CHAPTER 7. INITIAL ALTERNATIVES

This chapter describes components of initial alternatives that will be evaluated during the plan formulation stage of the Investigation. Initial alternatives will combine one or more storage measures with operations scenarios for the management and use of new water supplies. Because river restoration, river water quality, and exchange and conjunctive management actions have not been established, minimum accomplishments that each alternative must satisfy also have not yet been defined.

A two-step approach was used to screen surface water storage measures for inclusion in initial alternatives. The first step, described in **Chapter 6**, focused on characteristics of individual reservoir sites. The second step, described in this chapter, compares measures that provide similar amounts of new water supply based on construction cost, environmental impacts, hydropower facility impacts, and potential to develop replacement power generation capacity.

As plan formulation proceeds, it is anticipated that several restoration plans under development by others will be used to support the refinement, evaluation, and comparison of alternatives. Water quality operations evaluations made during plan formulation will provide information on the relationship between releases from Friant Dam to the San Joaquin River and downstream river water quality and guide the formulation of water quality operations objectives for each alternative. Operations approaches to support water quality exchanges with urban areas being developed by others will be used to the extent possible in formulating alternatives. Information on operational aspects to support additional conjunctive management actions will be developed as conjunctive management and groundwater storage measures are further refined.

The first section of this chapter compares surface storage measures retained from **Chapter 6** that provide similar accomplishments in developing new water supplies. Through this comparison, measures are either retained for inclusion in initial alternatives or dropped from further consideration in the Investigation. The second section of this chapter describes initial water operations components based on scenarios that address river restoration, river water quality and enhanced conjunctive management and exchanges. It concludes with results from the initial operations scenarios applied to one reservoir size.

COMPARISON OF SURFACE WATER STORAGE MEASURES

In **Chapter 6**, surface water storage measures were described and evaluated for each site retained from Phase 1 and for sites suggested during scoping. At several potential reservoir locations, multiple sizes and configurations were considered to address a range of dam designs, heights, and replacement power options. On the basis of these evaluations, some sites were dropped from further consideration, thereby reducing the range of sizes to be considered at each retained site. In most cases, the range of sizes to be evaluated at each site was reduced because of significant changes in impacts to environmental resources and hydropower generation. **Table 7-1** summarizes the results from step one of measures screening that was documented in **Chapter 6**.

TABLE 7-1.
SUMMARY OF SURFACE WATER STORAGE MEASURES SCREENING – STEP 1

Surface Water Storage Measure	New Storage Capacity (TAF)	New Water Supply (TAF/year)	Status Following Site Evaluations[1]	Key Findings from Site Evaluations
Raise Friant Dam				
25-foot Raise	130	24	Retained	A raise greater than 60 feet would result in extensive residential relocation, significant power generation losses, and environmental impacts around Millerton Lake, along the San Joaquin River, and in the Fine Gold Creek watershed.
60-foot Raise	340	68	Retained	
140-foot Raise	920	146	Dropped	
Temperance Flat RM 274				
Elevation 800	460	88	Retained	Measures larger than 1,310 TAF storage capacity were dropped because the small incremental new water supply would be associated with significant additional impacts to power generation and environmental resources, and higher construction costs.
Elevation 865	725	122	Retained	
Elevation 985	1,310	165	Retained	
Elevation 1,100	2,110	197	Dropped	
Temperance Flat RM 279				
Elevation 900	450	86	Retained	Measures larger than 1,350 TAF storage capacity were dropped because the small incremental new water supply would be associated with significant additional impacts to environmental resources and higher construction costs.
Elevation 985	725	122	Retained	
Elevation 1,115	1,350	168	Retained	
Elevation 1,200	1,910	188	Dropped	
Elevation 1,300	2,740	215	Dropped	
Temperance Flat RM 286				
Elevation 1,200	460	88	Retained	No measures ranging from 460 to 1,360 TAF were dropped because large changes in incremental cost or impacts to hydropower and environmental resources were not evident in the evaluation.
Elevation 1,275	725	122	Retained	
Elevation 1,400	1,360	169	Retained	
Fine Gold Reservoir Measures				
Elevation 900	120	17	Dropped	The 120 TAF measure was dropped because it has a significantly higher unit cost than larger sizes of Fine Gold Reservoir.
Elevation 1,020	400	65	Retained	
Elevation 1,110	800	113	Retained	
Yokohl Valley Reservoir				
Elevation 790	450	60	Dropped	Yokohl Valley Reservoir is the least cost-effective surface storage measure retained from Phase 1 due to operational constraints and conveyance limitations along the Friant-Kern Canal.
Elevation 860	800	97	Dropped	
Storage Measures Suggested During Scoping				
Granite Project	114	23	Dropped	No storage measures suggested during scoping were found cost-effective as water supply measures. Further consideration would require participation by a non-Federal sponsor with an interest in power development.
Jackass-Chiquito Project	180	37	Dropped	
RM 315 Reservoir	200	40	Dropped	
Fine Gold Reservoir Elevation 960[2]	230	80	Dropped	

Key:
elevation – elevation in feet above mean sea level
RM – river mile
TAF – thousand acre-feet
Notes:
[1] Status following evaluation of surface water storage measures at a specific reservoir site.
[2] Fine Gold Reservoir at elevation 960 (230 TAF capacity) was evaluated in combination with RM 315 Reservoir at 200 TAF capacity and a gravity diversion tunnel from Kerckhoff Lake.

Step two in the screening compares surface water storage measures retained from **Chapter 6** and further reduces the number of measures to be included in initial alternatives. The comparison uses information presented in **Chapter 6** for measures retained from the step one screening. Retained measures could provide average annual new water supply ranging from less than 30 TAF/year to more than 200 TAF/year. To facilitate site-by-site comparison, storage measures are grouped and compared based on water supply ranges of 0 to 50 TAF/year, 50 to 100 TAF/year, 100 to 150 TAF/year, and greater than 150 TAF/year. **Tables 7-2** through **7-4** present results from comparisons of measures providing similar new water supply. The comparison considers, construction cost, potential environmental impacts, effects to existing hydropower generation, and potential to develop replacement power generation capacity.

New Water Supply Range of 0 to 50 TAF/year

Several surface water storage measures considered in this report could provide up to 50 TAF/year of new water supply. These include raising Friant Dam up to 25 feet, Fine Gold Reservoir with a capacity of 120 TAF, and the three storage measures upstream of Redinger Lake suggested during scoping – RM 315 Reservoir, Granite Project, and Jackass-Chiquito Project. As concluded in **Chapter 6**, Fine Gold Reservoir with a capacity of 120 TAF and all three upstream options were dropped from further consideration because of cost and environmental issues. Therefore, only one storage measure that provides less than 50 TAF/year of new water supply, a 25-foot raise of Friant Dam, was retained for further consideration in the formulation of initial alternatives.

As described previously, specific restoration and water quality objectives have not been established; therefore, the quantity of additional water releases from Friant Dam to support restoration has not been quantified. Preliminary estimates of seepage to groundwater at Gravelly Ford, however, suggest that annual losses associated with seasonal or year-round releases from Friant Dam could range from about 35 to 70 TAF/year. Therefore, it is anticipated that storage measures providing less than 50 TAF/year of new water supply would not be formulated as stand-alone storage components of alternatives, and would have to be combined with other storage measures to develop alternatives.

