available. This constraint does not reflect reductions in canal capacity at locations down-canal from Friant Dam.

A second constraint on deliveries of water for additional recharge relates to the effect of wetness in the Tulare Lake Basin. Review of historical Friant Division operations shows that Friant-Kern Canal deliveries are reduced when water users in the Tulare Lake Basin can take advantage of high flows in the Kings, Kaweah, and Tule rivers. To reflect this condition, a Tulare Basin wetness index constraint was incorporated into the analyses. When this constraint is applied, deliveries for additional recharge would not be accepted when monthly flows in the Tule River exceed 45 TAF.

Assumed Millerton Lake Operations

Analyses were initially conducted assuming that current rules for managing storage in Millerton Lake would apply. Currently, operators seek to achieve minimum storage levels (canal outlets) at the end of September. Inflows from fall and winter rains are captured subject to requirements to maintain available space for flood control storage. In some years, actual end-of-year storage in September is higher than the canal outlet because of changes in inflow patterns or reductions in actual demand.

A second set of analyses was performed assuming a re-operation of Millerton Lake to increase deliveries to potential recharge sites. The reoperation assumed that water could be "predelivered" to recharge facilities in years when a spill would occur. This was accomplished by the use of "perfect foresight" to identify years in which spills would occur in future months. In cases when future spills would occur, the reoperation entailed moving as much water as possible to theoretical recharge facilities. In addition to the conveyance capacity, recharge capacity, and wetness assumptions described previously, two assumptions were made regarding the amount of water that could be diverted in the reoperation. First, the maximum diversion was limited to the amount that would spill in later months. Second, the reoperation was constrained by the amount of water that could be evacuated from active storage in Millerton Lake (above the canal outlets) or at a level that would assure the ability to divert to the canals in subsequent months. These constraints were applied to assure that reoperation did not simply reallocate existing water deliveries.

An alternative approach to reoperation could include "predelivery" of water in any year when storage is above some minimum level. This type of approach would likely result in a need to withdraw banked water to make up for reductions in direct deliveries. The feasibility study will evaluate banking operations that have defined facilities, operational objectives, and implementation guidelines if such options are developed with stakeholder input.

Findings from Theoretical Groundwater Recharge Analyses

Results from several theoretical analyses of groundwater recharge opportunities are displayed in Figure 4-19. The theoretical analyses were made using four combinations of the constraints described above. For each combination of constraints, an analysis was made using current Millerton Lake operational rules and with an assumed reoperation methodology, as describe above. Results show that additional groundwater recharge with the potential development of new groundwater storage facilities and reoperation of Millerton Lake ranges from zero to the available water supply in the San Joaquin River.

