SECTION 6 - APPROACH FOR WATER MANAGEMENT ACTIONS ANALYSIS

6.1 Identification of Water Management Actions to Be Analyzed

A variety of potential water management actions have been identified and quantified by previous projects and studies, including the following:

- Least-Cost CVP Yield Increase Plan (Reclamation, 1995)
- The Delivery Impact of CVPIA (Reclamation, 2005)
- California Water Plan Update 2009 (DWR, 2009a)
- Common Assumptions Characterization and Quantification Effort (DWR, 2006)
- Central Valley Project Yield Feasibility Investigation Program Strategy Workshops (Reclamation, 2009)

For the CVP IRP, the project team reviewed these previous studies along with information available from other reports and ongoing local, State, and federal programs. Information and new ideas obtained from all of these sources were used to compile a comprehensive list of potential actions.

A prescreening process was applied to narrow the complete list of water manage-ment actions to a subset to be analyzed by the CVP IRP. Table 6-1 shows the selected systemwide and local water management actions that were analyzed for the CVP IRP report.

6.2 Analysis of Water Management Actions in CalLite

The CVP IRP CalLite model was applied to simulate these categories of potential water management actions by combining them into thematic portfolios consisting of several different types of actions. The primary purpose of the modeling was to quantify a reasonable range of the effects of uncertainties in future socioeconomic and climatic conditions on metrics of importance in the CVP Service Area. To accomplish these objectives efficiently, the CVP IRP CalLite model was designed to be a comprehensive but simplified representation of the CVP, SWP, and non-project water management systems. Therefore, the results presented in this report should not be viewed as fully representative of benefits that might be derived from the water management actions examined in this study. However, the results should provide useful insights into how robust individual actions and combina-tions of actions in the portfolios described below might be against a wide range of future socioeconomic and climatic uncertainties. For these reasons, the CVP IRP CalLite modeling included representations of both local and major systemwide water management actions including new conveyance in the Delta regulatory actions providing additional fishery and ecosystem protection through salinity and flow management; CALFED storage projects such as the Shasta Lake Water Resources Investigation (SLWRI), North-of-Delta Offstream Storage (NODOS), and increased South-of-Delta Storage; and ecosystem restoration projects.

The implementation of local water management actions such as increased water conservation, conjunctive management of groundwater, and other local projects were simulated in the CVP IRP CalLite model by adjusting the supply and demand in each CVP Division, which in turn modifies CVP or SWP deliveries in the Division and affects the Division's supply-demand balance. Implementation of systemwide water management actions was simulated by incorporating them into the CVP IRP CalLite representation of the CVP-SWP integrated system and simulating their operations along with the rest of the system. These actions allowed simulation of flow and storage changes throughout the CVP-SWP water system, and delivery changes to each CVP Division.

A graphical user interface was developed for CVP IRP CalLite model to allow users to control

Table 6-1. Water Management Actions Analyzed by the CVP IRP

Delta Actions	Surface and Groundwater Storage Actions	Local Actions
New Delta Conveyance Enhanced Environmental Flows	Shasta Enlargement North-of-Delta Offstream Storage South-of Delta Surface or Groundwater Storage	Urban Water Use Efficiency • Modest • Aggressive Municipal Recycled Water Desalination Agricultural Water Use Efficiency • Modest • Aggressive

which options to include in the simulations. By selecting various combinations of actions from a "dashboard" menu of available actions, users can specify the details of the parameters for a particular water management action. Example dashboards are shown on Figures 6-1 through 6-3.

6.3 Description of Water Management Actions

Brief descriptions of the assumptions used by the CVP IRP to analyze each water management action are provided below. It should be noted that the assumptions selected by the CVP IRP for each action are intended to be exploratory in nature, and do not reflect any particular proposed Reclamation policy or project. The assumptions for each action described below were implemented in CVP IRP CalLite when a particular action was included in any of the portfolios.

For the CVP IRP analyses, the local actions were implemented in a transient fashion, and all of the system actions were assumed to be implemented at the start of the simulation in 2011.

6.3.1 Local Actions

For the CVP IRP, local actions were implemented to simulate changes in demands within CVP Divisions. These demand-reduction actions included urban and agricultural water use efficiency improvements, and were implemented in the CVP IRP CalLite model as reductions in applied water demands within each CVP Division. Supply-enhancement actions consisting of municipal recycled water and/or desalination were implemented in the CVP IRP CalLite model as increased annual supplies within the CVP Division.

6.3.1.1 Urban and Agricultural Water Use Efficiency

Table 6-2 shows the assumed percent reductions in agricultural and urban applied water demands during the twenty-first century. In the CVP IRP study, these demand-reduction actions were applied uniformly to all CVP Divisions and represent additional demand reductions above the levels already included in the socioeconomic scenarios. The modest demand-reduction schedule assumed full implementation of a 20 percent reduction in urban applied water demand as well as a 5 percent reduction in agricultural applied water demand that would be achieved by 2020 and continue at the same level through 2100. The aggressive demand reduction includes these reductions plus additional water use efficiency measures to achieve a 40 percent reduction in urban demand and a 10 percent reduction in agricultural demand by 2050, and a 60 percent reduction in urban demand and a 15 percent reduction in agricultural demand by 2100. For all of these conservation actions, the changes were assumed to increase linearly between the years shown in the table.

6.3.1.2 Municipal Recycled Water and Desalination

Table 6-3 shows the assumed supply enhancements over time resulting from municipal

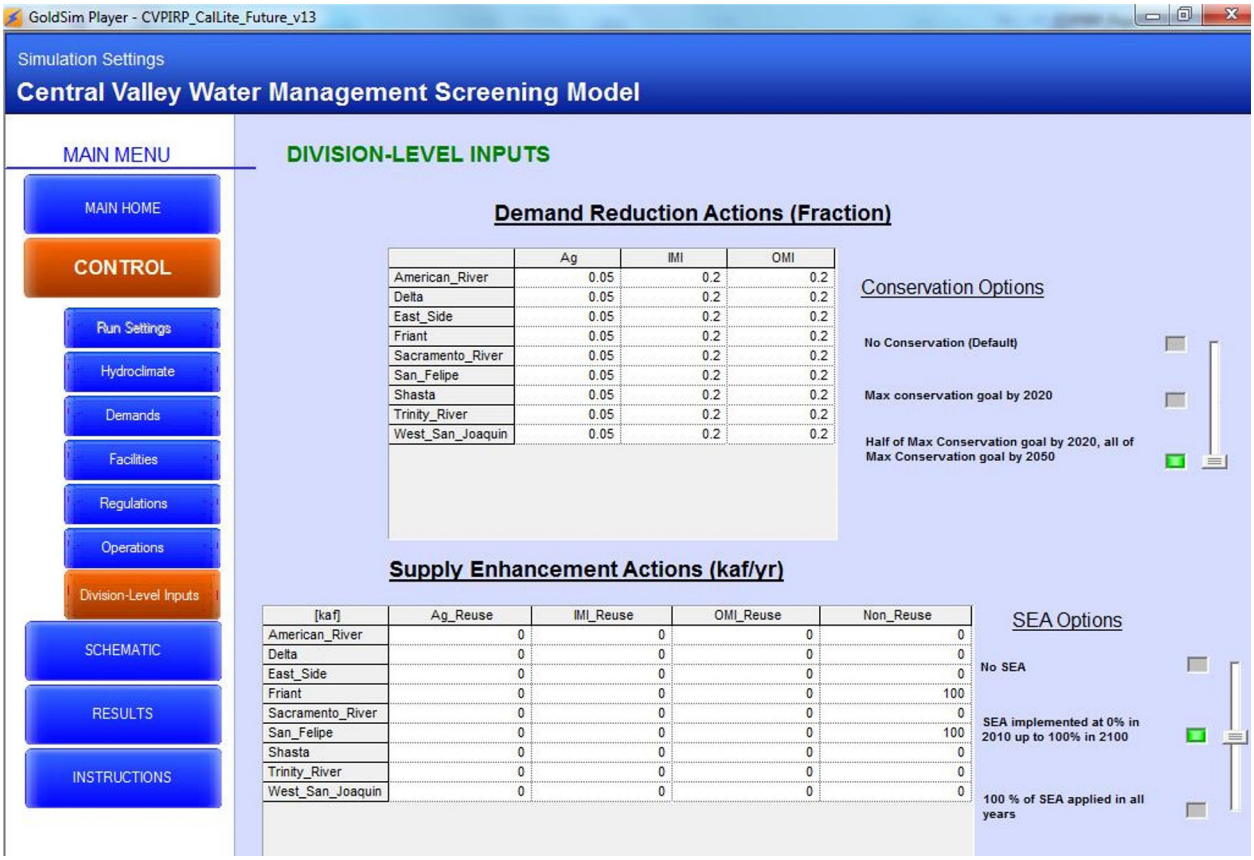

Figure 6-1. Example CalLite Dashboard for Specifying Local Water Management Actions

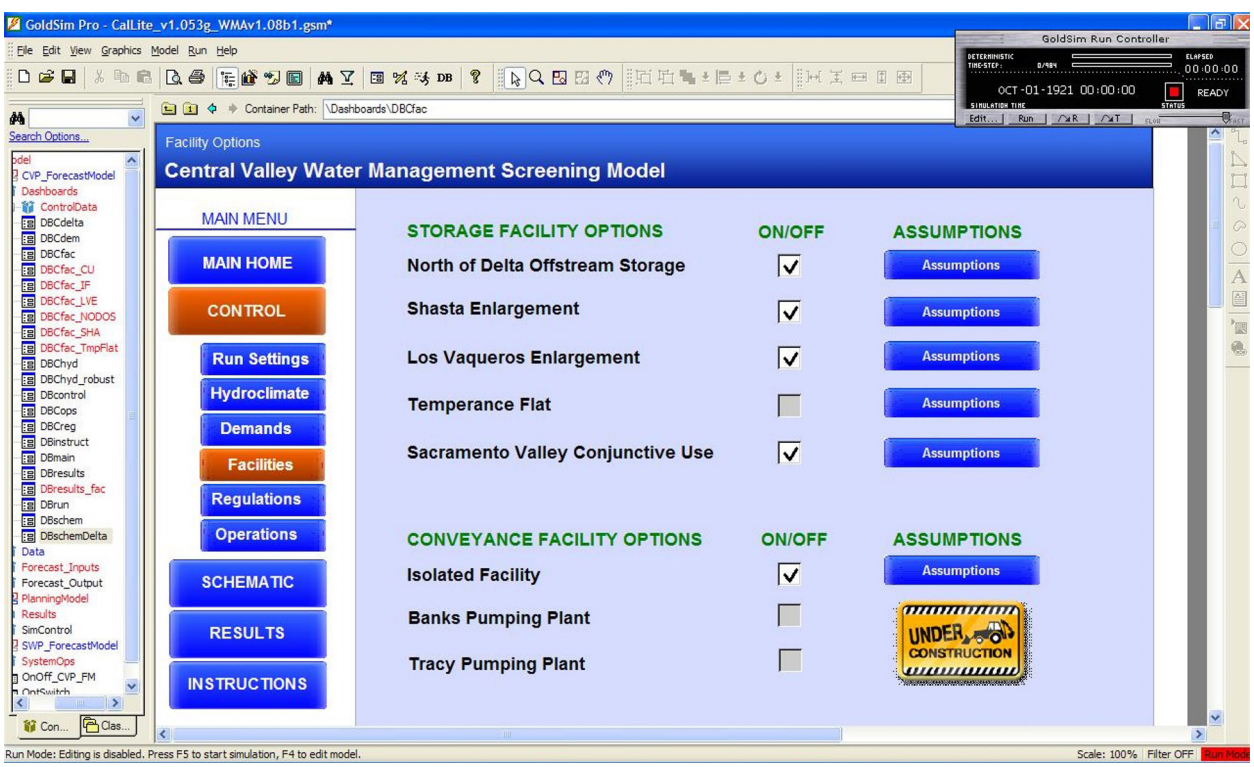

Figure 6-2. Example CalLite Dashboard for Triggering New Storage or Conveyance Facilities

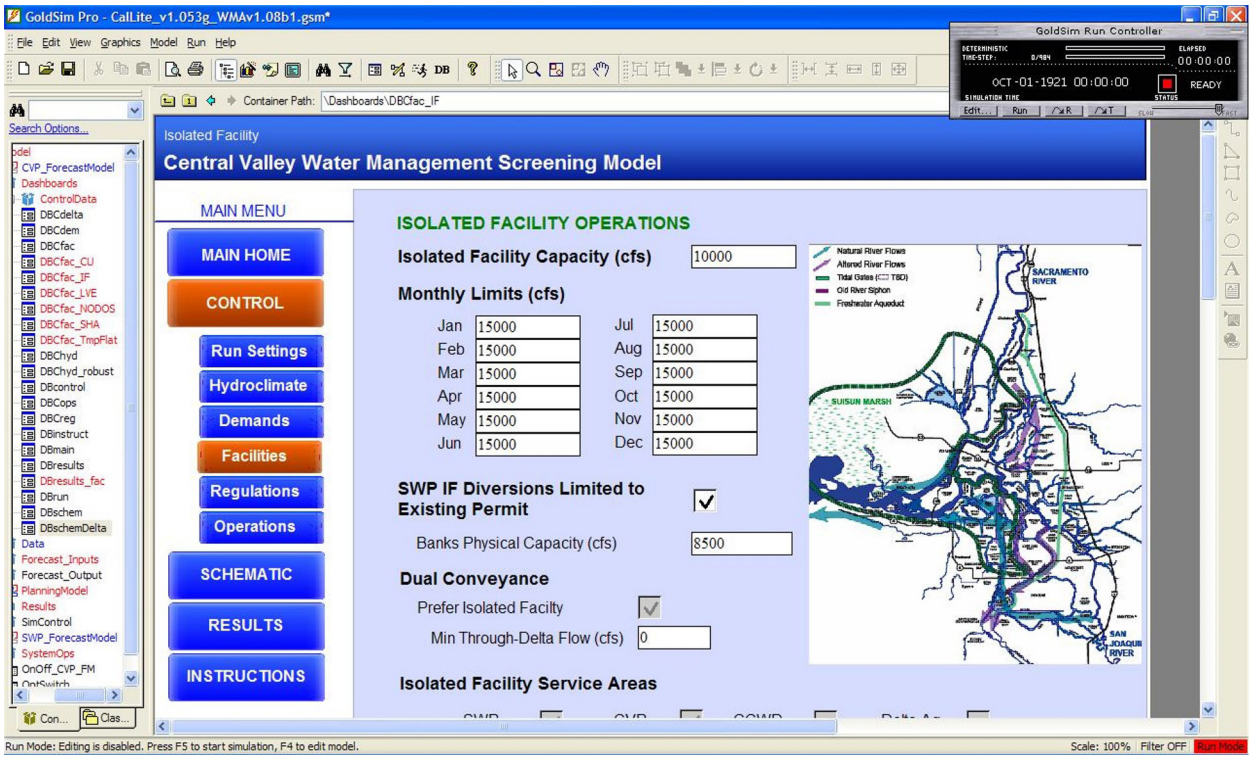

Figure 6-3. Example CalLite Dashboard for Specifying Storage and Conveyance Facility Assumptions (Isolated Facility Shown)

Table 6-2. Urban and Agricultural Water Use Efficiency Included in All CVP Divisions in the CVP IRP Portfolios

Action	Modest Demand Reduction (%)	Aggressive Demand Reduction (%)
Urban Water Use Efficiency		
2010	0	0
2020	20	20
2050	20	40
2100	20	60
Agricultural Water Use Efficiency		
2010	0	0
2020	5	5
2050	5	10
2100	5	15

Table 6-3. Municipal Recycling and Desalination Included in the Sacramento River and Friant Divisions in the CVP IRP Portfolios

Action	Sacramento River Division (TAF)	Friant Division (TAF)
Municipal Recycling		
2010	0	0
2100	65	100
Desalination		
2010	0	0
2100	35	0

recycling and desalination. For the CVP IRP study, these supply enhancements were applied only in the San Felipe and Friant Divisions because these are the only Divisions that have significant unmet urban demands in the Baseline. In the Sacramento River Division, 65 TAF of municipal recycling and 35 TAF of desalination were assumed to be implemented by 2100. In the Friant Division, 100 TAF of municipal recycling was assumed to be implemented by 2100. In both cases, linear increases were assumed between the years shown in the table.