New Water Supply Range of 50 to 100 TAF/year

All six surface water storage sites retained from Phase 1 could be configured at sizes that would provide 50 to 100 TAF/year of new water supply. As described in **Chapter 6** and shown in **Table 7-1**, five of these sites were retained for comparison in this chapter. Key characteristics of the five surface storage measures that would provide new water supply in the range of 50 to 100 TAF/year are listed in **Table 7-2.**

Two measures identified in **Table 7-2**, a 60-foot raise of Friant Dam and Fine Gold Reservoir with a capacity of 400 TAF, would provide approximately 65 TAF/year of new water supply. A 60-foot raise of Friant Dam would adversely affect existing hydropower generation and, with the inclusion of replacement power features, would result in a loss of energy generation of about 43 GWh/year. Raising Friant Dam 60 feet would require acquisition of dozens of developed residential parcels and several undeveloped parcels zoned for residential development around Millerton Lake, would submerge portions of the Millerton Lake Caves system, and would inundate significant portions of the Fine Gold Creek ADMA.

TABLE 7-2.
STORAGE MEASURES PROVIDING 50 TO 100 TAF/YEAR

		Raise Friant Dam 60 feet	Fine Gold Reservoir	Temperance Flat RM 274[1]	Temperance Flat RM 279[1, 2]		Temperance Flat RM 286[1, 2]	
Capacity and Water Supply	New Storage Capacity (TAF)	340	400	460	450		460	
	Gross Pool Elevation (feet above mean sea level)	638	1,020	800	900		1,200	
	Average New Water Supply (TAF/year)	68	65	88	86		88	
Environmental	Number of Potentially Impacted Regulated Species	24	10	24	24		36	
	Inundation of Aquatic Diversity Management Area	Partial	Yes	No	No		No	
	No. Buildings/Structures Inundated (other than hydropower facilities)	109	10	6	6		0	
	Total Inundated Acres[3]	1,400	3,400	2,200	2,300		3,200	
Power	Affected Hydropower Facilities							
	Kerckhoff (38 MW)	No	No	Yes	Yes		Yes	
	Kerckhoff No. 2 (155 MW)	Yes	No	Yes	Yes		Yes	
	Wishon (20 MW)	No	No	No	No		Yes	
	Big Creek No. 4 (100 MW)	No	No	No	No		Yes	
	Potential Replacement Power Facilities	New 90 MW K2 PH, Additional 13 MW capacity at Friant	N/A[5]	Up to 80 MW PH at RM 274 Dam, Up to 20 MW PH at Kerckhoff Dam	Up to 120 MW PH at RM 279 Dam	Up to 120 MW PH on ext. K2 tunnel, 15 MW PH at RM 279 Dam	Up to 160 MW PH at RM 286 Dam, Replace Wishon and BC4 PHs	Up to 180 MW New K2 PH, Replace Wishon and BC4 PHs
	Lost Generation (GWh/year)[4]	-473	N/E[6]	-507	-507	-507	-981	-981
	New Generation (GWh/year)[5]	430	N/E[6]	N/E	N/E	N/E	N/E	N/E
	Net Generation (GWh/year)	-43	N/E[6]	N/E	N/E	N/E	N/E	N/E
	Construction Cost ($ Million)[3,7]	600	470	800	670	800	710	870
Key Findings		**High residential and environmental impacts**	**No power impacts, small residential impacts**	**Highest cost for similar environmental impacts and water supply**	**Highest potential for replacement power**		**Greatest power and environmental impacts**	
Result from Comparative Screening		**DROPPED**	**RETAINED**	**DROPPED**	**RETAINED**		**DROPPED**	

Key:
BC4 - Big Creek No. 4 PH
GWh – gigawatt hour
K2 - Kerckhoff No. 2 PH
MW – megawatt
N/A – not applicable
N/E – not evaluated
PH – powerhouse
RM – River mile
TAF – Thousand acre-feet

Notes:
1 Replacement hydropower evaluations were not performed for RM 274, RM 279, or RM 286 with a capacity of about 450 TAF. Unit sizes and cost for replacement power facilities estimated from 725 TAF reservoir sizes for each site.
2 The two sets of replacement power facilities, power generation values, and cost values for the RM 279 and RM 286 measures represent two different power replacement options. See Chapter 6 for more details.
3 Cost and acreage values have been rounded to two significant figures.
4 Lost generation represents the estimated average future without-project generation at the affected power generation facilities.
5 New generation represents the average generation at the potential replacement power facilities.
6 Fine Gold Reservoir would not impact any existing power facilities. More energy would be required for the pump-back than would be generated by releases through a new powerhouse at the base of Fine Gold Dam.
7 All cost estimates are preliminary. Construction cost represents the sum of field costs and indirect costs for planning, engineering, design, and construction management, estimated at 25 percent of field costs. Costs do not include environmental mitigation, new or relocated recreation facilities, acquisition of impacted power facilities, or compensation for lost future power generation.

Fine Gold Reservoir with a storage capacity of about 400 TAF would not adversely affect existing hydropower generation, although it would require more energy for pumping than could be generated. Fine Gold Reservoir also would affect habitat in the Fine Gold Creek ADMA more significantly than a 60-foot raise of Friant Dam but would require acquisition of fewer developed properties. In consideration of these issues, a 60-foot raise of Friant Dam is dropped from further consideration and Fine Gold Reservoir at a capacity of about 400 TAF is retained for inclusion in initial alternatives.

Each of the three Temperance Flat measures with a storage capacity of about 460 TAF would provide approximately 85 TAF/year new water supply. Key distinctions between these measures relate to environmental impacts in areas upstream of Millerton Lake, impacts to existing power facilities, potential replacement power opportunities, and resulting project costs. Among the three measures, RM 286 would potentially affect the greatest number of regulated species and would have the most significant effect on existing hydropower generation. Although replacement power evaluations were not completed for the 460 TAF size configurations, it is expected that this measure would result in the greatest net loss of hydropower generation based on evaluations completed for larger sizes at these three sites. In comparison to the RM 274 and RM 279 sites, the RM 286 site with a capacity of 460 TAF would be more costly and more environmentally damaging, and therefore is dropped from further consideration.

The RM 274 and RM 279 sites with a capacity of about 460 TAF would result in similar environmental impacts. Both would inundate the reach of the San Joaquin River from Millerton Lake to Kerckhoff Dam, including the Millerton Lake Caves system, and RM 279 would create a deeper reservoir than RM 274. The RM 274 and RM 279 measures would both have similar adverse effects on hydropower generation; however, it may be possible to configure RM 279 to result in almost no net loss of generation (described later in this section, capacity of 725 TAF). RM 274 could not likely be configured to develop replacement power generation, would require dam construction in Millerton Lake and construction access through or near established residences around Millerton Lake, and would result in a reduction in the extent of Millerton Lake. On the basis of this comparison, RM 274 with a capacity of 460 TAF is dropped from further consideration, and RM 279 with a capacity of 450 TAF is retained for inclusion in initial alternatives.

It is anticipated that storage measures providing 50 to 100 TAF/year of new water supply would be combined with other storage or operational measures in formulating initial alternatives.