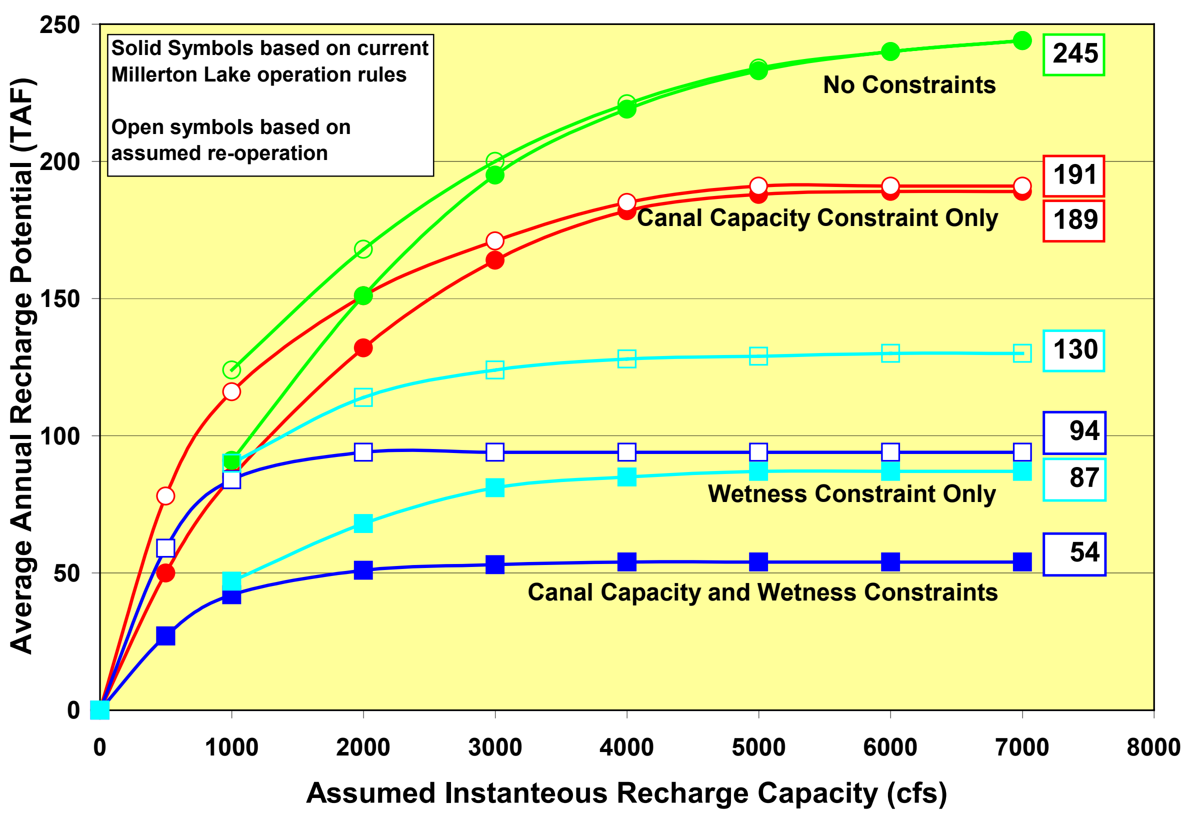


FIGURE 4-19. THEORETICAL GROUNDWATER RECHARGE ANALYSES

Releases or spills to the San Joaquin River at Friant Dam in excess of those required for downstream users vary considerably from year to year. On a long-term basis, the spills average approximately 245 TAF/year. This average amount reflects the maximum amount of additional water that could be developed from the San Joaquin River.

As shown in Figure 4-19, an unconstrained simulation (no limitations on conveyance capacity or wetness effects) suggests that up to 245 TAF/year could be stored in the groundwater basin if an additional recharge capacity of 7,000 cfs were available. When this approach is used with reoperation of Millerton Lake, the upper limit of recharge potential is not affected, but long-term average recharge amounts increase with the same installed recharge capacity.

Applying canal headwork capacity constraints would reduce the maximum potential recharge amount to about 190 TAF/year. Reoperation would produce similar effects, no increase in the upper limit, but higher recharge potential with the same installed recharge capacity. Application of the wetness constraint, without a limitation on canal capacity, results in considerably lower recharge opportunities. With no change in Millerton Lake operations, this analysis suggests a maximum recharge amount of 87 TAF/year with an additional installed recharge capacity of 4,000 cfs. If Millerton Lake were reoperated in this scenario, the total recharge opportunity could rise to about 130 TAF/year with an additional installed recharge capacity of 3,000 cfs. Lastly, an analysis that applies both canal capacity and basin wetness constraints shows that about 54 TAF/year could be recharged with developing 2,000 cfs additional recharge capacity. If Millerton Lake were reoperated in this manner, average annual recharge amounts could rise to 94 TAF/year with the development of about 2,000 cfs additional recharge capacity.

These results suggest that an opportunity to store additional San Joaquin River water may be possible with development of additional conjunctive management and potential reoperation of Millerton Lake. The ability for these approaches to support the purposes of the feasibility study, however, will depend on identifying specific facilities and operational objectives. The following sections describe an approach currently underway that is intended to identify specific locally controlled options that could increase the use of groundwater storage.

Conjunctive Management Options Formation

Similar to the approach used to evaluate surface storage options, conjunctive management options will be incorporated into the feasibility study to the extent that they can contribute to the purposes of the Investigation. Further, the identification and development of groundwater storage options will be consistent with the CALFED policy of supporting voluntary, locally controlled groundwater management projects that are designed to address local water needs first, before considering regional or statewide benefits. The focus will be to identify specific options, including policy actions and facilities that would result in additional conjunctive management of water from Millerton Lake in a manner that would contribute to the purposes of the Investigation.

Conjunctive Management Evaluation Approach

The evaluation approach for conjunctive management began with a review of potential constraints to conveying additional water from Millerton Lake. This evaluation indicated that capacity to transport water to groundwater storage locations along the Friant-Kern and Madera canals, and in the San Joaquin River downstream of Friant Dam, did not appear to be a significant limiting factor. Through coordination with the ISI Conjunctive Management Program, the study team identified stakeholders interested in expanding their conjunctive management operations. Various agencies were contacted to determine their interest in regional conjunctive management actions that could contribute to the purposes of the Investigation in a manner equivalent to adding surface storage at Friant. The agencies included CVP and non-CVP contractors that reflect a wide range of agricultural and M&I demands, accessibility to alternative surface water supplies, and underlying groundwater conditions.

As conjunctive management options are identified, they will be subject to screening criteria that recognize hydrologic, physical, institutional, and legal constraints. Institutional impediments will be identified that would need to be removed to allow the implementation of certain options. Operational assumptions, including the potential reoperation of Millerton Lake, will be identified with specific options.