6.3.2 New Delta Conveyance

The New Delta Conveyance option assumed the construction of a peripheral conveyance structure with an intake on the Sacramento River and an isolated connection at the CVP and SWP pumping facilities. Similar to studies currently being done under the BDCP, it is assumed that the new facilities would include positive-barrier fish screens on the Sacramento River near Hood or Clarksburg; a peripheral conveyance structure and associated conveyance facilities (such as pumps and siphons) that would traverse from the new intake facility along the Sacramento River along a southerly alignment adjacent to, and west of, Interstate 5; and terminal facilities that would allow discharge into the Clifton Court Forebay (CCF) with an intertie between CCF and C. W. Jones PP.

6.3.2.1 Options Available

The following options are available in the CVP IRP CalLite model:

- Diversion options: 0–15,000 cubic feet per second (cfs) (variable)
- Minimum South Delta pumping options: 0–15,000 cfs (variable)
- Bank PP capacity options: 8,500 cfs and 10,300 cfs (two options only)
- Bypass flow options: Controlled by Rio Vista flow requirements (user-specified)
- Beneficiary options: SWP and CVP (three options only: shared, SWP only, CVP only)

6.3.2.2 Options Used for CVP IRP Simulations

The CVP IRP simulations employed the following conveyance assumptions for all simulations in which Delta Conveyance was included:

- 9,000-cfs capacity Division facility at Hood
- No minimum South Delta pumping
- 10,300-cfs Banks PP capacity
- Bypass flow controlled by Rio Vista flow requirements
- Shared SWP and CVP beneficiaries

Note that these assumptions were developed solely for the purpose of the screening analysis performed for the CVP IRP study and do not reflect Reclamation policy regarding the BDCP program.

6.3.2.3 Schematic Representation

The schematic representation in CVP IRP CalLite involves a diversion at Hood and a tie-in at CCF. The general alignment studied under this action is shown on Figure 6-4.

6.3.2.4 Facility Operations

Many of the facility parameters were identified previously and were specified through the options available. However, some core functionality was

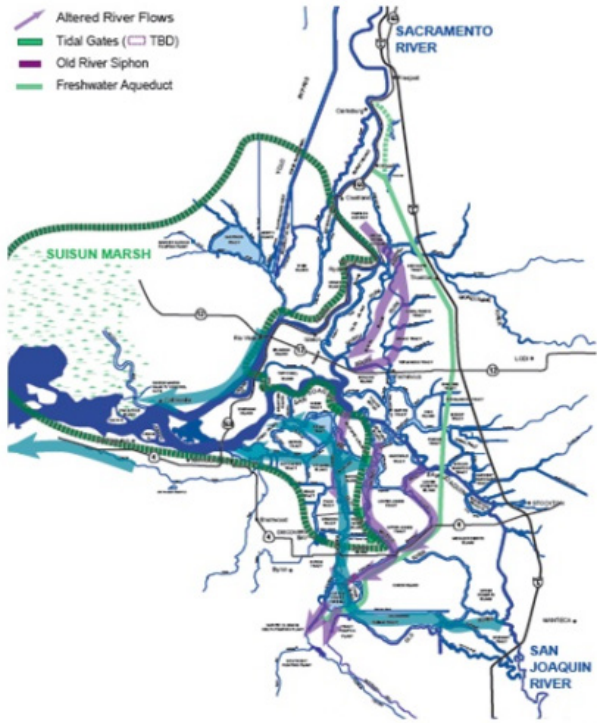

Figure 6-4. General Location of Delta Conveyance Features

incorporated in the CVP IRP CalLite model to effect proper operations when these options are selected. These core operations are listed below.

Isolated Facility Diversions

- Maximum available diversion is determined by considering both the maximum rates provided by the user and the flow upstream of the Delta Cross Channel needed for Rio Vista (with consideration of Delta Cross Channel gate position).
- Isolated facility (IF) diversions will always be preferred after satisfaction of minimum South Delta pumping.
- Available diversion capacity will be shared 50/50 between SWP and CVP (when this option is triggered), but actual diversions will be strictly governed by Coordinated Operations Agreement (COA) sharing

Banks and Tracy Exports

- Banks PP physical capacity will limit the IF diversion, not the permitted CCF diversion as currently permitted. User specifies the physical operating capacity at Banks PP as either 8,500 or 10,300 cfs.
- Salinity at CCF is a blend of Sacramento River quality at Hood (approximately 125 microSiemens per centimeter) and Old River at CCF quality (regression based on Old River at Rock Slough quality). Jones PP quality is a blend of the CCF quality and the quality of Old River at Tracy (regression based on Old River at Rock Slough quality).

6.3.2.5 Integration with SWP-CVP System

As implemented, the IF is considered an SWP-CVP project and is directly integrated into the COA and project operational decisions.

6.3.3 Enhanced Environmental Flows

The goal of the Enhanced Environmental Flows (EEF) option is to simulate actions intended to provide additional flows for environmental purposes by requiring additional upstream reservoir releases and operational changes to meet Delta outflow requirements designed to produce flows in the river system and in the Delta that are more similar to a natural hydrograph.

6.3.3.1 Available Options

The following options are available in the CVP IRP CalLite model:

- Unimpaired flows below Shasta Lake, Lake Oroville, and Folsom Lake can be applied as minimum instream flow requirements at these locations. These are defined as percentages of the inflows into each reservoir.
- A monthly Delta outflow requirement can be selected as a proportion of the unimpaired Delta outflow. The Delta outflow requirement defined by the user is met through reduced exports. Exports can be reduced down to health and safety limits (1,500 cfs). No reservoir releases are made to meet this requirement.
- Offramps can be applied to limit the required reservoir releases to meet the minimum instream requirements. These offramps are defined as step functions based on reservoir storage in each certain month.

6.3.3.2 Options Used for CVP IRP Simulations

For the CVP IRP study, all of the above available options were included in every simulation for which EEFs were implemented. The Delta outflow requirement was 60 percent of total unimpaired flow in each month from February through June. The assumptions for the other

options are described in the Facility Operations section below.

6.3.3.3 Facility Operations

If monthly unimpaired flows below Shasta, Oroville, and Folsom Lakes are selected, releases from these reservoirs from February through June are required to equal at least a specified percentage of that month's reservoir inflow in a given month. The required percentages used for the CVP IRP in each month are shown in Table 6-4.

Table 6-4. Percentage of Reservoir Inflow

Month	Release Percentage
February	40
March	100
April	100
May	60
June	40

If offramps on reservoir releases are selected, then the required releases to meet unimpaired flows are limited by offramp schedules for each reservoir. The schedules shown in Table 6-5 were used for in the CVP IRP simulations.

6.3.3.4 Integration with SWP-CVP System

The EEF releases are inherently integrated with the SWP-CVP system operations.

6.3.4 Lake Shasta Enlargement

The primary objectives of the alternatives identified in the SLWRI are to (1) increase survival of anadromous fish populations in the Sacramento River primarily upstream from the Red Bluff Diversion Dam; and (2) increase water supplies and water supply reliability for agricultural, M&I, and environmental purposes to help meet future water demands, with a focus on enlarging Shasta Dam and Reservoir.

The Shasta Dam enlargement alternatives available in CVP IRP CalLite include dam raises of 6.5 feet (256 TAF), 12.5 feet (443 TAF), and 18.5 feet (634 TAF).

6.3.4.1 Program Core Elements

The following core elements are included in the SLWRI program:

- Shasta Dam enlargement alternatives as described above
- Increased Shasta storage identified as a component of the CVP for water supply operation and Central Valley Project Improvement Act (CVPIA) (b)(2) accounting
- Use of increased storage for water supply operation allocated for use by the SWP to meet in-basin use requirements or Delta export needs of the SWP

The CVP IRP CalLite representation of SLWRI excludes CVPIA (b)(2) requirements because the model is currently constructed only for the State Water Resource Control Board Decision 1641 level of requirements.

6.3.4.2 Available Options

In the CVP IRP CalLite model, Shasta Lake enlargement alternative dam raises of 6.5 feet (256 TAF), 12.5 feet (443 TAF), and 18.5 feet (634 TAF) are available. The Banks PP capacity options (6,680 cfs and 8,500 cfs) included in SLWRI are not explicitly included in CVP IRP CalLite.

6.3.4.3 Options Used for CVP IRP Simulations

For the CVP IRP, an 18.5-foot dam raise was assumed in every simulation that includes the Enlarged Shasta action.

6.3.4.4 Schematic Representation

Unlike the additional storage element in the CALSIM II representation of Enlarged Shasta, the schematic representation in CVP IRP CalLite includes only a single reservoir with increased capacity.

6.3.4.5 Facility Operations

To effect proper operation of the enlarged reservoir, storage-area and storage-elevation curves were modified, and the target storage level was adjusted by the user-defined increased storage to make sure that the same flood control space is preserved in Enlarged Shasta reservoir. Once these modifications are activated, Shasta Reservoir functions as the original reservoir element, and the enlargement volume operates as an additional storage component of the CVP.

Table 6-5. Storage Offramps Schedules for Each Reservoir

Month	Cap 1	Storage 1	Cap 2	Storage 2	Cap 3
Reservoir Bypass Flow Caps (Shasta)					
February	15,000	2,800	9,125	2,400	3,250
March	15,000	3,000	9,125	2,600	3,250
April	15,000	3,200	9,125	2,800	3,250
May	15,000	3,000	9,125	2,600	3,250
June	15,000	2,800	9,125	2,400	3,250
Reservoir Bypass Flow Caps (Oroville)					
February	10,000	2,000	5,375	1,300	750
March	10,000	2,200	5,375	1,500	750
April	10,000	2,400	5,375	1,700	750
May	10,000	2,200	5,375	1,500	750
June	10,000	2,000	5,375	1,300	750
Reservoir Bypass Flow Caps (Folsom)					
February	3,000	350	1,900	250	800
March	3,000	400	1,900	300	800
April	3,000	450	1,900	350	800
May	3,000	400	1,900	300	800
June	3,000	350	1,900	250	800

Trinity import adjustments are also needed to re-balance the Trinity with the increase in Enlarged Shasta reservoir storage.

6.3.4.6 Integration with SWP-CVP System

The Shasta enlargement options were considered a component of the CVP storage and were directly integrated into COA, water supply indices, and other opera-tional decisions. The Water Supply Index – Delivery Index curves used in the CALSIM II simulations were incorporated into the CVP IRP CalLite model.

A portion of the increased water supply from Shasta Lake enlargement was considered for SWP to meet in-basin use requirements or Delta export needs of the SWP. Regardless of Shasta Lake storage condition, a maximum of 75 TAF is allocated to the SWP in critically dry years, and a maximum of 150 TAF is allocated to the SWP in dry years. These values are based on the Shasta Lake enlargement alternative dam raise of 18.5 feet (634 TAF). The annual cumulative releases from Shasta Lake during the year for SWP use are limited to the allocation assumed (from the total storage available under the alternative). However, only one-third of the allocation can be used in the month of June. Following June, only one-half of the remaining allocation can be used in the month of July. Following July, all of the remaining allocation can be used in any month between August and December.

6.3.4.7 Limitations

Limitations of the SLWRI implementation in CVP IRP CalLite include exclusion of CVPIA (b)(2) requirements to simplified model schematic.

The CVP IRP CalLite model representation of the SLWRI implementation varies significantly from the CALSIM II model representation. Rule curve and guide curves were adjusted in CVP IRP CalLite to tune the SLWRI operations in the CalLite simulations to be as similar as possible

to the operations observed in CALSIM II model simulations. However, because of differences in the baseline assumptions and differences in how the models implement assumptions and operations criteria, there are differences in the results among the models. Because the CALSIM II model has a more detailed representation of Enlarged Shasta and CVP operations, CALSIM II results are considered to be quantitatively more accurate. However, CVP IRP results do provide useful insights for understanding the potential impacts of socioeconomic and climate uncertainties on objectives addressed by Enlarged Shasta.

6.3.5 North-of-Delta Offstream Storage

The North-of-Delta Offstream Storage (NODOS) project is a proposed offstream storage facility that could be used to store water in wetter years and release water in drier years for increasing long-term beneficial use of water throughout regions supplied by the SWP and CVP. The specific alternative simulated in the CVP IRP study is the proposed Sites Reservoir, located 10 miles west of Maxwell, in northern Colusa and southern Glenn Counties. The alternative includes 1.81 MAF in new storage capacity and improvements to existing Tehama-Colusa (TC) Canal and Glenn-Colusa (GC) Canals, as well as a new Delevan Pipeline to divert flow from the Sacramento River in wetter periods and release stored water back to the river and local users. In addition to supplementing local water use in drier periods, NODOS has the potential to provide ecological benefits to the Sacramento River, ecological and water quality benefits to the Delta through outflow augmentation and water supply reliability benefits to local users, CVP-SWP water contractors, wildlife refuges, and hydropower benefits. In CVP IRP CalLite simulations, NODOS was also used to increase coldwater pool storage in Shasta Lake and to provide water supply reliability improvements for CVP-SWP contractors by increasing drier-year allocations for existing water supply contracts. Because of the simplifications included in the CVP IRP simulations, the results presented here do not represent the full range of benefits possible with NODOS. More detailed analysis is currently being prepared for the NODOS Feasibility Report. However, CVP IRP results provide useful insights for understanding the potential impacts of socioeconomic and climate uncertainties on objectives addressed by NODOS.