New Water Supply Range of 100 to 150 TAF/year

Five of the six storage sites retained from Phase 1 could be configured at sizes that would provide 100 to 150 TAF/year of new water supply. As described in **Chapter 6** and shown in **Table 7-1**, four of these sites were retained for comparison. Key characteristics of the four surface storage measures that would provide new water supply in the range of 100 to 150 TAF/year are listed in **Table 7-3.** All four measures identified in **Table 7-3**, Fine Gold Reservoir with a capacity of 800 TAF, and the three Temperance Flat measures each with a capacity of 725 TAF, would provide approximately 120 TAF/year new water supply.

TABLE 7-3.
STORAGE MEASURES PROVIDING 100 TO 150 TAF/YEAR

		Fine Gold Reservoir	Temperance Flat RM 274	Temperance Flat RM 279[1]		Temperance Flat RM 286[1]	
Capacity and Water Supply	New Storage Capacity (TAF)	800	725	725		725	
	Gross Pool Elevation (feet above mean sea level)	1,110	865	985		1,275	
	Average New Water Supply (TAF/year)	113	122	122		122	
Environmental	Number of Potentially Impacted Regulated Species	10	24	24		36	
	Inundation of Aquatic Diversity Management Area	Yes	No	No		No	
	No. Buildings/Structures Inundated (other than hydropower facilities)	10	6	6		0	
	Total Inundated Acres[2]	5,400	3,100	3,500		4,300	
Power	Affected Hydropower Facilities						
	Kerckhoff (38 MW)	No	Yes	Yes		Yes	
	Kerckhoff No. 2 (155 MW)	No	Yes	Yes		Yes	
	Wishon (20 MW)	No	No	No		Yes	
	Big Creek No. 4 (100 MW)	No	No	No		Yes	
	Potential Replacement Power Facilities	N/A[5]	80 MW PH at RM 274 Dam, 20 MW PH at Kerckhoff Dam	120 MW PH at RM 279 Dam	120 MW PH on ext. K2 tunnel, 15 MW PH at RM 279 Dam	160 MW PH at RM 286 Dam, Replace Wishon and BC4 PHs	New 180 MW K2 PH, Replace Wishon and BC4 PHs
	Lost Generation (GWh/year)[3]	-154[5]	-507	-507	-507	-981	-981
	New Generation (GWh/year)[4]	114[5]	332	386	484	729	859
	Net Generation (GWh/year)	-40[5]	-175	-121	-23	-252	-122
	Construction Cost ($ Million)[2,6]	640	890	870	1,000	790	980
Key Findings		**No impact to power generation**	**Greater power and environmental impacts than RM 279 site**	**Greatest potential to develop replacement power**		**Greatest power and environmental impacts of sites considered**	
Result from Comparative Screening		**RETAINED**	**DROPPED**	**RETAINED**		**DROPPED**	

Key:
BC4 - Big Creek No. 4 PH
GWh – gigawatt hour
K2 - Kerckhoff No. 2 PH
MW – megawatt
N/A – not applicable
PH – powerhouse
RM – River mile
TAF – Thousand acre-feet

Notes:

[1] The two sets of replacement power facilities, power generation values, and cost values for the RM 279 and RM 286 measures represent two different power replacement options. See Chapter 6 for more details.

[2] Cost and acreage values have been rounded to two significant figures.

[3] Lost generation represents the estimated average future without-project generation at the affected power generation facilities.

[4] New generation represents the average generation at the potential replacement power facilities.

[5] Fine Gold Reservoir would not impact any existing power facilities. More energy would be required for the pump-back than would be generated by releases through a new powerhouse at the base of Fine Gold Dam.

[6] All cost estimates are preliminary. Construction cost represents the sum of field costs and indirect costs for planning, engineering, design, and construction management, estimated at 25 percent of field costs. Costs do not include environmental mitigation, new or relocated recreation facilities, acquisition of impacted power facilities, or compensation for lost future power generation.

In general, costs for water storage and replacement power features would be similar at all sites but net energy generation would vary considerably. As described earlier, only the RM 279 site has the potential to develop full replacement power to offset losses to existing generation. Both RM 274 and RM 286 at 725 TAF storage capacity would result in net losses of hydropower generation in the upper San Joaquin River basin. Fine Gold Reservoir would not adversely affect the operation of hydropower facilities in the region but would require power for pumping. Energy requirements for Fine Gold Reservoir would be significantly less than the net losses associated with RM 274 or RM 286 for this storage capacity range.

Environmental impacts associated with RM 274 would be similar to, but more extensive than, those resulting from RM 279 at the 725 TAF storage capacity. Both measures would inundate the Millerton Lake Caves system in Temperance Flat. Environmental impacts for RM 286 are expected to be more varied and extensive than those associated with RM 274 or RM 279. A RM 286 reservoir would affect a Critical Aquatic Refuge and USFS Backbone Creek RNA near Horseshoe Bend, four powerhouses and require the relocation of Powerhouse Road and bridge. Fine Gold Reservoir would adversely affect the Fine Gold ADMA. Development of suitable nearby mitigation sites for this measure could present a challenge and needs to be considered as the Investigation proceeds.

In consideration of cost, environmental impacts, potential for replacement hydropower and net power generation, the RM 274 at 725 TAF and the RM 286 at 725 TAF measures are dropped from further consideration. The Fine Gold Reservoir at 800 TAF and the RM 279 at 725 TAF measures are retained for inclusion in initial alternatives.

It is anticipated these storage measures could be formulated as stand-alone alternatives or combined with other storage or operational measures to develop initial alternatives.

New Water Supply Range Greater than 150 TAF/year

Each of the three Temperance Flat reservoir sites retained from Phase 1 could be configured at sizes that would provide greater than 150 TAF/year of new water supply, although the costs, effects on hydropower generation, and environmental impacts would vary considerably between the sites. As described in **Chapter 6**, the largest sizes retained for each of the Temperance Flat sites range from 1,310 TAF to 1,360 TAF, generally because of adverse impacts to existing hydropower generation facilities. Key characteristics of the surface storage measures that would provide new water supply in this range are listed in **Table 7-4**, and discussed below.

Comparing the three Temperance Flat measures with storage capacities ranging from 1,310 TAF to 1,360 TAF shows that construction costs for storage and replacement power features for RM 279 significantly exceed costs for similarly sized RM 274 and RM 286 measures. Although net power loss would be lower for the RM 279 measure it is unlikely that the additional cost compared to the RM 274 measure would be justified by the difference in net power loss. The RM 279 site also would have the greatest environmental impacts of the measures considered for this storage capacity because it would affect all of the Temperance Flat and Millerton Bottoms and Patterson Bend reaches and portions of the Horseshoe Bend reach. The Temperance Flat and Millerton Bottoms reach of the San Joaquin River includes the Millerton Lake Caves system. The Horseshoe Bend reach of the San Joaquin River includes a Critical Aquatic Refuge and USFS Backbone Creek RNA. It also would require the abandonment and replacement of four powerhouses and the relocation of Powerhouse Road and bridge over Kerckhoff Lake.