The Friant Division of the CVP covers an area that can receive water from seven rivers, numerous local streams, and Delta exports from CVP and SWP facilities. Water supplies from sources other than the San Joaquin River could contribute to the same purposes as this Investigation, but would not be considered in the Investigation unless operated in a manner functionally equivalent to enlarging Millerton Lake. This approach is consistent with the approach used to identify potential surface storage options in other watersheds.

The following steps describe the identification and preliminary evaluation of conjunctive management options.

Step 1: Identify Potential Significance of, and Stakeholder Interest in, Regional Conjunctive Management Options.

This step is essentially complete. As described above, a potential for additional groundwater storage was identified through a series of theoretical analyses. On the basis on these results, conjunctive management as a measure to store San Joaquin River water was retained for further definition and consideration. In addition to the theoretical analyses, a set of stakeholders that would likely be involved in implementing conjunctive management actions was contacted to identify their degree of interest. The stakeholders were identified based on previous implementation of groundwater storage projects and an expressed interest in conjunctive management as identified by the CALFED ISI Conjunctive Management Program. The stakeholders indicated a high degree of interest in regional, cooperative opportunities for groundwater storage and banking. Through these interviews, however, no specific projects were identified that could be considered in the feasibility study and significant physical and legal constraints were identified that could limit opportunities.

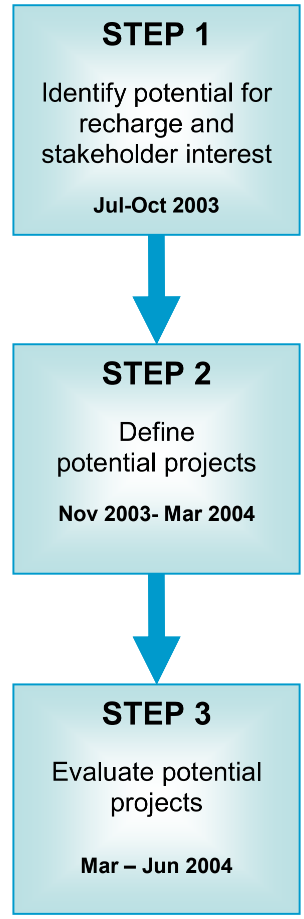
Step 2: Define Potential Conjunctive Management Options.

Inclusion of conjunctive management options cannot be limited to a theoretical evaluation. Step 1 of the process revealed an interest by stakeholders to participate in formulating conjunctive management options, but did not result in identifying specific actions that could be evaluated. To consider a conjunctive management option in the feasibility study, its components need to be described at a level of detail that enables comparison with other storage options. Consistent with the CALFED ROD, potential conjunctive management options will be locally initiated and managed. Because local project proponents must support any conjunctive management option, these details will be developed through a stakeholder coordination process.

Water agencies and organizations that have shown an interest in participating, and have the ability to implement conjunctive management actions, will assist in formulating conjunctive management options. This group will be tasked with identifying specific components, including water sources, operational assumptions, and conveyance, recharge, extraction, and distribution facilities. The group will also help identify institutional and legal constraints associated with developing and operating specific conjunctive management options.

Step 3: Evaluate Potential Conjunctive Management Options.

Potential options identified through stakeholder coordination will be evaluated in relation to hydrologic, physical, institutional, and legal criteria to identify those options that could contribute to the purposes of the Investigation, with or without additional surface water storage capacity. Four criteria will be considered, as described below.



Conjunctive Management Evaluation Approach

- ***Sources of Water***

Some conjunctive management options may be based on multiple water supplies, including Millerton Lake. The evaluation will consider portions of the options that would make water available at Millerton Lake to contribute to the purposes of the Investigation. The coincidence of water supplies from multiple sources, the ability of new facilities to accept delivery of Millerton floodwater during wet periods, and exchanges of Millerton water with other waters may be considered.

- ***Project Facilities***

The location of lands, recharge facilities, conveyance facilities, and extraction facilities will be defined, including hydrologic and geophysical groundwater basin characteristics. The level of detail will be consistent with estimates of surface storage facilities to enable meaningful comparison of options.

- ***Institutional Issues***

County ordinances, the need for new contracts with the Federal government, or the need to modify the terms of existing contracts for delivery of Class 1 and Class 2 water will be identified. Assumptions regarding the maintenance of long-term historical water deliveries will be clearly identified.

- ***Operational Assumptions***

Operational requirements will be described, including assumptions regarding seasonal or multiyear storage and withdrawal operations. Opportunities for predelivery of contract supplies and exchanges that can provide water to contribute to the purposes of the Investigation will be identified.

Specific operational criteria for each option will define the physical characteristics, operational assumptions, and quantity of water that could be stored in underground aquifers to contribute to the purposes of the Investigation. Options that can be implemented without developing additional surface water storage, and are not already included in the without-project future condition, will provide the basis for an alternative to new surface storage. Options that would rely on additional surface water storage capacity before a local entity is able to begin implementation will be included in surface storage alternatives.

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