6.3.5.1 Program Core Elements

The CVP IRP NODOS simulations included the following core elements:

- Storage capacity of 1.81 MAF
- Diversion to NODOS through TC Canal (2,100-cfs capacity)
- Diversion to NODOS through GC Canal (1,800-cfs capacity)
- Diversion to NODOS from the Sacramento River through the New Pipeline (2,000-cfs capacity); releases to Sacramento River from NODOS through the New Pipeline (1,500-cfs capacity)
- Diversions to NODOS limited to Delta surplus conditions and flows in excess of the Sacramento River Navigation Control Point flow requirements
- Diversions to NODOS limited if resulting flow below GC Canal intake falls below a set level (default is 4,000 cfs)
- NODOS release to local water users only to meet irrigation needs with simultaneous reduction in TC and GC Canal diversions from the Sacramento River; by this method, NODOS releases result in additional flow in the Sacramento River due to reductions in diversion; this operation is limited to one-half of the local water users' irrigation needs (the portion of the TC Canal and Glenn-Colusa Irrigation District (GCID) service areas that are downstream of the Sites Reservoir project location)
- Dead pool storage of 120 TAF

6.3.5.2 Available Options

The following options are available in the CVP IRP CalLite model:

- Total NODOS storage capacity can range from a minimum of 120 TAF (dead storage) to a maximum of 3,000 TAF.
- Adjustable percentage of project share of NODOS storage capacity.
- New Pipeline capacity for use in diverting to NODOS can vary from a minimum of 0 cfs to a maximum of 2,000 cfs; release capacity from NODOS to the Sacramento River is assumed to be 75 percent of the New Pipeline capacity for diverting to NODOS.

- TC Canal capacity for use in diverting to NODOS can vary between 0 cfs and 2,100 cfs.
- GC Canal capacity for use in diverting to NODOS can range between 0 cfs and 1,800 cfs.
- Adjustable GCID minimum flow requirement for diversion to NODOS.

6.3.5.3 Options Used for CVP IRP Simulations

The following assumptions were used in the CVP IRP simulations of NODOS:

- Total NODOS storage capacity of 1,810 TAF
- 60 percent of active storage capacity for SWP use and 40 percent of active storage capacity for CVP use
- New Pipeline capacity of 2,000 cfs
- TC Canal capacity of 2,100 cfs
- GC Canal capacity of 1,800 cfs
- GCID minimum flow requirement of 4,000 cfs

6.3.5.4 Schematic Representation

Three major conveyances are used to divert water into NODOS from the Sacramento River. The TC Canal diverts water near Red Bluff. The GC Canal diverts water near Hamilton. The New Pipeline Canal both diverts and releases water to the Sacramento River several miles north of Maxwell (as shown on Figure 6-5).

The CVP IRP CalLite model schematic of NODOS differs somewhat from the general representation described above. Both TC and GC Canals originate from a node designated as "Red Bluff." They are treated, however, as separate canals and are operated by separate rules. The New Pipeline in CVP IRP CalLite connects with the Sacramento River at a node labeled as "Wilkins Slough." These simplifications were necessary because CVP IRP CalLite uses aggregated hydrology to represent the flow system.

6.3.5.5 Facility Operations

Many of the facility parameters were identified previously. However, some core functionality was also embedded in the model structure to effect proper operations. These operations are listed below.

NODOS Diversions

- Diversions to NODOS through TC and GC Canals take place during the months of November and March (this is a simplification of diversion criteria specific to the CVP IRP CalLite implementation).
- Diversion to NODOS through New Pipeline can take place year-round.

NODOS Storage Operations

- Sites Reservoir is simulated as two separate reservoirs (SWP and CVP components designated as "NODOS SWP" and "NODOS CVP," respectively).
- Equal fill priorities for both SWP and CVP.

NODOS Releases

- Release made to provide supply reliability to SWP and CVP.
- Equal release priority and capacity shared between SWP and CVP.

6.3.5.6 Integration with SWP-CVP System

NODOS was considered an SWP-CVP project and was directly integrated into COA and operational decisions. Shasta Lake coldwater pool storage enhancement was simulated as a preferred use of the CVP share of NODOS.

CVP IRP CalLite allows users to adjust criteria that govern when NODOS provides flows to support the SWP and/or the CVP systemwide operations, as follows:

- NODOS releases for SWP use were triggered on the basis of Lake Oroville storage between 0 TAF and 3,558 TAF (maximum Oroville capacity).
- NODOS releases for CVP use are triggered on the basis of Shasta Lake storage between 0 TAF and 4,552 TAF (maximum Shasta capacity).

6.3.5.7 Limitations

Limitations of the NODOS implementation in CVP IRP CalLite include the following:

- Simplified model schematic compared to CALSIM II especially with respect to Colusa Basin hydrology.

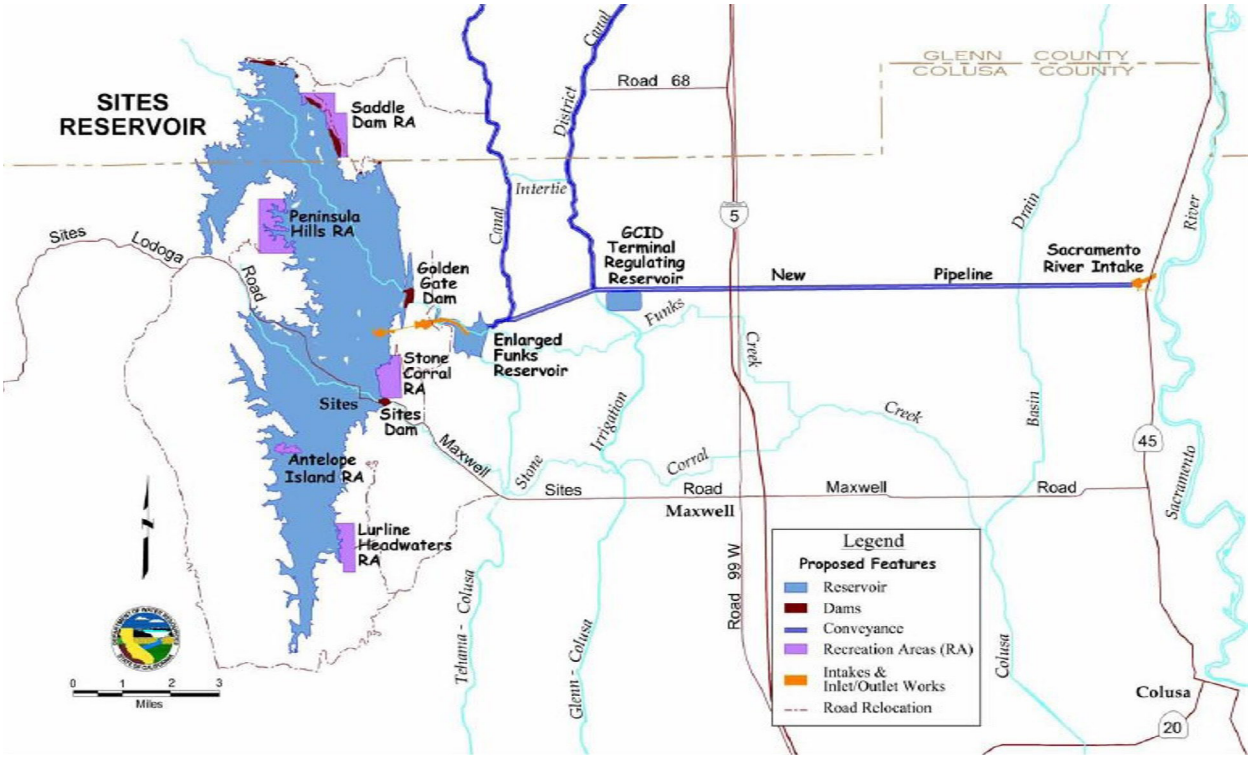

Figure 6-5. General Location of NODOS Program Features

- Simplification of daily excess flows for diversion to NODOS.
- CVP IRP CalLite does not include criteria to provide for the full range of benefits described used in analyses performed for the NODOS Program.
- NODOS releases for SWP and CVP releases are based on Lake Oroville and Shasta Lake storages, and do not account for a much more complex system of checks and balances to manage storage in Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake in concert with NODOS operations.
- CVP IRP CalLite rule and guide curves are adjusted to reflect CALSIM II model simulations, but because of differences in the baseline assumptions, differences in the model results occur.

The CVP IRP CalLite model representation and operation of NODOS varies significantly from the CALSIM II model representation. Because the CALSIM II model has a more detailed representation of NODOS and CVP-SWP operations, CALSIM II results are considered to be quantitatively more accurate. However, CVP IRP results provide useful insights for understanding the potential impacts of socioeconomic and climate uncertainties on objectives addressed by NODOS.

6.3.6 South-of-Delta Storage

The CVP IRP simulation South-of-Delta Storage action employs a hypothetical reservoir to represent options including additional surface storage, groundwater storage, or conjunctive use management opportunities within the South-of-Delta CVP Service Areas. This additional storage is simulated as an addition to the existing San Luis Reservoir in CVP IRP CalLite. It is assumed that export water would only fill the new South-of-Delta storage after existing SWP-CVP San Luis accounts were full, and that water would be released from this South-of-Delta storage prior to releasing storage from existing San Luis Reservoir accounts. This “last in, first out” principle was implemented to have the operation be additional to the current reservoir operations.

6.3.6.1 Available Options

The following options are available in the CVP IRP CalLite model:

- Size of the additional storage to both the CVP and SWP portion of the San Luis Reservoir can be specified by the user.
- Similarly, the user can also define the dead pool and initial storage conditions for both CVP and SWP separately.

6.3.6.2 Options Used for CVP IRP Simulations

For all simulations in which new South-of-Delta storage was included, it was assumed that the additional storage would be as large as the existing San Luis Reservoir, with the same CVP/SWP ratio as the existing reservoir, and with the same dead pool and initial storage conditions. Therefore, the maximum simulated storage capacities were 1,067 TAF for the SWP portion and 972 TAF for the CVP portion of the South-of-Delta storage reservoir.

6.3.6.3 Schematic Representation

There is no change in schematic due to this option because it is an addition to the existing San Luis Reservoir representation.

6.3.6.4 Facility Operations

Additional South-of-Delta storage was modeled as an addition to the existing San Luis Reservoir that fills after the existing San Luis Reservoir has been filled. In addition, the South-of-Delta releases are made before releases from the existing San Luis Reservoir.

6.3.6.5 Integration with SWP-CVP System

The new South-of-Delta storage was integrated with the current CVP-SWP operations in the CVP IRP simulations.

SECTION 7 - RESULTS OF WATER MANAGEMENT ACTIONS ANALYSIS

The CVP IRP's approach for analysis of water management actions explored combinations of potential water management actions grouped into portfolios designed to achieve particular objectives. These portfolios were designed around different themes, and analyzed by simulating each one with the same suite of 18 socioeconomic-climate scenarios used in the previous Baseline analysis. With the exception of Portfolio B, each portfolio was implemented using a preference hierarchy in which potential water management actions were added to the portfolio one by one to analyze the incremental effects of each action. In Portfolio B, the two surface storage projects were implemented separately to investigate the effects of implementing each one.

The following five portfolios of water management actions were analyzed using the CVP IRP modeling tools:

- Portfolio A: Aggressive Local Actions
- Portfolio B: North-of-Delta Surface Storage
- Portfolio C: Delta Conveyance and North-of-Delta Storage
- Portfolio D: Delta Conveyance and South-of-Delta Storage
- Portfolio E: Aggressive Local Actions, Enhanced Environmental Flows, and North-of-Delta Storage

The sections below describe the results of each portfolio of actions. The metrics shown are similar to those used for the Baseline analysis. To give an overview of the range of results associated with the different socioeconomic-climate scenarios, average annual results are shown for all 18 socioeconomic-climate scenarios for the CVP Service Area and each Division. Time-series and exceedance plots from CVP IRP CalLite and the other performance assessment tools are only shown for the CVP Service Area with the following three scenarios, selected to reflect a reasonable range of potential futures uncertainties:

- Current Trends with median temperature change and median precipitation future climate (CT-Q5)
- Expansive Growth with higher temperature change and lower precipitation future climate (EG-Q2)
- Slow Growth with lower temperature change and higher precipitation future climate (SG-Q4)

The assumptions and results of each portfolio are described in the following sections.

7.1 Portfolio A: Aggressive Local Actions

The Aggressive Local Actions portfolio was designed to investigate potential improvements in supply reliability through local water management actions. Three separate actions were analyzed in sequential steps in which subsequent actions were added while maintaining the previous ones in the following order:

1. Modest agricultural and urban conservation
2. Municipal recycling and desalination
3. Aggressive agricultural and urban conservation

Table 7-1 shows the assumptions that are included in each simulation suite.

7.1.1 Supplies and Demands in CVP Divisions

Figure 7-1 shows the average reduction in unmet demand over the twenty-first century in the CVP Service Area for each of the Portfolio A suites in each scenario. Figures 7-2 through 7-10 show the same information for each CVP Division. The reductions in unmet demand in the CVP Service Area ranged from 297–814 TAF/year (8 to 16 percent of Baseline unmet demands) with the modest conservation A1 actions, with a modest increase to 316–911 TAF/year (8 to 18 percent of Baseline unmet demands) with the addition of

Table 7-1. Simulation Suites and Assumptions Included in Portfolio A

Assumption	Simulation Suite A1	Simulation Suite A2	Simulation Suite A3
Baseline Assumptions	x	x	x
Local Actions			
Modest Ag and M&I Conservation	x	x	x
Municipal Recycling and Desalination		x	x
Aggressive Ag and M&I Conservation			x
Systemwide Actions			
Delta Conveyance			
Shasta Lake Enlargement			
North-of-Delta Offstream Storage			
South-of-Delta SW or GW Storage			
Enhanced Environmental Flows			

Notes:

GW = groundwater
SW = surface water

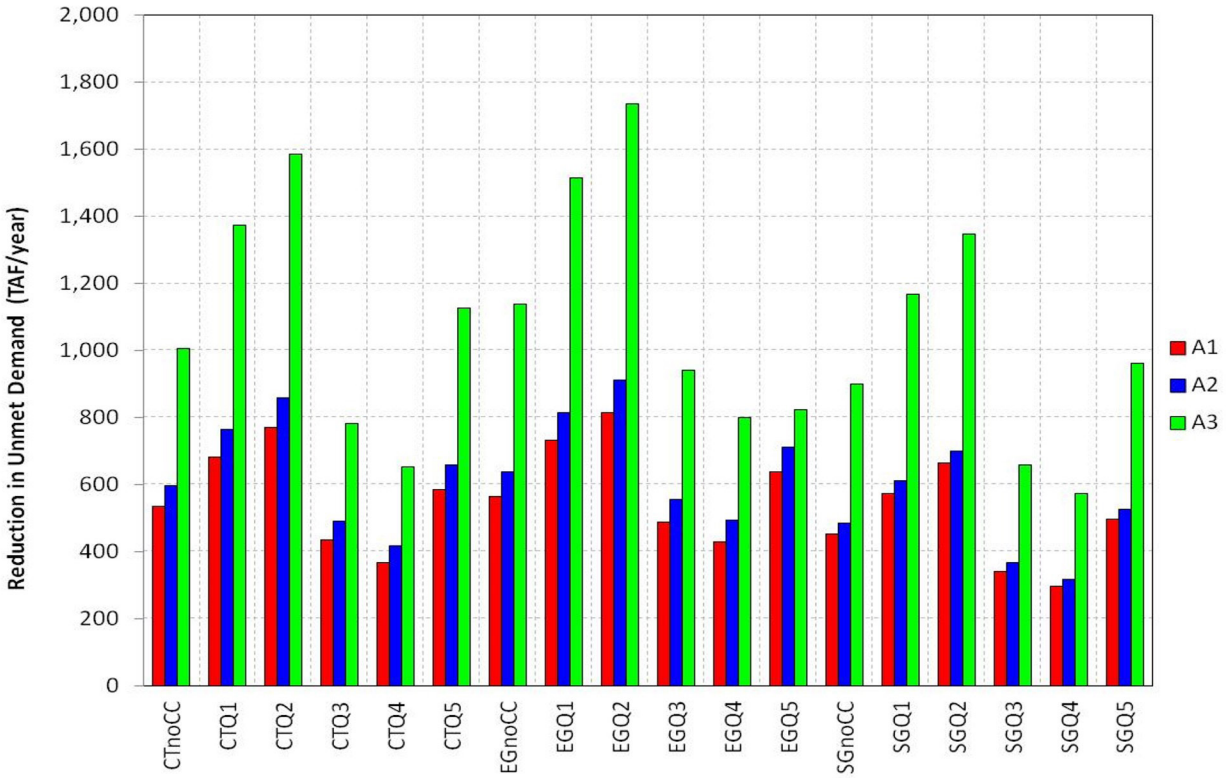

Figure 7-1. Average Annual Reduction in Unmet Demand in the CVP Service Area for Portfolio A in Each Scenario