TABLE 7-4.
STORAGE MEASURES PROVIDING GREATER THAN 150 TAF/YEAR

		Temperance Flat RM 274	Temperance Flat RM 279[1]		Temperance Flat RM 286[1]	
Capacity and Water Supply	New Storage Capacity (TAF)	1,310	1,350		1,360	
	Gross Pool Elevation (feet above mean sea level)	985	1,115		1,400	
	Average New Water Supply (TAF/year)	165	168		169	
Environmental	Total Regulated Species Potentially Impacted	24	36		36	
	Inundation of Aquatic Diversity Management Area	No	No		No	
	No. Buildings/Structures Inundated (other than hydropower facilities)	6	7		0	
	Total Inundated Acres[2]	5,000	5,500		6,300	
Power	Affected Hydropower Facilities					
	Kerckhoff (38 MW)	Yes	Yes		Yes	
	Kerckhoff No. 2 (155 MW)	Yes	Yes		Yes	
	Wishon (20 MW)	No	Yes		Yes	
	Big Creek No. 4 (100 MW)	No	Yes		Yes	
	Potential Replacement Power Facilities	100 MW PH at RM 274 Dam	120 MW PH at RM 279 Dam, Replace Wishon, and BC4 PHs	120 MW PH on ext. K2 tunnel, 15 MW PH at RM 279 Dam, Replace Wishon, and BC4 PHs	180 MW PH at RM 286 Dam, Replace Wishon PH	New 200 MW K2 PH, Replace Wishon PH
	Lost Generation (GWh/year)[3]	-507	-981	-981	-981	-981
	New Generation (GWh/year)[4]	291	840	933	655	794
	Net Generation (GWh/year)	-216	-141	-48	-326	-187
	Construction Cost ($ Million)[2,5]	1,000	1,400	1,600	980	1,200
Key Findings		**Least cost and lowest environmental impact**	**Highest cost and environmental impacts**		**Greater power and environmental impacts than RM 274 site**	
Result from Comparative Screening		**RETAINED**	**DROPPED**		**DROPPED**	

Key:
BC4 - Big Creek No. 4 PH
GWh – gigawatt hour
K2 - Kerckhoff No. 2 PH
MW – megawatt
PH – powerhouse
RM – River mile
TAF – Thousand acre-feet

Notes:
[1] The two sets of replacement power facilities, power generation values, and cost values for the RM 279 and RM 286 measures represent two different power replacement options. See Chapter 6 for more details.
[2] Cost and acreage values have been rounded to two significant figures.
[3] Lost generation represents the estimated average future without-project generation at the affected power generation facilities.
[4] New generation represents the average generation at the potential replacement power facilities.
[5] All cost estimates are preliminary. Construction cost represents the sum of field costs and indirect costs for planning, engineering, design, and construction management, estimated at 25 percent of field costs. Costs do not include environmental mitigation, new or relocated recreation facilities, acquisition of impacted power facilities, or compensation for lost future power generation.

In contrast, the RM 274 measure would affect the Patterson Bend reach of the San Joaquin River from Millerton Lake to Kerckhoff Dam, would affect two powerhouses, and would not affect the area around or upstream of Kerckhoff Lake. On the basis of this comparison, the RM 279 at 1,350 TAF measure is dropped from further consideration.

Further comparison of similarly sized RM 274 and RM 286 measures results in dropping the RM 286 measure with a capacity of 1,360 TAF because of environmental, cost, and replacement power considerations. The RM 286 measure at 1,360 TAF would affect the upper portion of Patterson Bend and the Horseshoe Bend reach to Redinger Dam, impacting four powerhouses and requiring the relocation of Powerhouse Road and bridge. The Horseshoe Bend reach of the San Joaquin River includes a Critical Aquatic Refuge and USFS Backbone Creek RNA.

Configurations at RM 286 would result in larger power losses or are more costly than similarly sized configurations at RM 274. For example, a configuration at RM 274 costing approximately $1 billion would result in a net power loss of about 216 GWh/year, whereas a configuration at RM 286 with similar cost ($980 million) would result in a significantly greater net power loss of about 326 GWh/year. The lowest net power loss configuration for the RM 286 measure, which results in a loss of 187 GWh/year would cost about $200 million more than the configuration at RM 274 that results in a net loss of 216 GW/year. It is unlikely that this difference in cost would be justified by such a small difference in additional power generation. On the basis of this comparison, the RM 286 measure with a capacity of 1,360 TAF is dropped from further consideration.

The RM 274 site with a storage capacity of about 1,310 TAF is the only measure retained in the water supply range greater than 150 TAF/year for inclusion in initial alternatives. It is anticipated that this measure could be considered as stand-alone alternative and may also be combined with other storage or operational measures to develop initial alternatives.

Surface Water Storage Measures Retained for Initial Alternatives

The two-step approach applied for screening surface water storage measures resulted in retaining six measures for inclusion initial alternatives. **Table 7-5** presents summary information about surface water storage measures retained for inclusion in initial alternatives. Retained surface storage measures range in size from 130 TAF (raise Friant Dam 25 feet) to about 1,310 TAF (Temperance Flat RM 274). These storage measures could provide average annual new water supply ranging from about 24 to 165 TAF/year and would have construction costs ranging from about $220 million to $1 billion. Construction costs are preliminary and do not include environmental mitigation, new or relocated recreation facilities, acquisition of impacted power facilities, or compensation for lost future power generation. As shown in **Table 7-5,** four retained surface water storage measures would affect the operation of existing hydropower facilities upstream of Millerton Lake.

TABLE 7-5.
SURFACE WATER STORAGE MEASURES IN INTIAL ALTERNATIVES

		Raise Friant Dam 25 feet	Fine Gold Reservoir		Temperance Flat RM 274	Temperance Flat RM 279[1]			
Capacity and Water Supply	New Storage Capacity (TAF)	130	400	800	1,310	450		725	
	Gross Pool Elevation (feet above mean sea level)	603	1,020	1,110	985	900		985	
	Average New Water Supply (TAF/year)[2]	24	65	113	165	86		122	
Environmental	Number of Potentially Impacted Regulated Species	24	10	10	24	24		24	
	Inundation of Aquatic Diversity Management Area	Yes	Yes	Yes	No	No		No	
	Total Inundated Acres[3]	870	3,400	5,400	5,000	2,300		3,500	
Power	Affected Hydropower Facilities								
	Kerckhoff (38 MW)	No	No	No	Yes	Yes		Yes	
	Kerckhoff No. 2 (155 MW)	Yes[4]	No	No	Yes	Yes		Yes	
	Wishon (20 MW)	No	No	No	No	No		No	
	Big Creek No. 4 (100 MW)	No	No	No	No	No		No	
	Potential Replacement Facilities	Additional 5 MW capacity at Friant	N/A[8]	N/A[8]	100 MW PH at RM 274 Dam	Up to 120 MW PH at RM 279 Dam[5]	Up to 120 MW PH on ext. K2 tunnel, 15 MW PH at RM 279 Dam[5]	120 MW PH at RM 279 Dam	120 MW PH on ext. K2 tunnel, 15 MW PH at RM 279 Dam
	Lost Generation (GWh/year)[6]	-32	N/E[8]	-154[8]	-507	-507	-507	-507	-507
	New Generation (GWh/year)[7]	32	N/E[8]	114[8]	291	N/E	N/E	386	484
	Net Generation (GWh/year)	0	N/E[8]	-40[8]	-216	N/E	N/E	-121	-23
	Construction Cost ($ Million)[3,9]	220	470	640	1,000	670	800	870	1,000

Key:

GWh – gigawatt hour
K2 - Kerckhoff No. 2 PH
MW – megawatt
N/A – not applicable
N/E – not evaluated
PH – powerhouse
RM – river mile
TAF – thousand acre-feet

Notes:

[1] The two sets of replacement power facilities, power generation values, and cost values for the RM 279 measures represent different replacement power options. See Chapter 6 for more details.