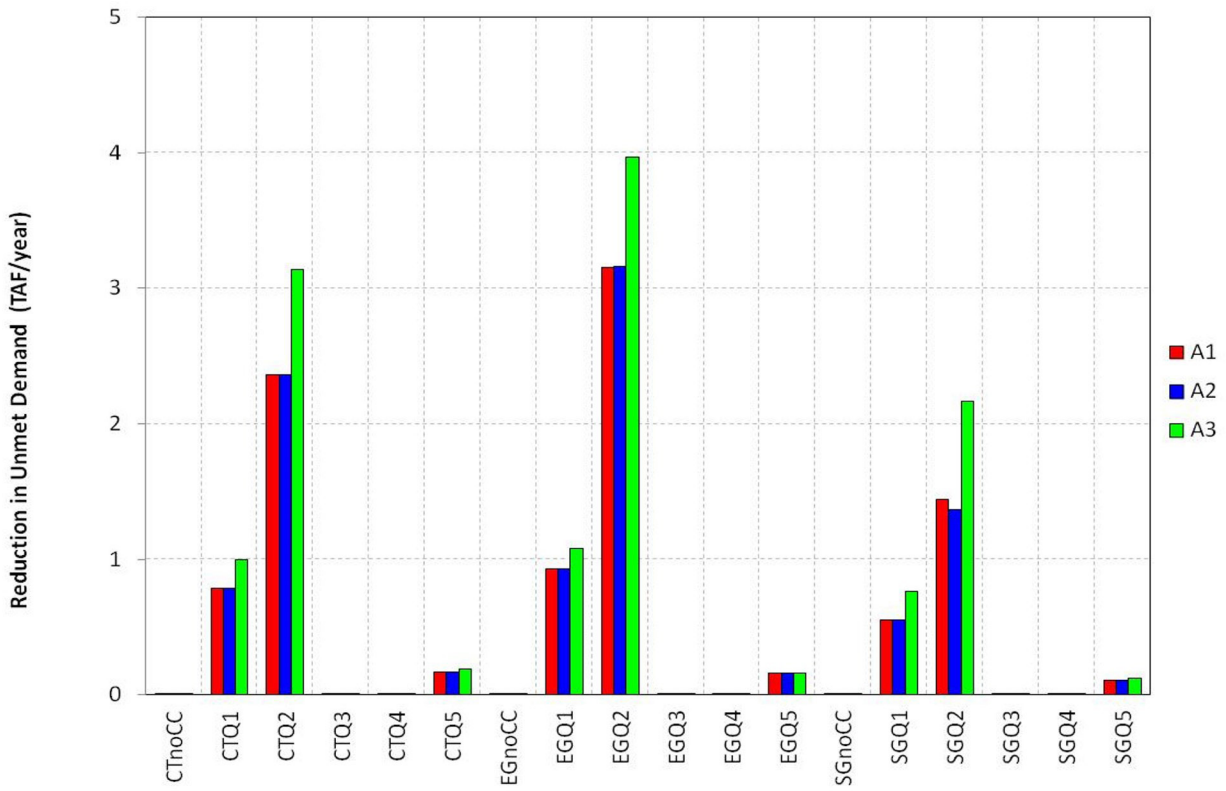

Figure 7-2. Average Annual Reduction in Unmet Demand in the American River Division for Portfolio A in Each Scenario

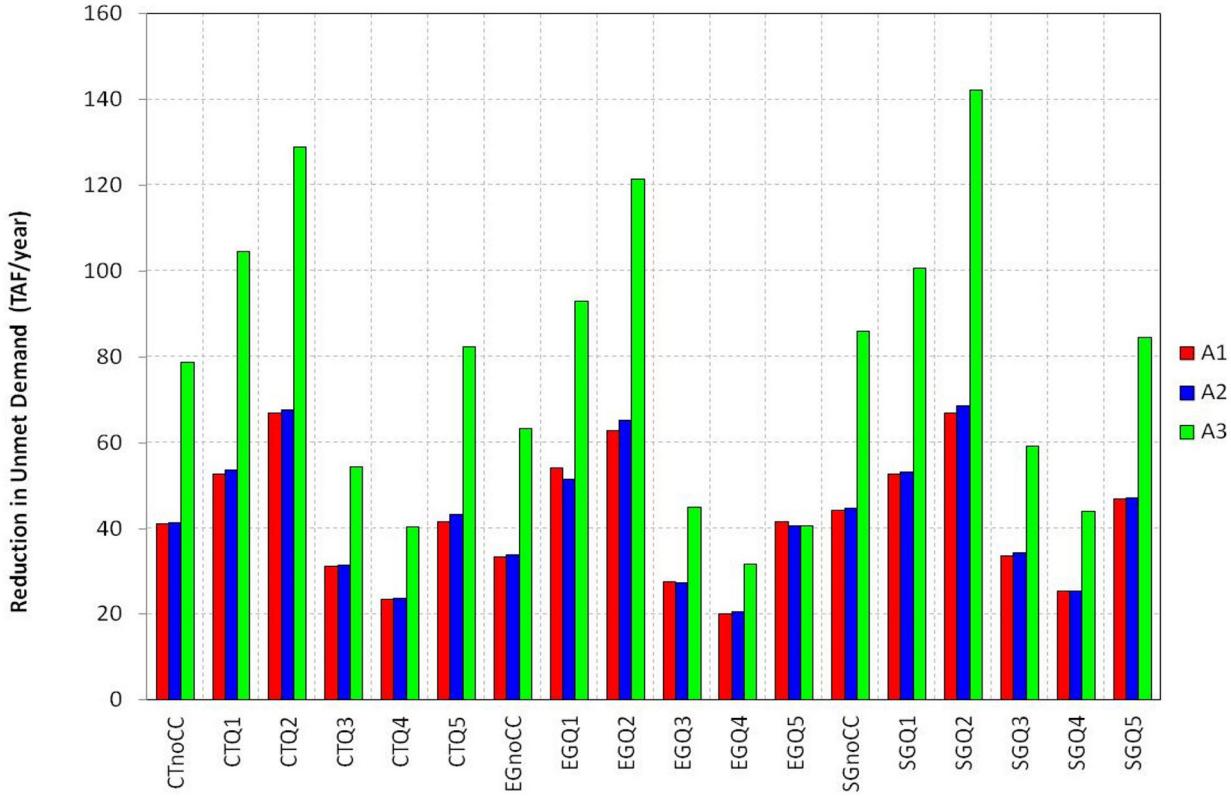

Figure 7-3. Average Annual Reduction in Unmet Demand in the Delta Division for Portfolio A in Each Scenario

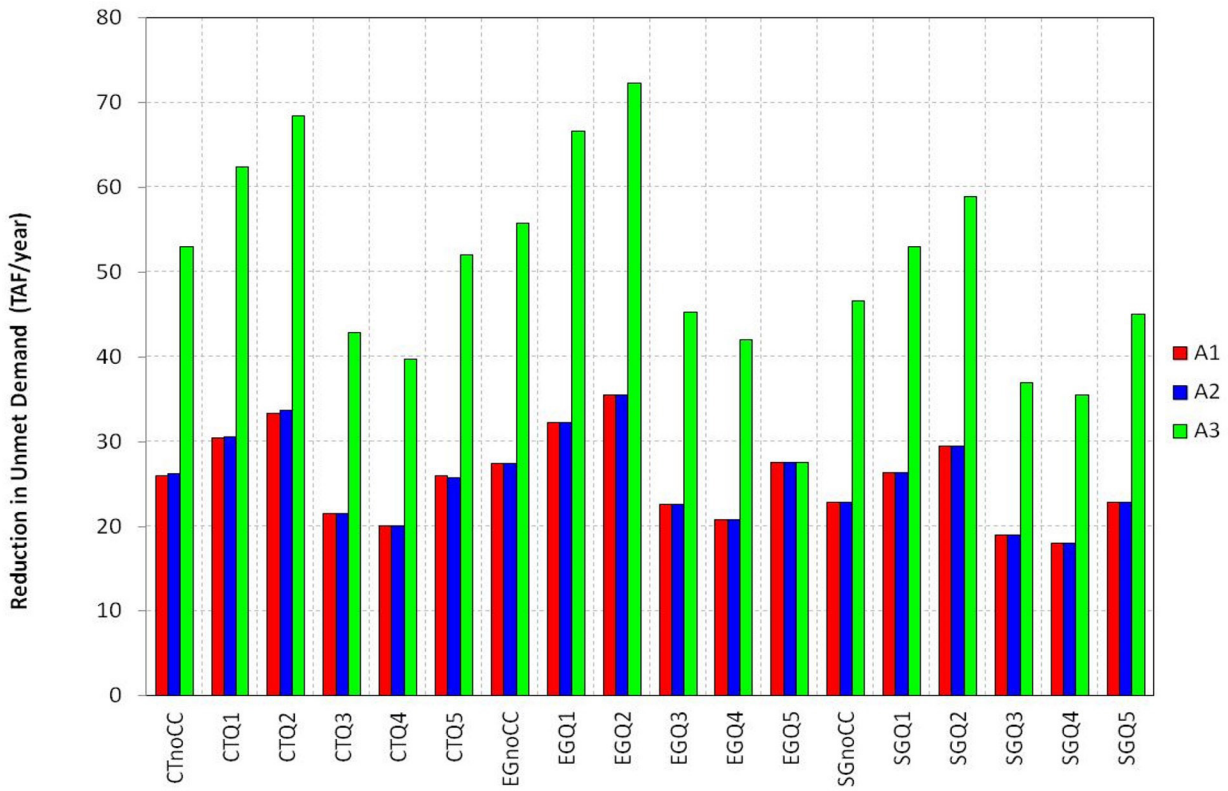

Figure 7-4. Average Annual Reduction in Unmet Demand in the East Side Division for Portfolio A in Each Scenario

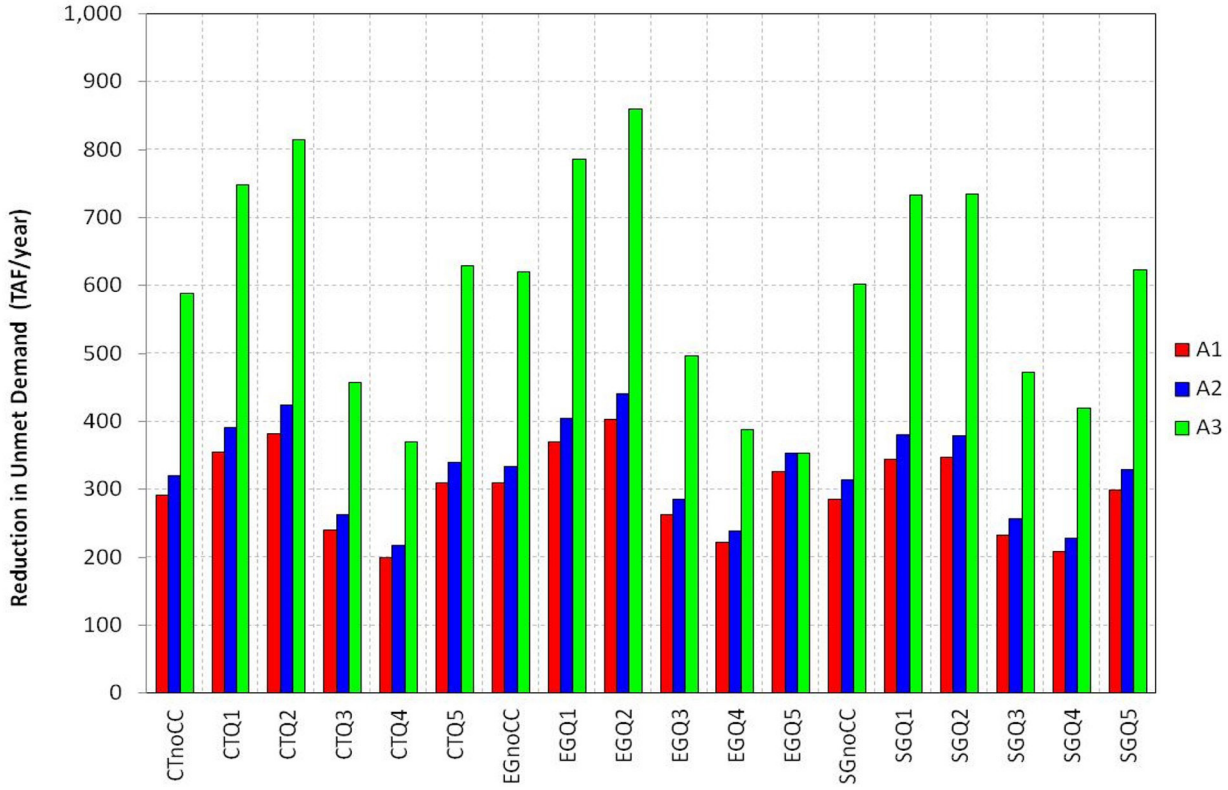

Figure 7-5. Average Annual Reduction in Unmet Demand in the Friant Division for Portfolio A in Each Scenario