[2] New water supply is defined as the average annual supply that could be developed in excess of historic water deliveries from Friant Dam.

[3] Cost and acreage values have been rounded to two significant figures.

[4] Kerckhoff No. 2 powerhouse would remain operational with a 25-foot raise of Friant Dam. A concrete wall to protect K2 access would be constructed.

[5] Replacement hydropower evaluations were not performed for RM 279 with a capacity of 450 TAF. Unit sizes estimated from 725 TAF reservoir size.

[6] Lost generation represents the estimated average future without-project generation at the affected power generation facilities. For Fine Gold Reservoir, it represents energy to pump water from Millerton Lake.

[7] New generation represents the average generation at the potential replacement power facilities.

[8] Fine Gold Reservoir would not impact any existing power facilities. More energy would be required for pump-back than would be generated by releases through a new powerhouse at the base of Fine Gold Dam.

[9] All cost estimates are preliminary. Construction cost represents the sum of field costs and indirect costs for planning, engineering, design, and construction management, estimated at 25 percent of field costs. Costs do not include environmental mitigation, new or relocated recreation facilities, acquisition of impacted power facilities, or compensation for lost future power generation.

WATER OPERATIONS FOR INITIAL ALTERNATIVES

Implementing any of the storage measures and operating the new water supply for release to the San Joaquin River or diversion to the Friant-Kern and Madera canals could cause significant changes in water management in the San Joaquin Valley. Significant effects could result in Friant Division canal delivery, San Joaquin River flow and water quality, project operations on tributaries to the San Joaquin River, New Melones Reservoir operations, South-of-Delta CVP and SWP deliveries, and Delta and upstream system operations. This section describes an approach to developing operations scenarios for inclusion in the initial alternatives. Detailed descriptions of preliminary operations scenario development and application described in this section are presented in the **Water Operations TA**.

Approach and Methodology

Water operations evaluations began during Phase 1 and continued through preparation of the IAIR. Two distinct evaluations were completed. These included single-purpose analyses to estimate available new water supplies as presented in the Phase 1 Investigation Report, and the development of operations scenarios focused on water supply allocation and reservoir storage rules. New water supply is defined as the average annual supply that could be developed in excess of historic water deliveries from Friant Dam.

Phase 1 Single-Purpose Analyses

Phase 1 evaluations focused only on estimating the amount of new water that could be developed with surface water and groundwater storage measures. Several reservoir sizes were evaluated using a series of single-purpose analyses focused on releasing water to support restoration, improving water quality, or increasing water supply reliability in the Friant Division. Results from Phase 1 single-purpose analyses were used to identify the new water supply of storage measures described in **Chapter 6**. A significant limitation of Phase 1 modeling was the application of a constraint that maintained average annual canal deliveries the same as for the without-project condition for each year type. The use of the constraint limited the opportunity to manage water supplies in a manner that could support new demands in all years. Phase 1 modeling did not consider downstream effects of releasing water from additional storage.

Development of Operations Scenarios for Initial Alternatives

Water operations evaluations completed during the preparation of the IAIR focused on developing new criteria for managing existing and new water supplies to support Investigation objectives through the operation of additional storage. Operations scenario development began by identifying decision points associated with managing an enlarged or new reservoir. An operational screening tool was developed to evaluate preliminary scenarios and to test the effectiveness of changing operational variables, such as allocation and reservoir storage rules, to meet the objectives of the scenarios. A three-step process was established to develop operations scenarios for initial alternatives:

Step 1 – Allocate Water Supplies at Friant Dam and Mendota Pool

This step was completed with the development and application of an operations screening model. The screening model was developed using data and logic from CALSIM to assure consistency with accepted models. The screening model was used to evaluate the effect of several operational decisions before the decision criteria would be implemented in CALSIM. Alternative reservoir carryover targets were established to cause changes in the year-to-year delivery of new water supply to the canals or river. Water supply allocation variables were established to support supply-dependent decisions on the allocation of water to new project purposes, such as river releases for restoration or water quality.

The operations screening model includes features to allow simulation of alternative patterns of releasing new water supply to the river, alternative patterns of delivering new water supply to the canals, alternative storage allocations for flood control, and alternative bypass requirements (if any) for water reaching Mendota Pool. Each of these features can be modified in combination with or independently of other features, providing flexibility in the development and evaluation of alternatives. A set of water operations scenarios was developed and evaluated during development of the screening model, as described in later sections in this chapter.

Step 2 – Estimate San Joaquin River Water Quality Effects

The next step in formulating and evaluating operations scenarios for initial alternatives involves estimating the effect of new water supplies on water quality in the San Joaquin River and southern Delta. Technical studies are under way to refine the hydrologic and water quality characteristics of CALSIM in river reaches between Friant Dam and the Delta. This step was not completed during preparation of the IAIR.

Step 3 – Identify System-Wide Responses

Following completion of a refined water quality estimation approach, the CALSIM model will be used to identify the extent of effects that releasing water from Friant Dam could have on water project operations in the Central Valley. Water released from Friant Dam that reaches Mendota Pool coincident with demands would be treated as an additional supply and thereby reduce the need for water from the DMC. Additional supplies at Mendota Pool could result in an alteration of west side operations. As described above, changes in water quality or quantity in the San Joaquin River could affect New Melones Reservoir operations or other San Joaquin River tributary operations, which in turn could affect inflow to the Delta. Changes in Delta pumping in response to increased San Joaquin River flow or reduced demands could affect storage conditions in CVP and SWP reservoirs. System-wide effects of alternatives will be evaluated following completion of the San Joaquin River water quality estimation.

Initial Water Operations Scenarios

Operations scenarios were defined and evaluated during preparation of the IAIR to aid in developing evaluation tools and to guide further development and evaluation of initial alternatives. Several operations scenarios were developed to illustrate a range of potential allocation strategies for the water supply developed by new storage. The objectives in formulating initial scenarios was to illustrate water allocation and management decisions, identify assumptions needed to describe water demands (e.g., restoration requirements), demonstrate an approach for year-to-year management of water supplies (carryover), and illustrate interdependencies between water management decisions.

All operations scenarios were developed and evaluated using a common set of assumptions regarding existing institutional conditions. These include the current contract and allocation structure for Class 1, Class 2, and Section 215 supplies, existing flood control rules, and existing minimum downstream riparian and contractual requirements (116.7 TAF). For scenarios that would release new water supplies to the San Joaquin River, a methodology was developed to maintain existing long-term basin supplies. New water supply available for river release was identified by comparing long-term average canal deliveries with new storage to the without-project canal deliveries. This approach can shift water deliveries from year to year, but does not result in reallocating existing supplies from Friant water users. All operations scenarios assume 1,400 TAF additional storage at Millerton Lake.

Operations scenarios were grouped into two themes, as summarized in **Table 7-6**. Four scenarios were developed that would provide water supply for river uses and two scenarios were developed that would provide water supply for canal uses. Operations scenarios are described in the following sections.

TABLE 7-6.
INITIAL WATER OPERATIONS SCENARIOS

San Joaquin River Supply Scenarios	
Scenario 1	Allocate new supply for San Joaquin River restoration, with Mendota Pool diversions
Scenario 2	Allocate new supply for San Joaquin River restoration, with Mendota Pool bypass flow
Scenario 3	Allocate new supply for San Joaquin River restoration, constant annual allocation
Scenario 4	Allocate new supply to improve San Joaquin River water quality
Canal Supply Scenarios	
Scenario 5	Allocate new supply for canal delivery
Scenario 6	Allocate new supply for canal delivery emphasizing multiyear reliability

Scenario 1 – Allocate New Supply for River Restoration with Mendota Pool Diversions

This scenario would allocate new water supply for additional releases to the San Joaquin River in excess of those required for existing riparian and contractual uses. The approach used to allocate additional water supplies for river releases is shown in **Figure 7-1**. Similar to the approach used in Phase 1, the monthly pattern for releases of additional supply from Friant Dam was based on the natural flow distribution of the San Joaquin River at Friant. Alternative patterns for distribution of supplemental releases may be described in restoration plans developed by others.

The annual allocation in this scenario is based on total annual water supply available with no provision for carryover storage other than the current minimum operating level of 130 TAF in Millerton Lake. Supplemental releases to the river would be made in all years, increasing in volume as water supply increases in wetter years. This water supply allocation approach may not result in a reliable annual water supply to support restoration of the San Joaquin River because little or no new supply would be available in dry years.

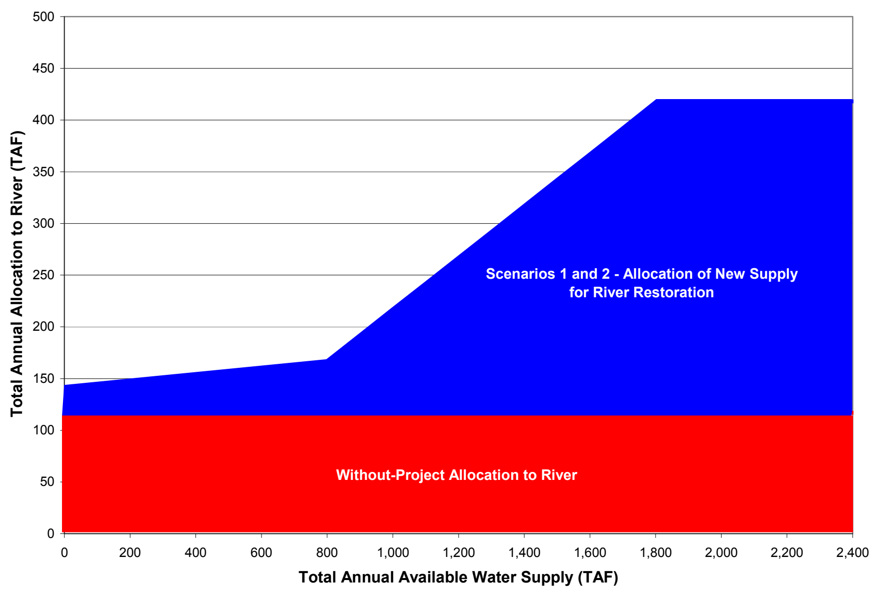

**FIGURE 7-1.
SCENARIOS 1 AND 2 ALLOCATION RULES**

In Scenario 1, supplemental releases made from Friant Dam to the San Joaquin River that reach Mendota Pool (after additional seepage losses) would be available for diversion at Mendota Pool. The screening model identifies the quantity of water that would be considered a new supply at Mendota Pool, thereby reducing the amount of water that would be delivered to Mendota Pool from the DMC. The effects to the remainder of the CVP or SWP were not evaluated, however any change that occurs would be considered an effect of releasing new supply from Friant Dam.

A model is being developed that will facilitate evaluation of changes to San Joaquin River water quality due to altering the source water to Mendota Pool. During the plan formulation stage, this tool will be applied and the potential benefits to water quality will be determined.

Scenario 2 – Allocate New Supply for River Restoration and Bypass Mendota Pool

Scenario 2 is a variation of Scenario 1, with only a change to the route of water downstream of Gravelly Ford. Similar to Scenario 1, supplemental water would be released to the San Joaquin River based on the water allocation and pattern assumptions described above, with no provision for carryover storage, other than the current minimum operating level of 130 TAF in Millerton Lake. In Scenario 2, it was assumed that the released water would not be available to offset deliveries from the DMC but would continue downstream of Mendota Pool. No site-specific assumptions were made regarding the manner in which water would flow past Mendota Pool and measures to allow bypass have not been considered.

Scenario 3 – Allocate New Supply for River Restoration with Constant Annual Allocation and Mendota Pool Diversions

In Scenario 3, a constant amount of new water supply would be released to the San Joaquin River each year. In the case of a 1,400 TAF reservoir, the long-term average new water supply would be about 175 TAF/year. To facilitate an annual supplemental water demand, a variable carryover storage target approach was used to assure that 175 TAF would be available for river release each year. The approach for allocating annual water supplies for river release for Scenario 3 is shown in **Figure 7-2** and the carryover storage target is shown in **Figure 7-3**. The use of carryover storage in Scenario 3 has the effect of reducing the average annual new water supply resulting from new storage, as compared to a scenario where all water supplies are allocated each year (Scenarios 1 and 2). Carried-over water would be available in dry years, thereby increasing dry year water supplies.