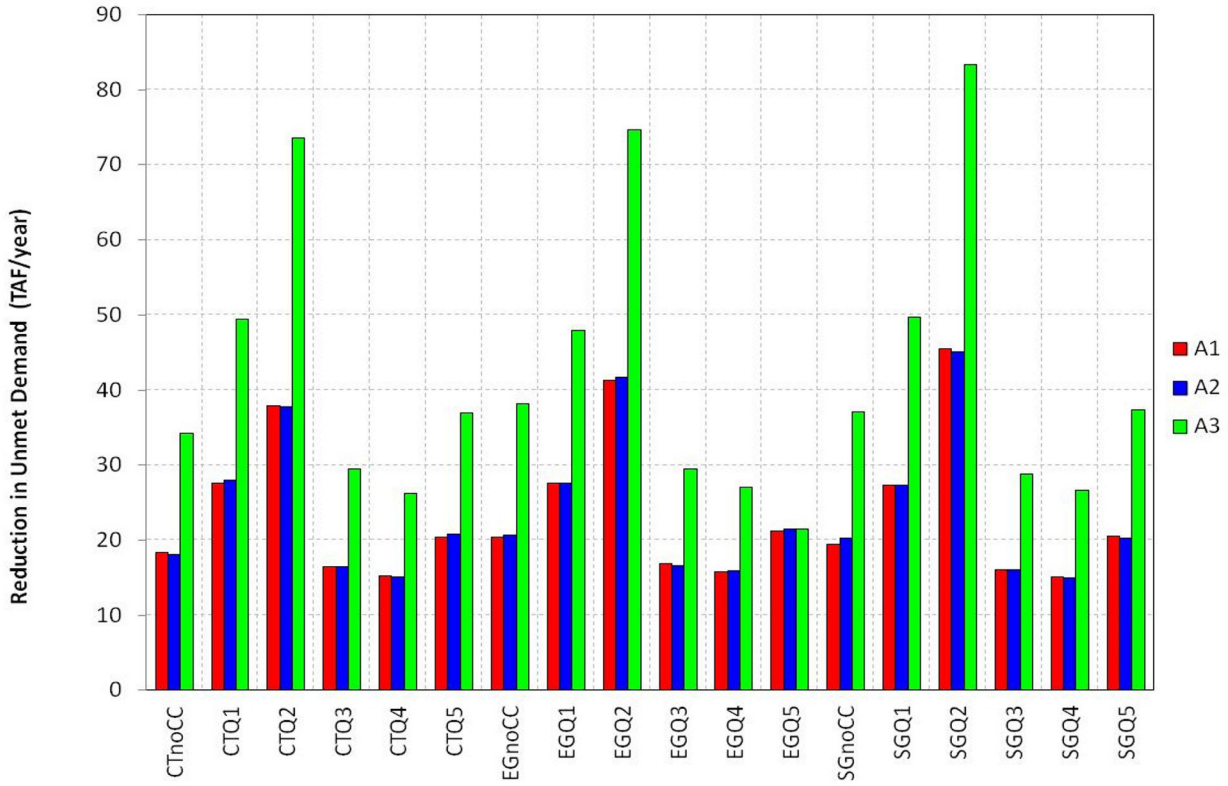

Figure 7-6. Average Annual Reduction in Unmet Demand in the Sacramento River Division for Portfolio A in Each Scenario

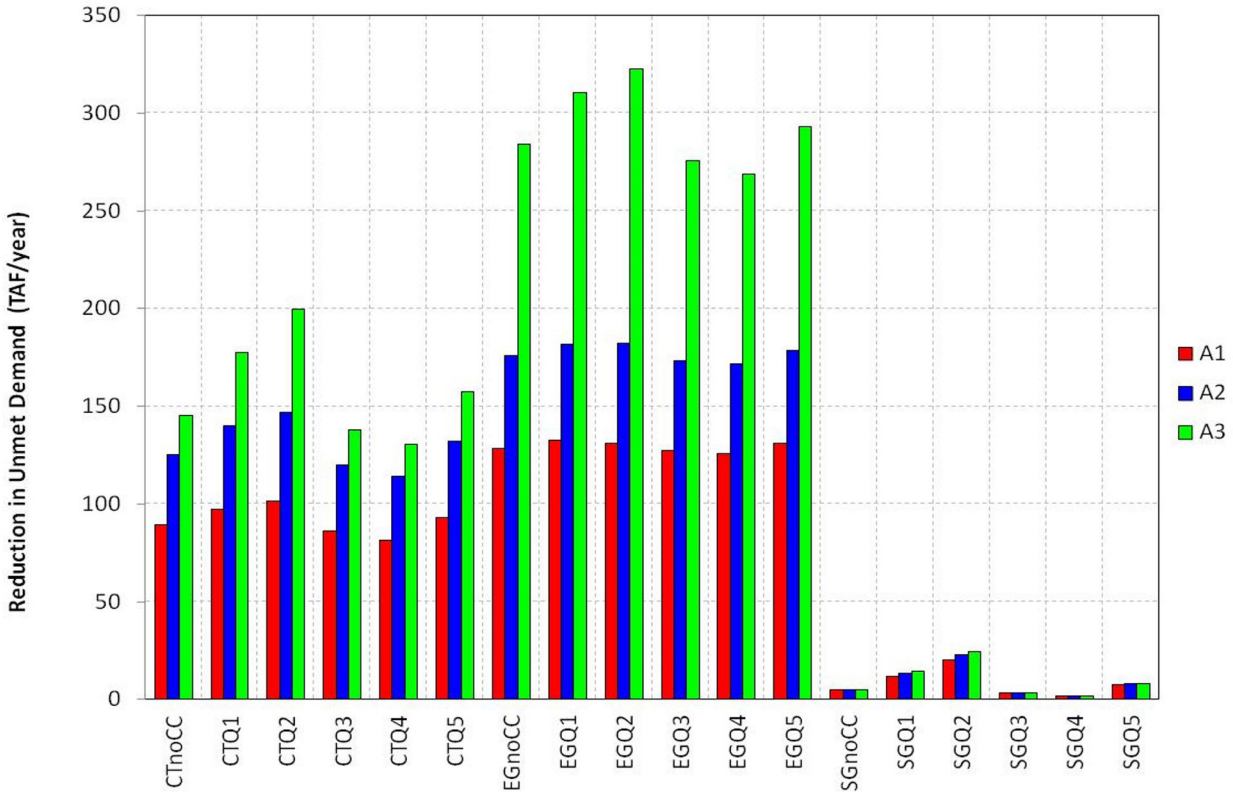

Figure 7-7. Average Annual Reduction in Unmet Demand in the San Felipe Division for Portfolio A in Each Scenario

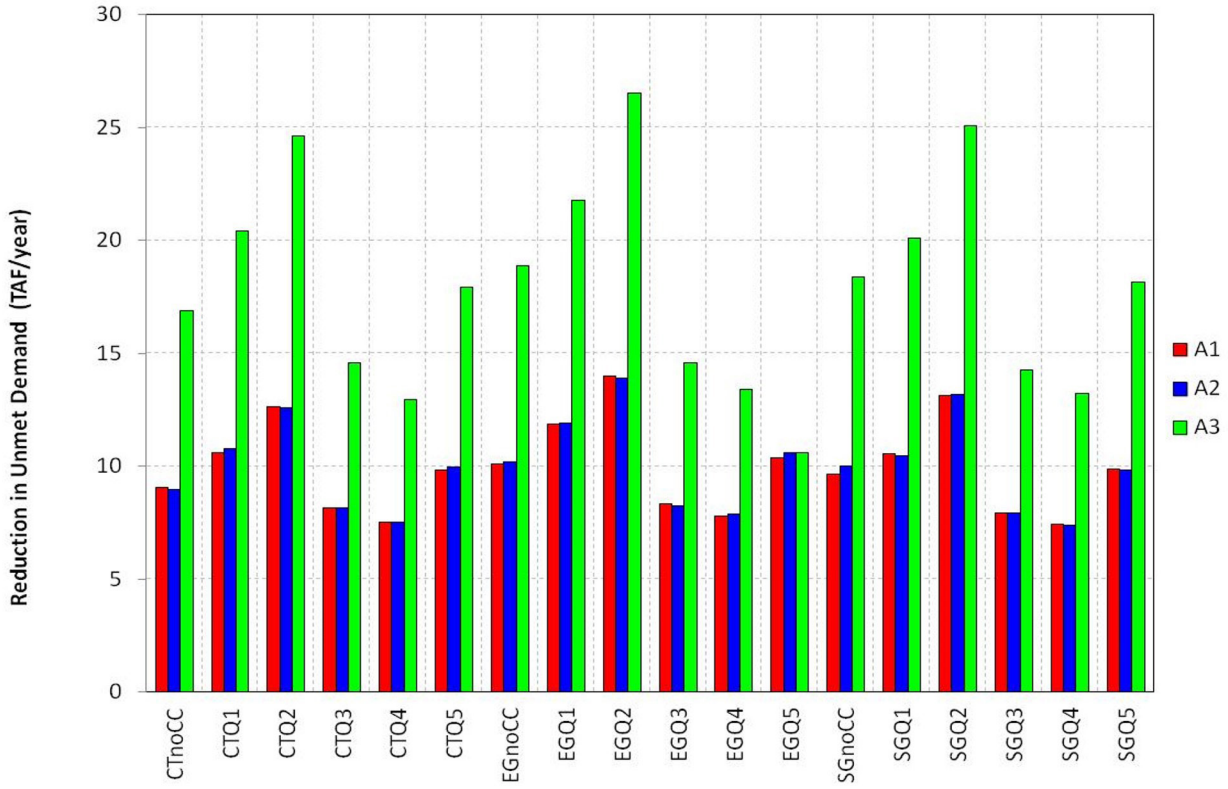

Figure 7-8. Average Annual Reduction in Unmet Demand in the Shasta Division for Portfolio A in Each Scenario

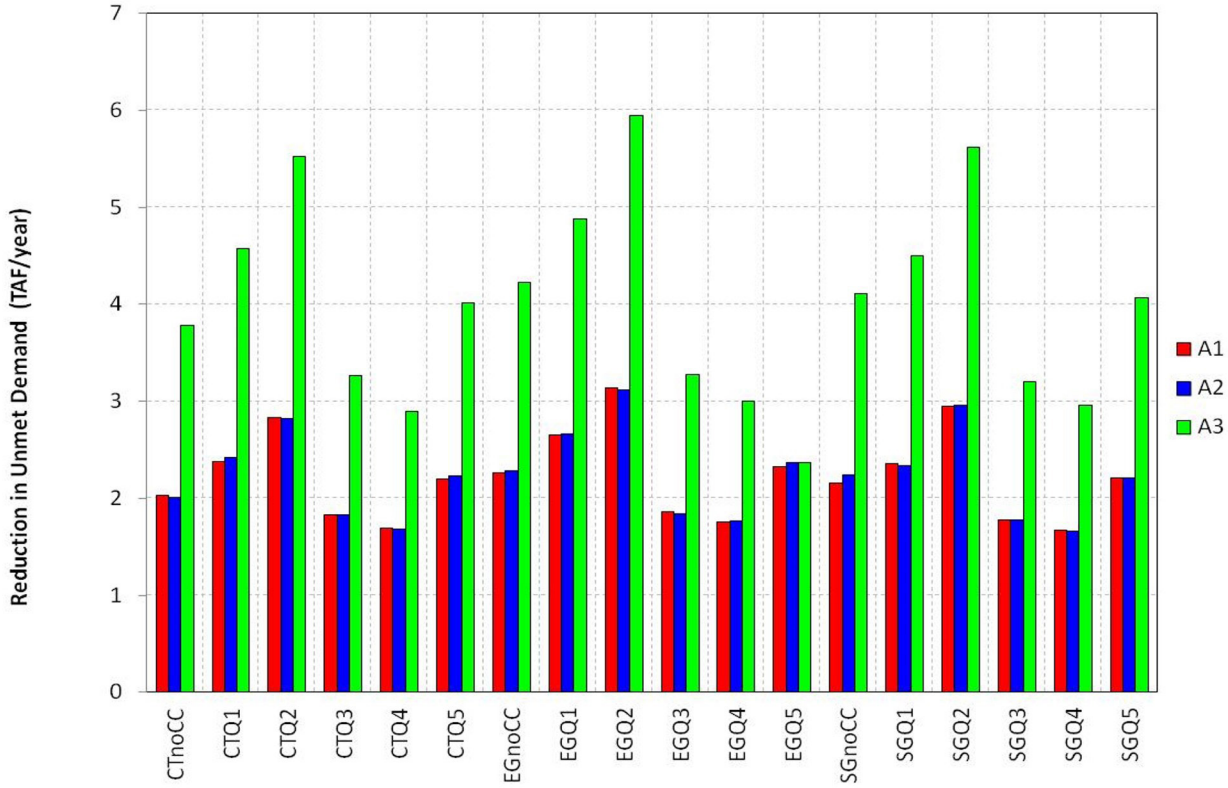

Figure 7-9. Average Annual Reduction in Unmet Demand in the Trinity Division for Portfolio A in Each Scenario

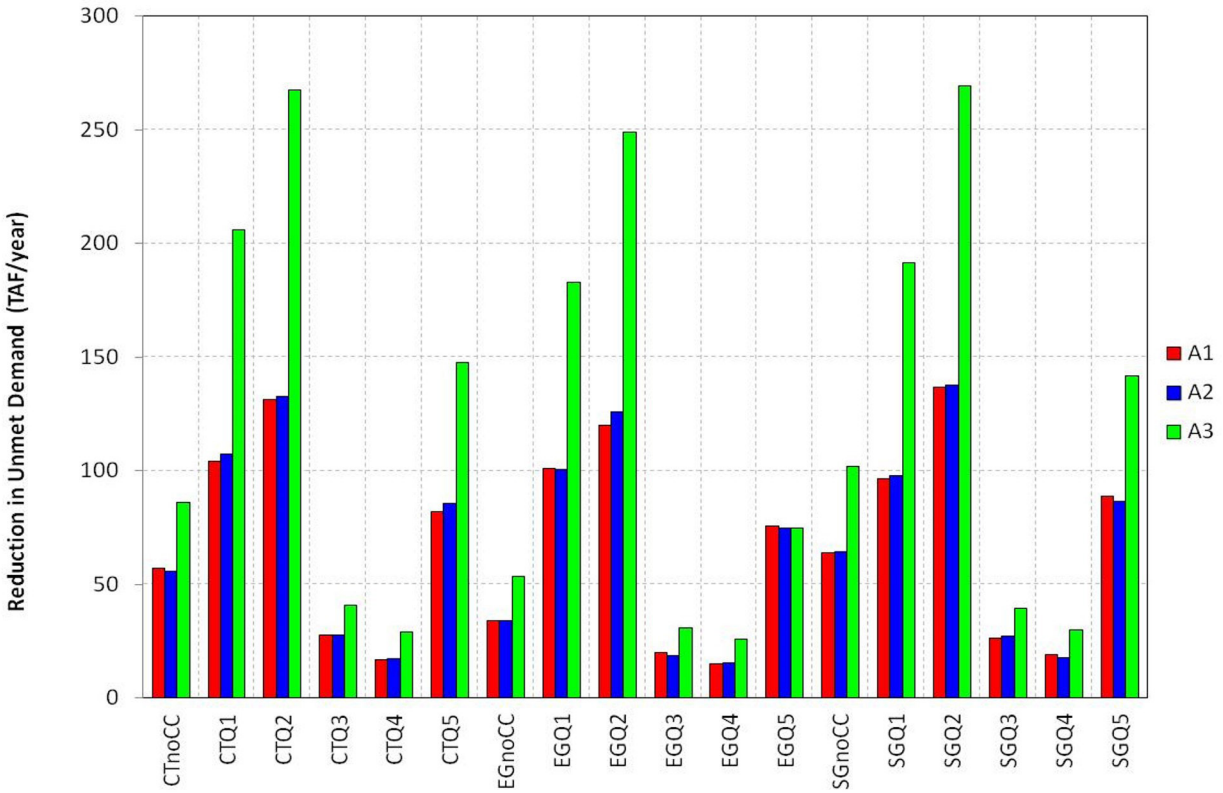

Figure 7-10. Average Annual Reduction in Unmet Demand in the San Felipe Division for Portfolio A in Each Scenario

local supply actions in A2, and a larger increase to 574–1,737 TAF/year (16 to 29 percent of Baseline unmet demands) with the addition of aggressive conservation actions in A3. The higher reductions in unmet demand in A3 reflect the full effect of all the combined Aggressive Local Actions considered in Portfolio A.

Figures 7-11 through 7-13 show the annual time series of groundwater, surface water, and local project supplies, and the unmet demands for the CVP Service Area under CT-Q5, EG-Q2, SG-Q4 scenarios under Portfolio A Suite A1. Figures 7-14 through 7-16 show the same information for Suite A2, and Figures 7-17 through 7 19 show the same information for Suite A3, in which all local actions are implemented. The results are summarized as follows:

- Unmet demands in A1 ranged from 800 to 10,900 TAF/year in CT Q5, from 800 to 14,600 TAF/year in EG-Q2, and from 700 to 7,000 TAF/year in SG-Q4.
- Unmet demands in A2 ranged from 800 to 10,900 TAF/year in CT-Q5, from 800 to 14,500 TAF/year in EG-Q2, and from 700 to 7,000 TAF/year in SG-Q4.
- Unmet demands in A3 ranged from 700 to 10,700 TAF/year in CT-Q5, from 800 to 14,100 TAF/year in EG-Q2, and from 600 to 6,800 TAF/year in SG-Q4.
- The unmet demands gradually decreased relative to Baseline conditions over the course of the twenty-first century because of the gradually increasing amounts of local demand-reduction and supply-enhancement actions included in the Portfolio A suites.

7.1.2 CVP and SWP System Operations

The following sections provide an overview of the results of each simulation suite.

7.1.2.1 CVP and SWP Project Storage

Figures 7-20 through 7-33 are exceedance plots of reservoir storage over the twenty-first century for the Baseline and each of the portfolios. These plots show end–of-May storage to represent available water supply at the beginning of the growing season, and end of September represents carryover storage conditions in Shasta, Folsom, Oroville, New Melones, Millerton, CVP San Luis, and SWP San Luis Reservoirs for the CT-Q5, EG-Q2, and SG-Q4 scenarios. The highest levels of storage were associated the wetter SG-Q4

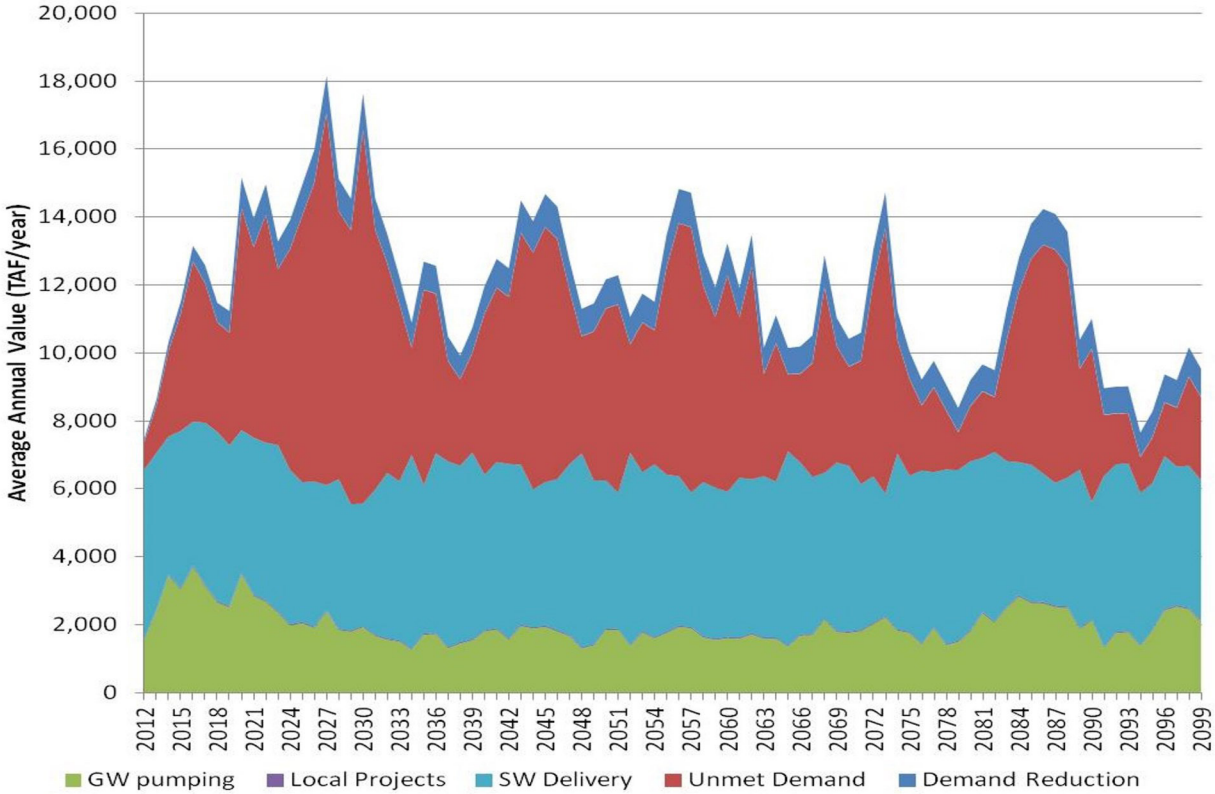

Figure 7-11. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite A1 in the CTQ5 Scenario

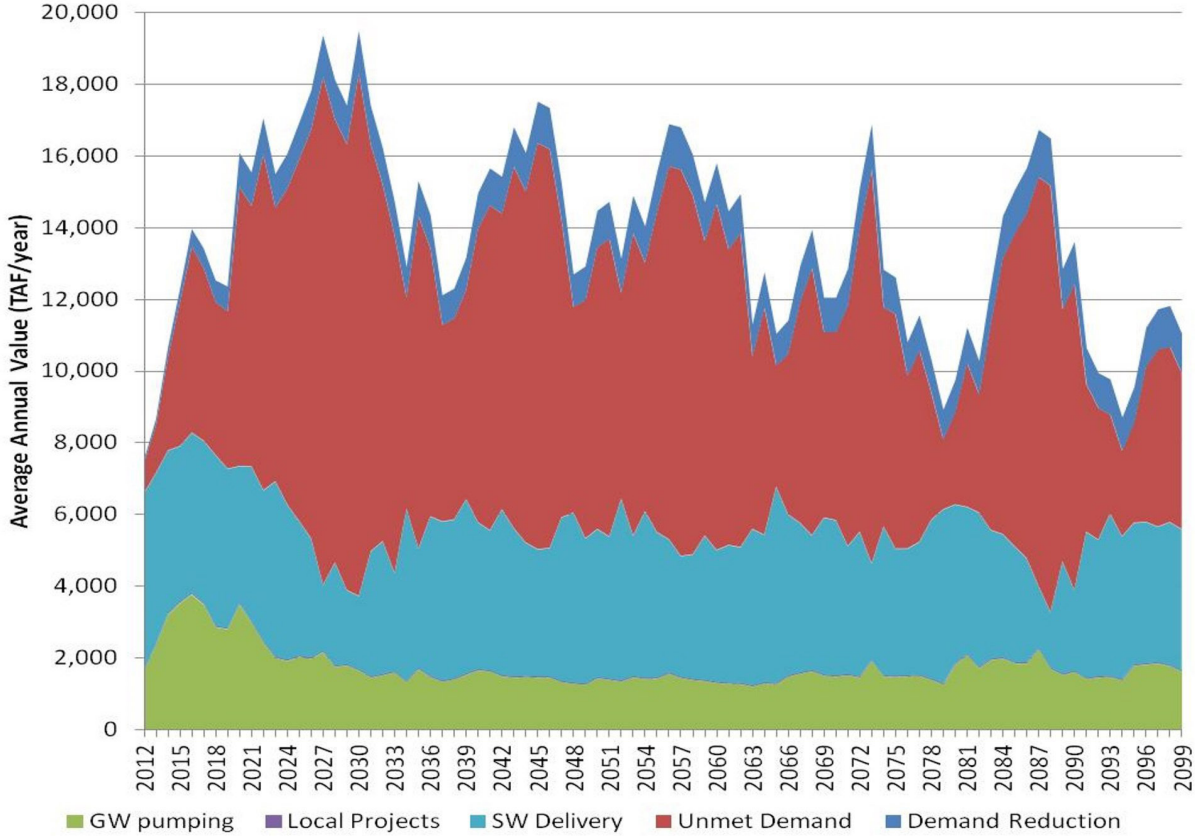

Figure 7-12. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite A1 in the EG-Q2 Scenario

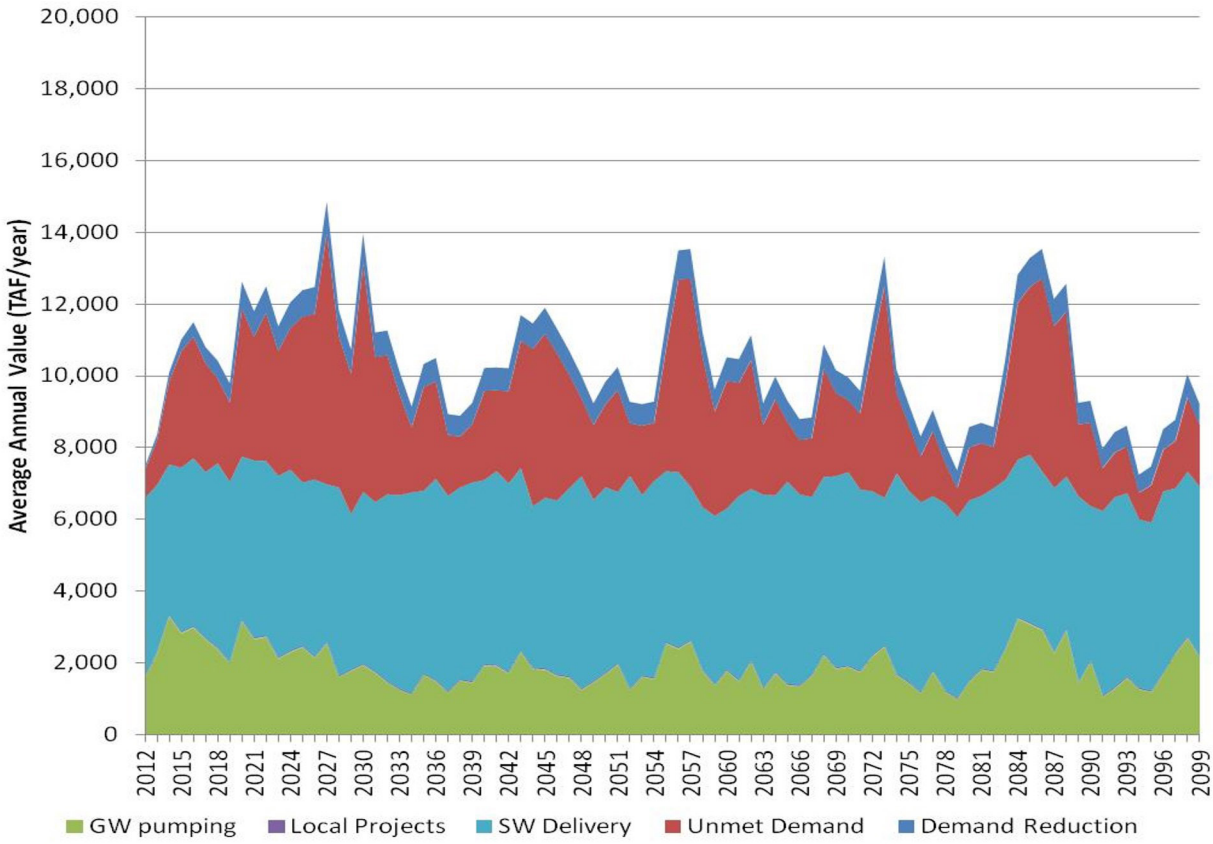

Figure 7-13. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite A1 in the SG-Q4 Scenario

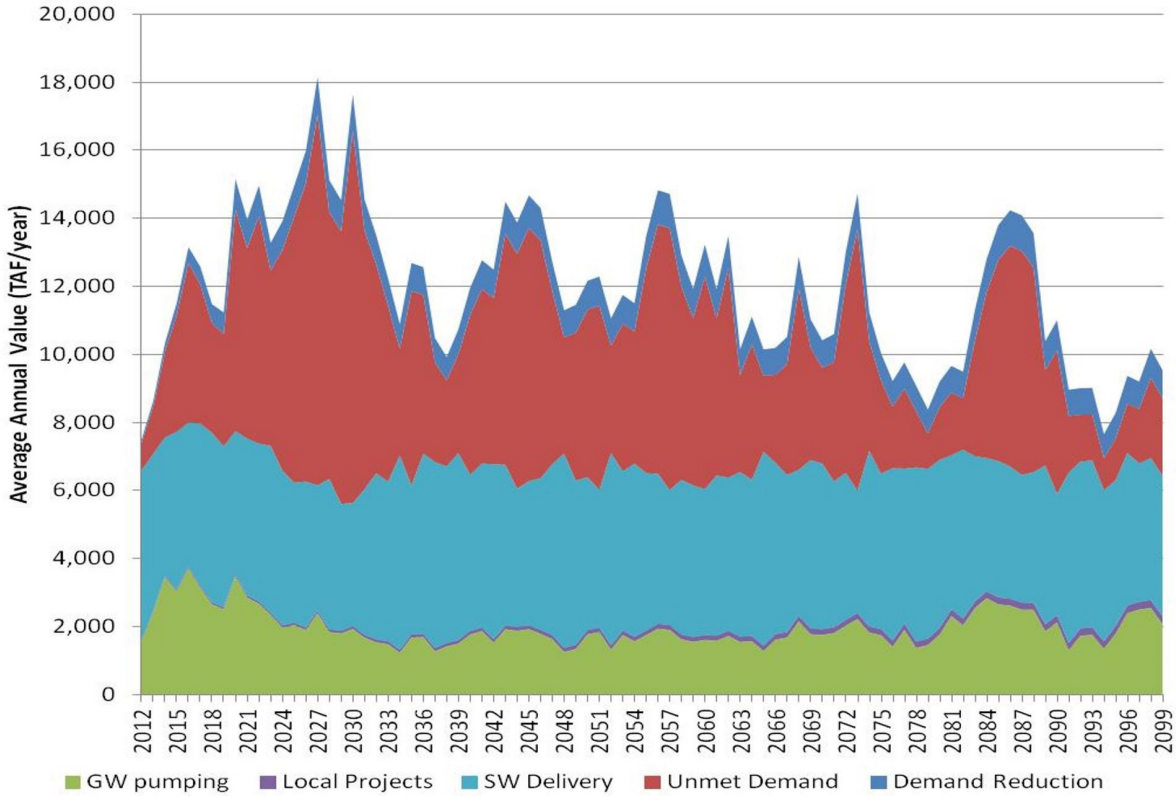

Figure 7-14. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite A2 in the CT-Q5 Scenario