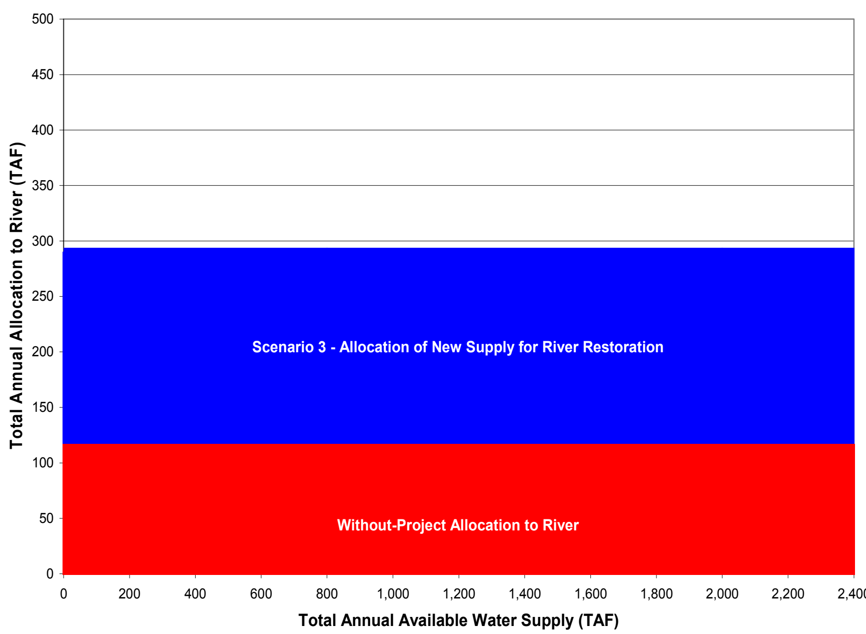

FIGURE 7-2.
SCENARIO 3 ALLOCATION RULES

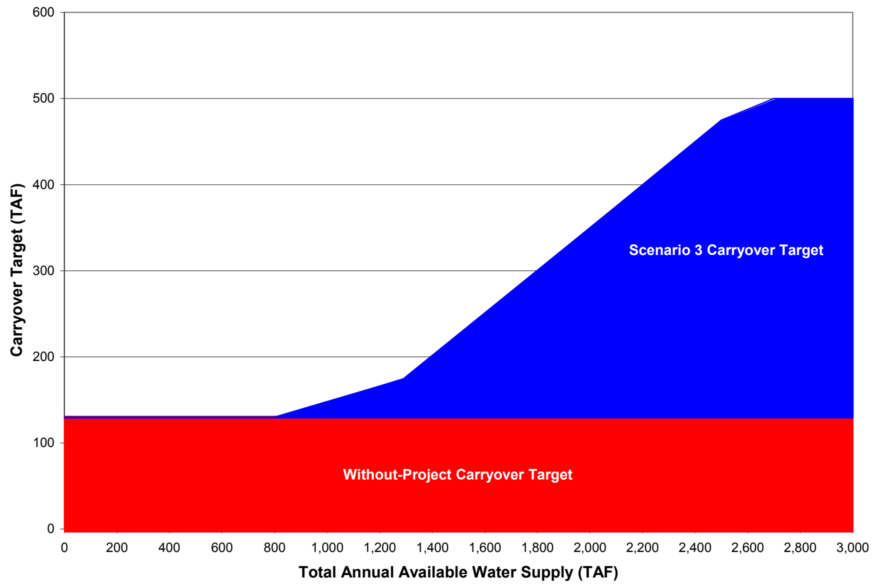

FIGURE 7-3.
SCENARIO 3 END-OF-SEPTEMBER CARRYOVER STORAGE TARGET

Scenario 4 – Allocate New Supply for River Water Quality Enhancement

Scenario 4 was developed to assess how water supplies from new storage could be released from Friant Dam specifically to improve San Joaquin River water quality. Carryover and allocation rules were used to emphasize the availability of new water supply in dry and below-normal years, when water quality problems are prevalent, as shown in **Figures 7-4** and **7-5**.

It should be noted that water quality responses have not been estimated because the model has not yet been developed. In dry years, water supply allocation for water quality would be low because of the limited availability of water supplies. A relatively low allocation in wet years was established based on an assumption that water quality problems are relatively minor in years when significant water supplies are available to the San Joaquin River from multiple tributary streams. By combining the allocation and carryover target rules, wet year water supplies are held in storage for use in subsequent years.

For this analysis, it is assumed that the monthly pattern of release of any volume of water quality allocation occurs evenly during the June through September period (irrigation pattern and presumed water quality concern season). This pattern may be revised as additional information is developed regarding water quality enhancement goals.

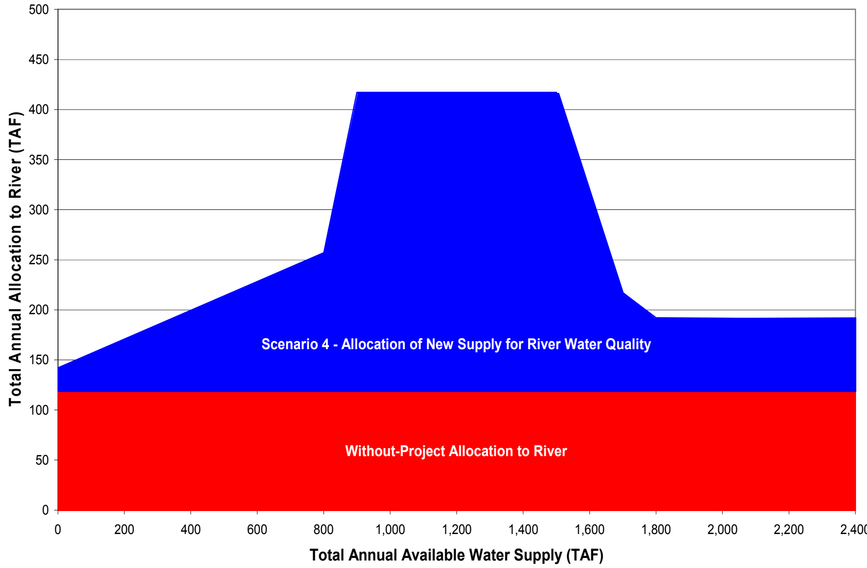

FIGURE 7-4.
SCENARIO 4 ALLOCATION RULES

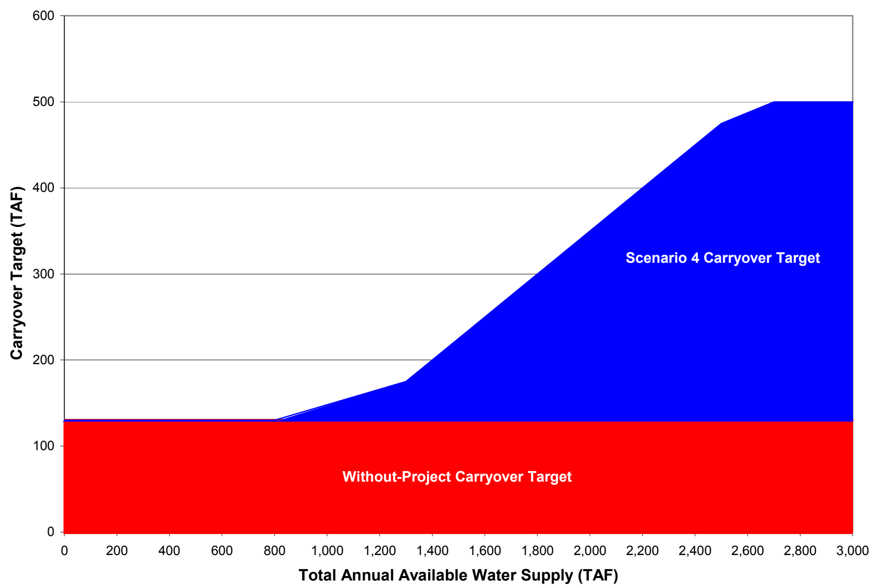

FIGURE 7-5.
SCENARIO 4 END-OF-SEPTEMBER CARRYOVER STORAGE TARGET

Scenario 5 – Allocate New Supply for Canal Delivery

This scenario represents an operation for which all new water supply would be allocated to the Friant-Kern and Madera canals similar to existing project operations, but with additional storage capacity. The existing annual water supply allocation procedure for Friant Dam is assumed, which establishes water deliveries based on the annual full drawdown of Millerton Lake. This operational objective would maximize the delivery of water supplies, only constrained by physical and contractual limitations inherent in current Friant contract deliveries.

Scenario 6 – Allocate New Supply for Canal Delivery Emphasizing Multiyear Reliability

This scenario represents a variation of Scenario 5 with all new water supplies allocated to the Friant-Kern and Madera canals, but managed to provide additional deliveries for longer duration, particularly during drier years. This is accomplished by applying a carryover storage target in the annual water delivery allocation procedure. **Figure 7-6** shows how the carryover storage target would be raised for this scenario as available water supplies increase. The use of carryover storage in this scenario would have a minimal effect on Class 1 deliveries during dry years because the carryover target was set to current minimum operating storage levels for years when the total available supply is less than 800 TAF.

During normal and wet years, additional water supply allocation would be less than in Scenario 5 because a portion of the water supply would be held in storage for use in subsequent years. Accordingly, the average annual new water supply resulting from new storage is less when carryover storage is in place, as compared to a scenario where all water supplies are allocated each year. The carried-over water would be available in dry years, thereby increasing dry year water supplies.

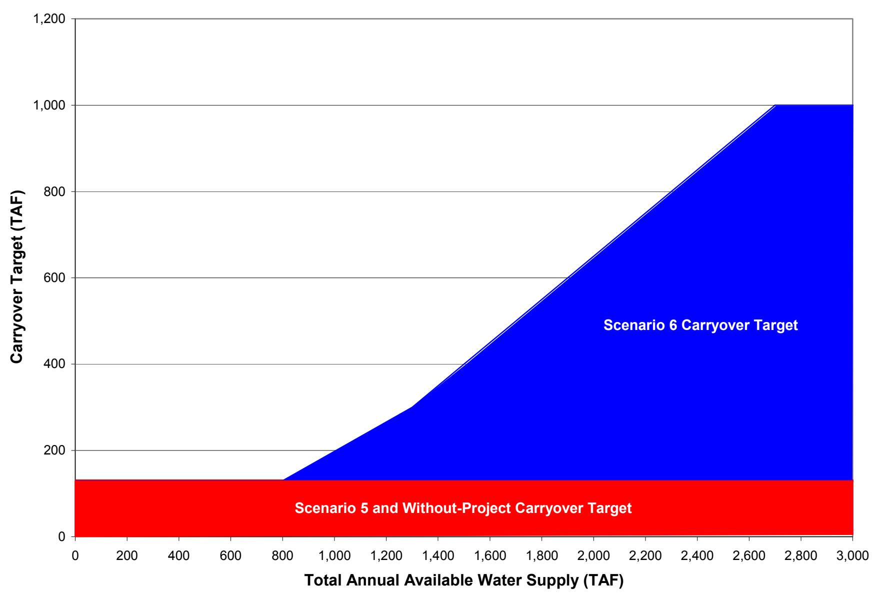

FIGURE 7-6.
SCENARIOS 5 AND 6 END-OF-SEPTEMBER CARRYOVER TARGETS

Results From Initial Operations Scenarios

The six operations scenarios described above were developed and evaluated using a screening tool based on the CALSIM model.. As the Investigation proceeds, the CALSIM model will be modified to include multiple purpose operations rules to support evaluation of the initial alternatives. Although the primary purpose of the analysis performed for the IAIR was identifying key decisions and assumptions to be included in the plan formulation stage of analysis, results also were derived. Preliminary results summarized in **Table 7-7.** provide a preview of the general magnitude of results that could be expected when alternatives are more thoroughly defined and analyzed.

Analyses and results presented in this section illustrate the range of water supply effects in relation to the different operational objectives represented in the scenarios. The initial operations scenarios and preliminary results are informational only and are not intended to represent the final set of operations rules or project accomplishments.

As described above, Scenarios 1 through 4 were designed to provide additional controlled releases to the San Joaquin River for restoration and water quality uses. Minor changes in canal diversions for these scenarios result from the modeling assumption to maintain average historical canal diversions, consistent with the planning constraint described in **Chapter 5**. These scenarios result in relatively minor differences in average river releases, but differ significantly in their ability to sustain releases over a series of years. Scenarios 3 and 4, which apply carryover rules to assure water supplies are available for release during dry years, result in lower average annual releases to the San Joaquin River than Scenarios 1 and 2, which do not include carryover provisions.

Scenario 5 results show that operating an additional 1,400 TAF of new storage under current water allocation rules could increase water deliveries by an average of about 165 TAF/year with a corresponding decrease in current flood control river releases. Comparing Scenarios 5 and 6 shows that increasing carryover storage in Millerton Lake would increase dry year water supplies but would reduce available active storage space, reduce the annual new water supply, and result in more flood control releases. For example, the average annual new water supply developed by Scenario 6, which includes carryover storage, would be about 25 percent lower than in Scenario 5 for a similar size reservoir but would provide more new water supply during dry years.

The six water operations scenarios will provide the basis for initial alternatives analysis as the Investigation proceeds. They will be applied to the retained storage measures, and will be modified as needed to evaluate the contribution of new storage to meeting specific restoration, water quality, or water supply reliability objectives, as plans developed through other studies become available.

TABLE 7-7.
PRELIMINARY RESULTS FROM INITIAL OPERATIONS SCENARIOS

	Operations Scenario[1] Difference from Without-Project Results (TAF)[2]					
	1	2	3	4	5	6
Operations Scenario Criteria						
Operating Objective	San Joaquin River Restoration			SJR Water Quality	Canal Delivery	
	Diversions at Mendota Pool	Flow Past Mendota Pool	Diversions at Mendota Pool	Diversions at Mendota Pool	Increase Annual Delivery	Increase Multiyear Reliability
Annual Water Supply Allocation	Variable		Constant	Variable		
Reservoir Carryover Storage Rule	Existing[3]		Proportional to Supply[4]		Existing[3]	Prop. to Supply[4]
Change in Friant Operations						
Total Canal Diversion	-1	-1	-1	0	+165	+128
Friant Class 1 Delivery[5]	-3	-3	-16	-12	+11	+34
Friant Class 2 Delivery[6]	+116	+116	+127	+119	+261	+187
Section 215 Delivery[7]	-114	-114	-112	-107	-107	-92
Friant Dedicated Release to SJR	+194	+194	+175	+161	0	0
Friant Spills to SJR	-198	-198	-183	-172	-174	-148
Total Friant Release to SJR	-4	-4	-8	-11	-174	-148
Change in San Joaquin River Flow and Operations						
SJR Flow to Mendota Pool	-44	-44	-51	-19	-162	-137
DMC Flow to Mendota Pool	-72	+45	-61	-97	+43	+39
SJR Flow Upstream from Merced River	-116	+1	-112	-117	-119	-98
Groundwater Recharge from Gravelly Ford to Merced River	Increase				Minor decrease from reduction in flood flow	
SJR Flood Flow at Vernalis	Decrease in all scenarios					
SJR Flow at Vernalis (non-flood periods)	No change	Potential increase	No change			
Effect on April/May SJR Flow w/o VAMP	Potential decrease	Potential decrease or increase	Potential decrease			

Key:
DMC – Delta-Mendota Canal
MP – Mendota Pool
SJR – San Joaquin River
TAF – thousand acre-feet
TDS – total dissolved solids
VAMP – Vernalis Adaptive Management Plan
w/o – without

Notes:

1 All operations scenarios assume existing contracts, existing flood control operations, existing Friant minimum downstream riparian and contractual requirements (116.7 TAF), no reallocation of existing supplies, and 1,400 TAF additional storage.

2 Results and scenarios are preliminary and will change in the future.

3 The existing end-of-September carryover target is 130 TAF.

4 End-of-September carryover target increases above existing target in proportion to supply when supply exceeds 800 TAF.

5 Class 1 contracts are based on a firm water supply and represent the first 800 TAF of annual water supply delivered. These contracts are generally assigned to M&I and agricultural water users who have limited access to good-quality groundwater.

6 Class 2 water is a supplemental supply and is delivered directly for agricultural use or for groundwater recharge, generally in areas that experience groundwater overdraft. Class 2 contractors typically have access to good-quality groundwater supplies and can use groundwater during periods of surface water deficiency.

7 Section 215 water is defined under Section 215 of the Reclamation Reform Act of 1982 as unstorable irrigation water to be released because of flood control criteria or unmanaged flood flows.