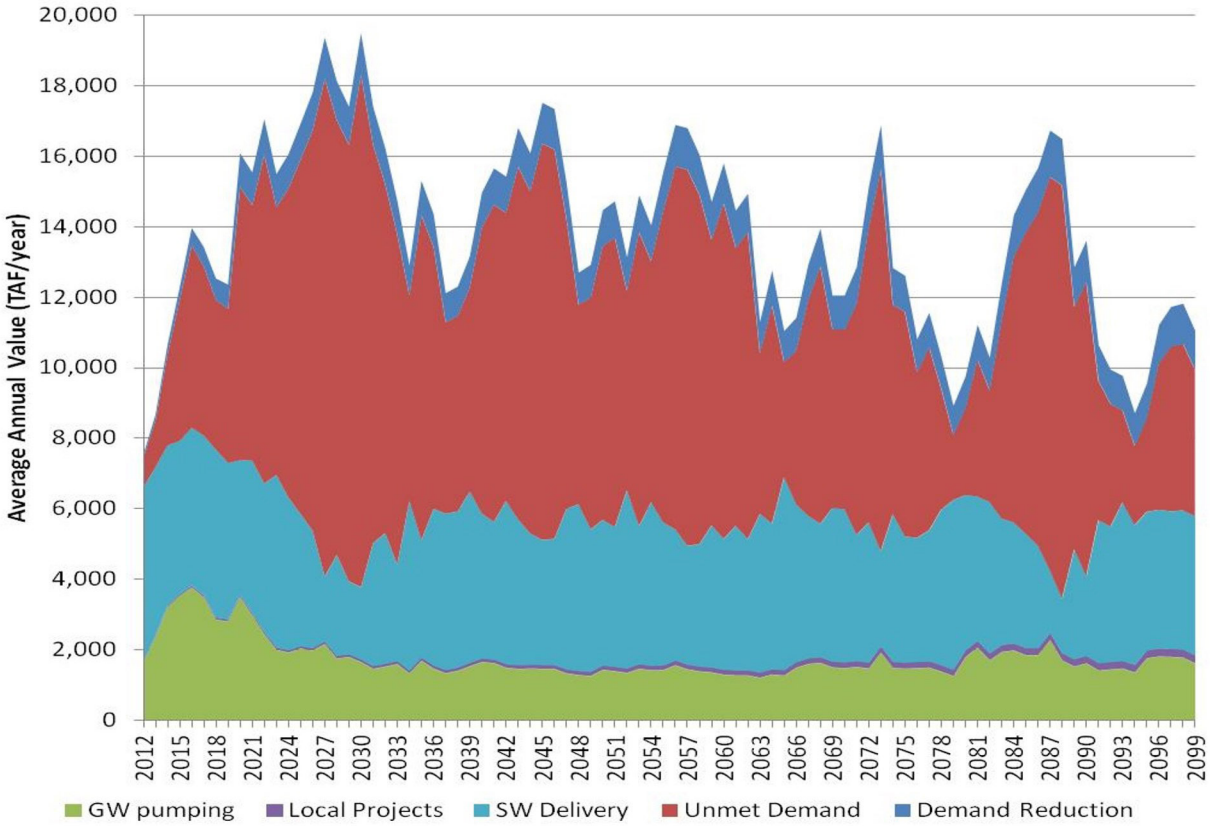

Figure 7-15. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite A2 in the EG-Q2 Scenario

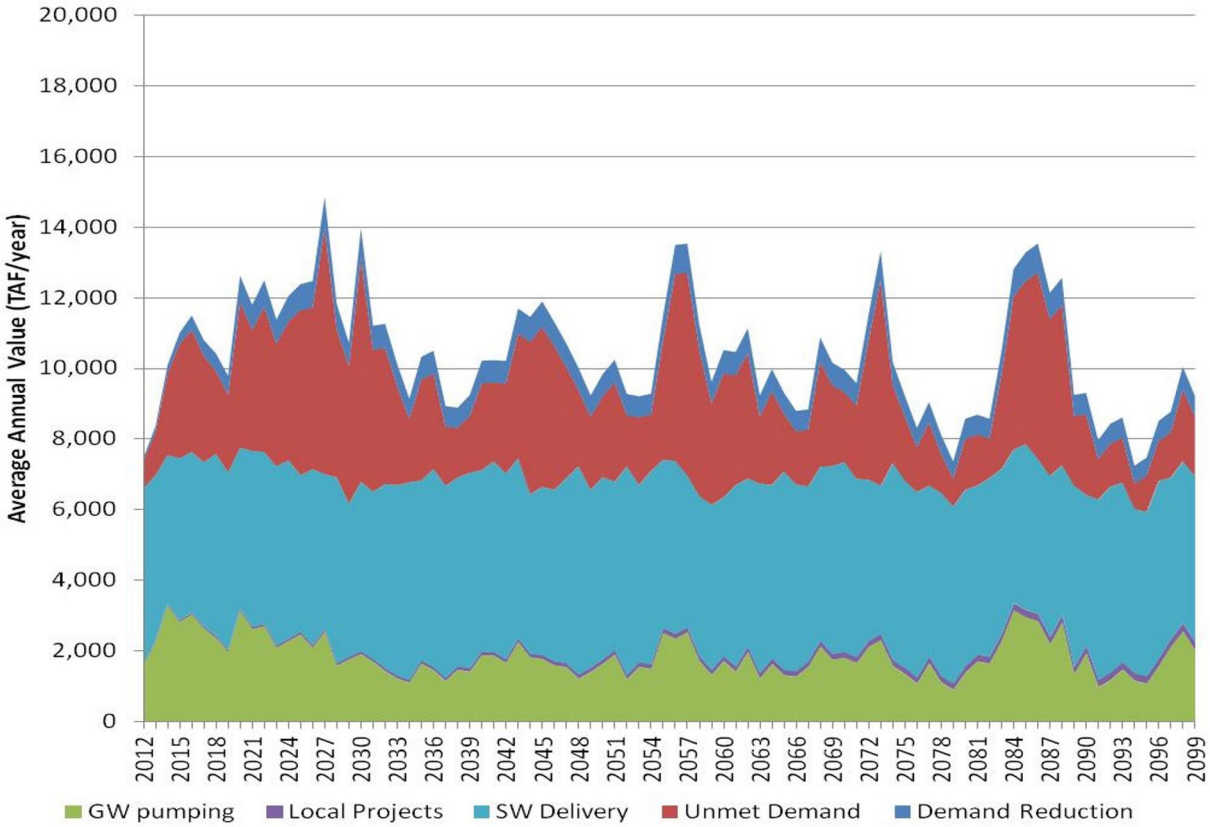

Figure 7-16. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite A2 in the SG-Q4 Scenario

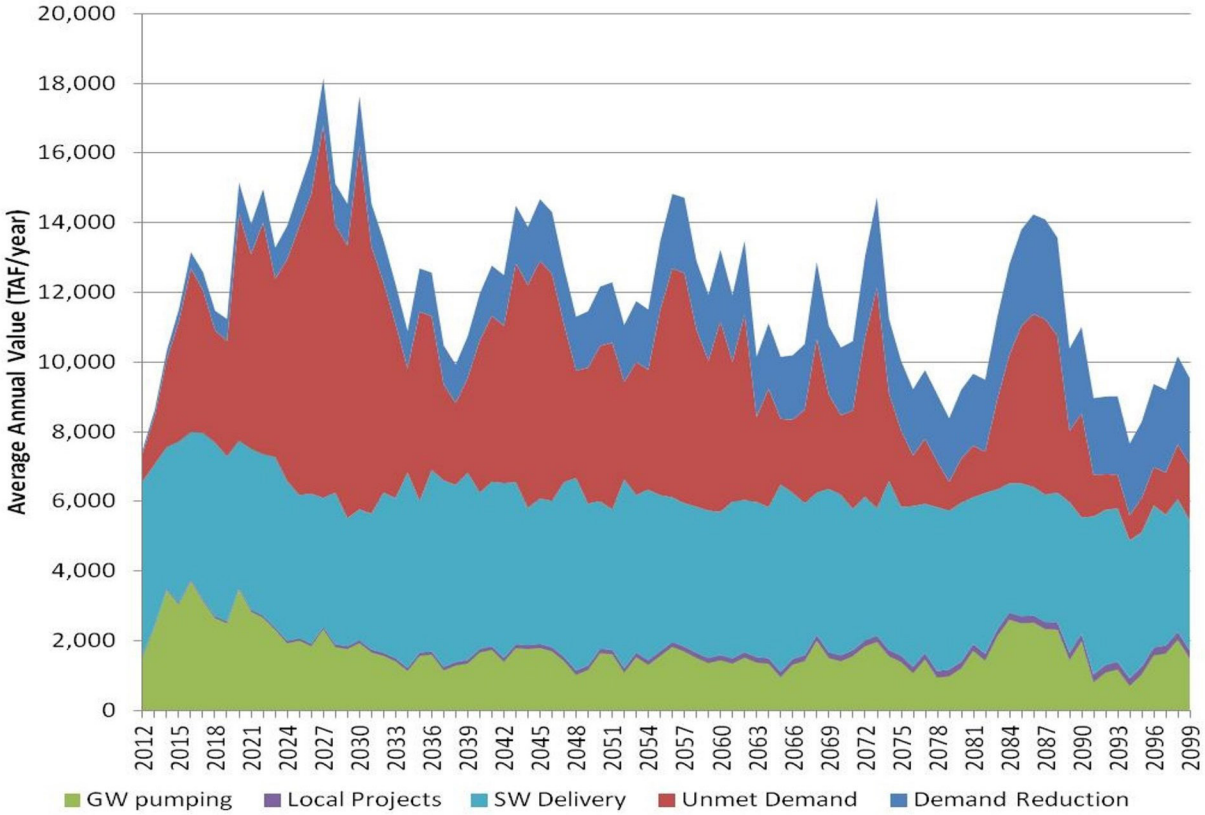

Figure 7-17. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite A3 in the CT-Q5 Scenario

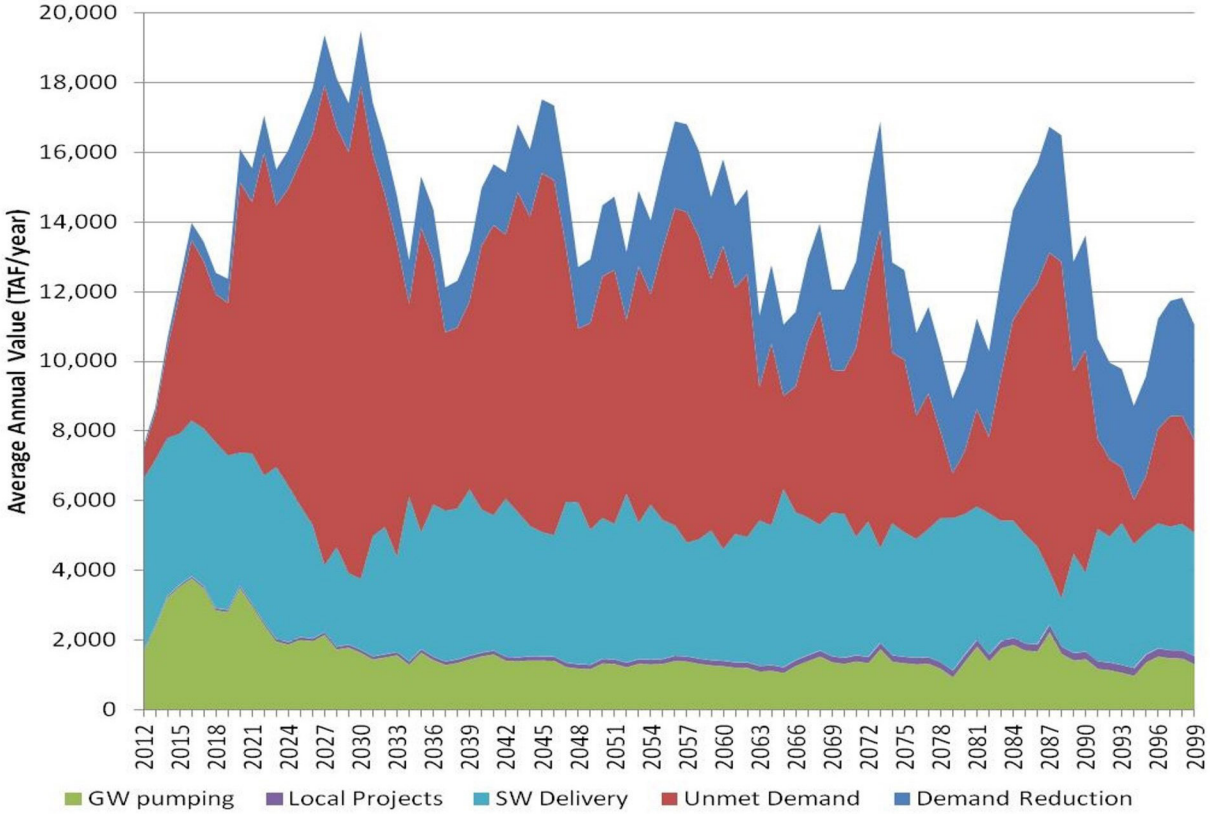

Figure 7-18. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite A3 in the EG-Q2 Scenario

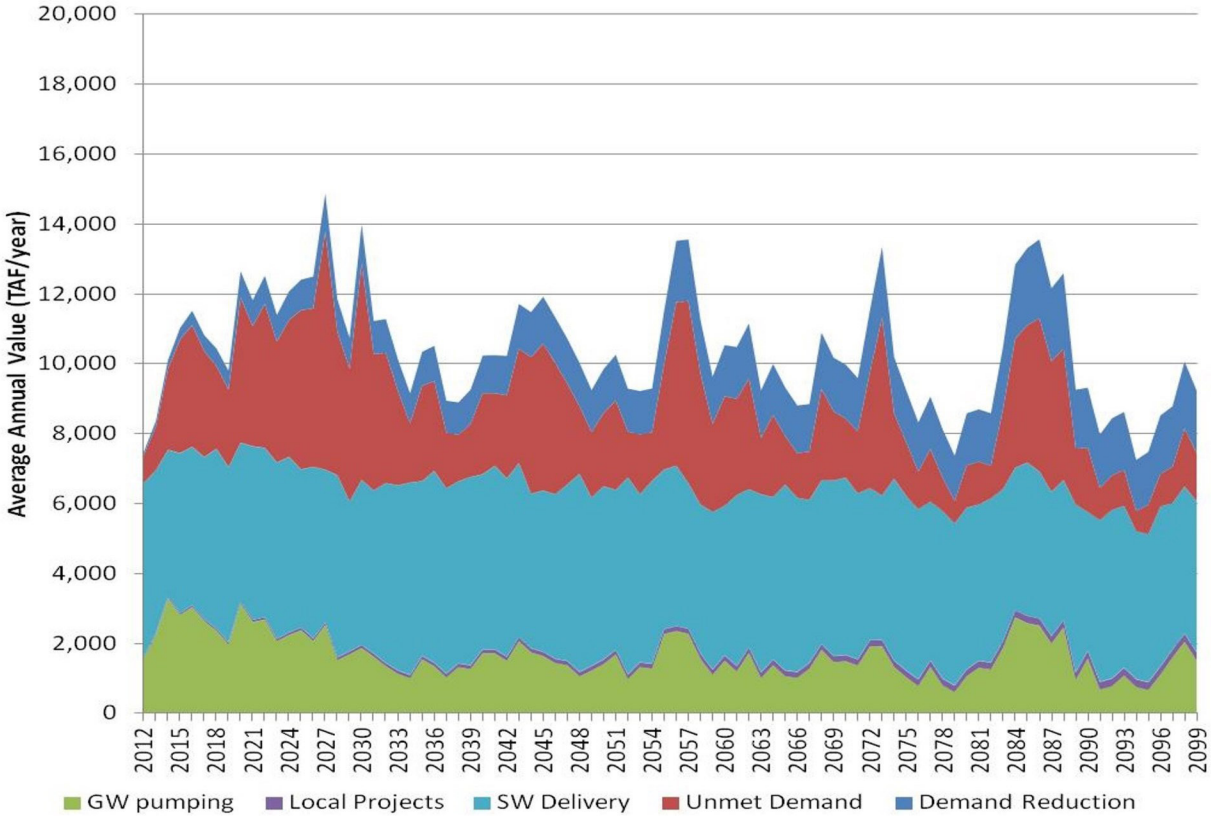

Figure 7-19. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite A3 in the SG-Q4 Scenario

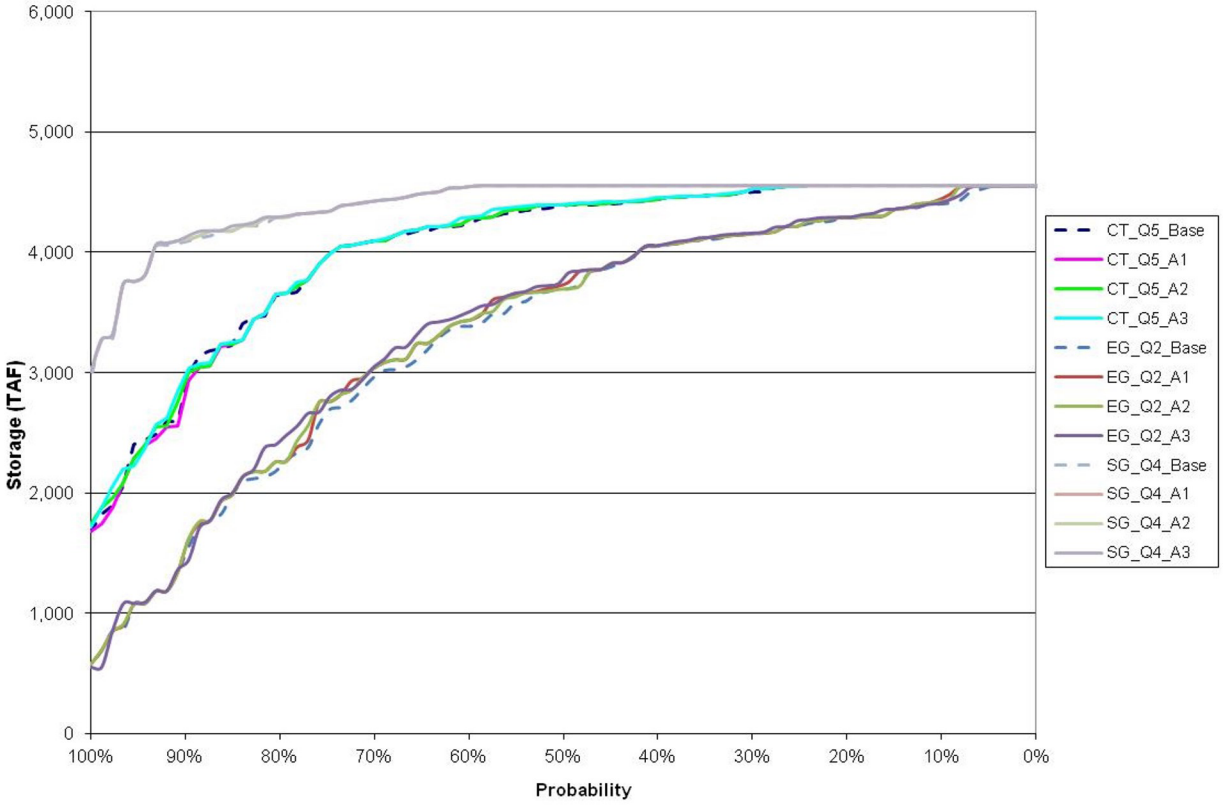

Figure 7-20. Exceedance of Lake Shasta End-of-May Storage in Portfolio A

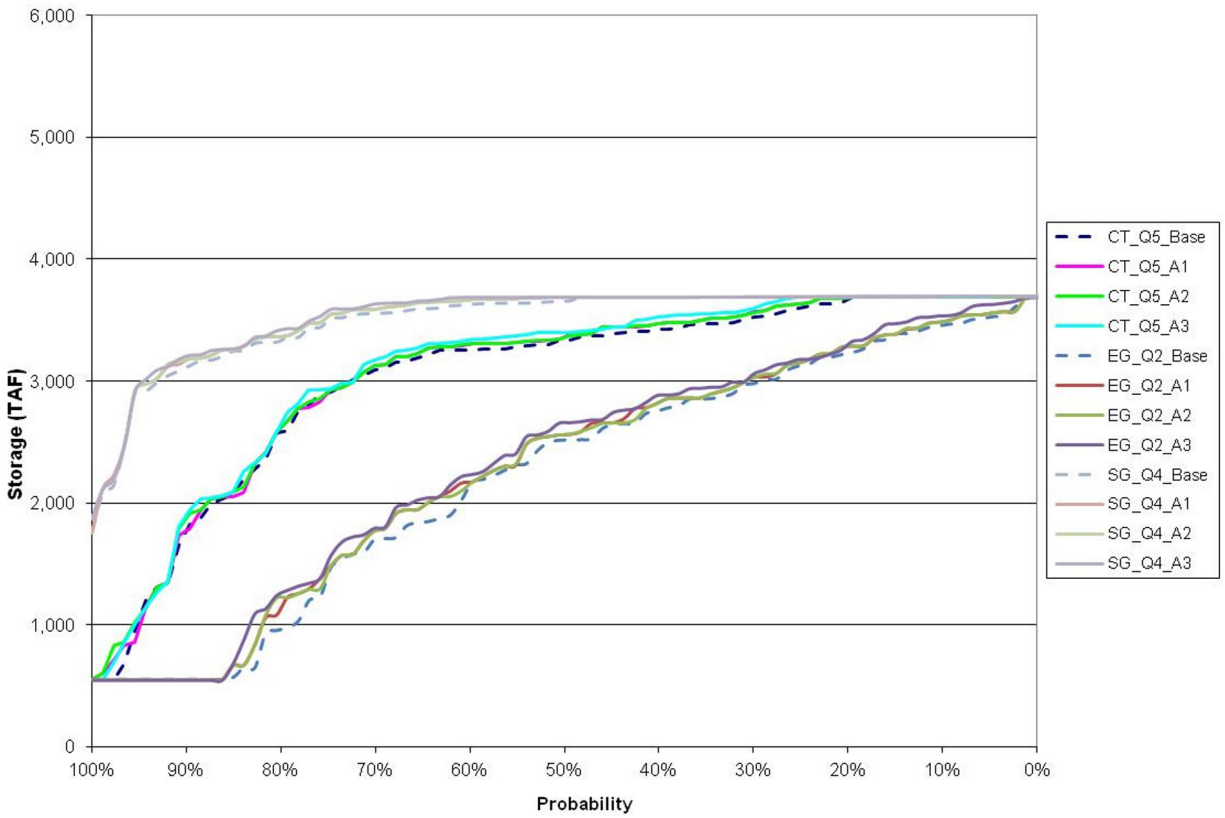

Figure 7-21. Exceedance of Lake Shasta End-of-September Storage in Portfolio A

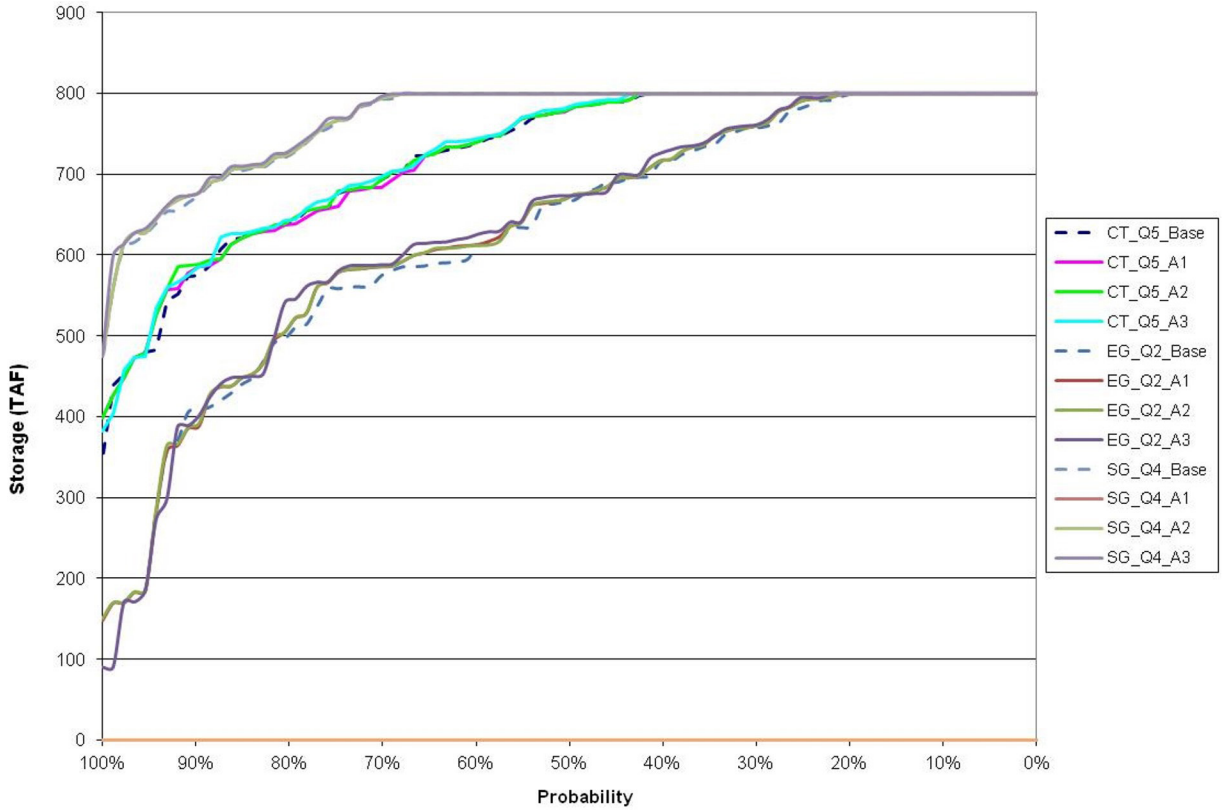

Figure 7-22. Exceedance of Folsom Lake End-of-May Storage in Portfolio A

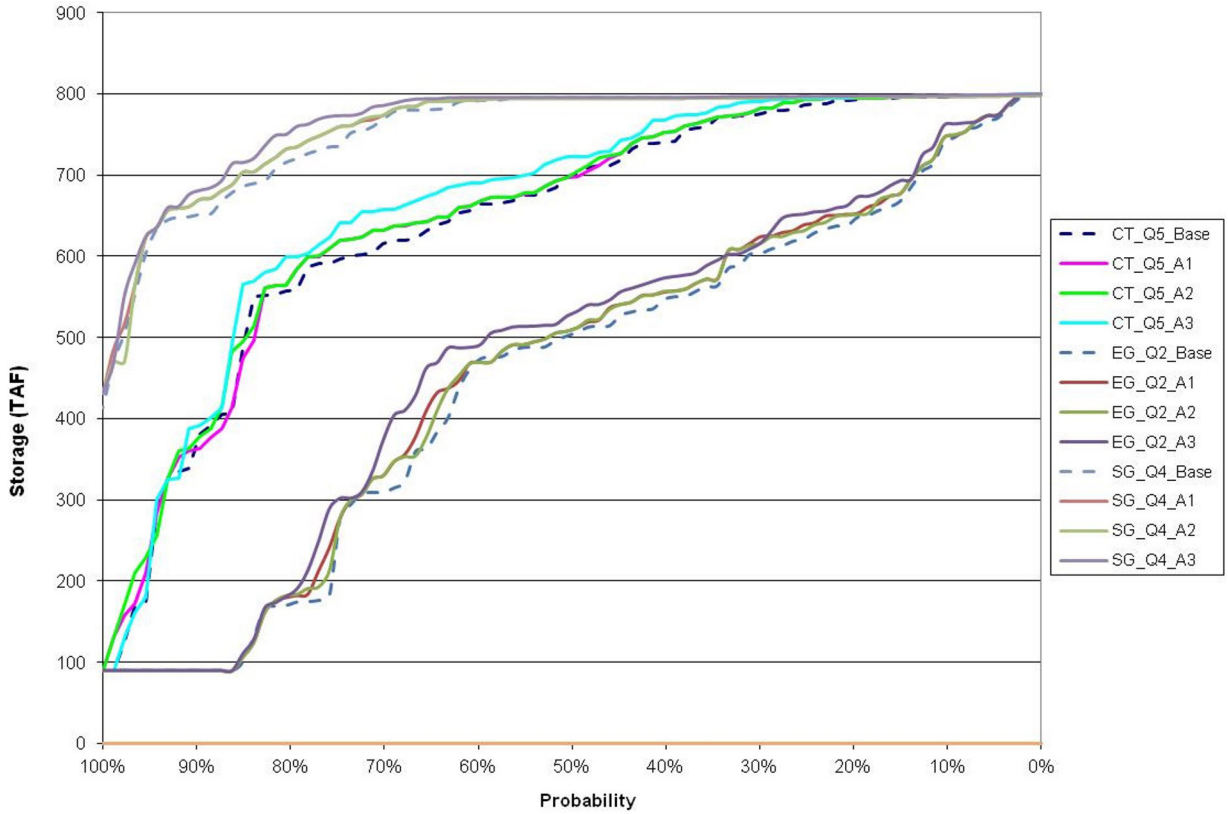

Figure 7-23. Exceedance of Folsom Lake End-of-September Storage in Portfolio A

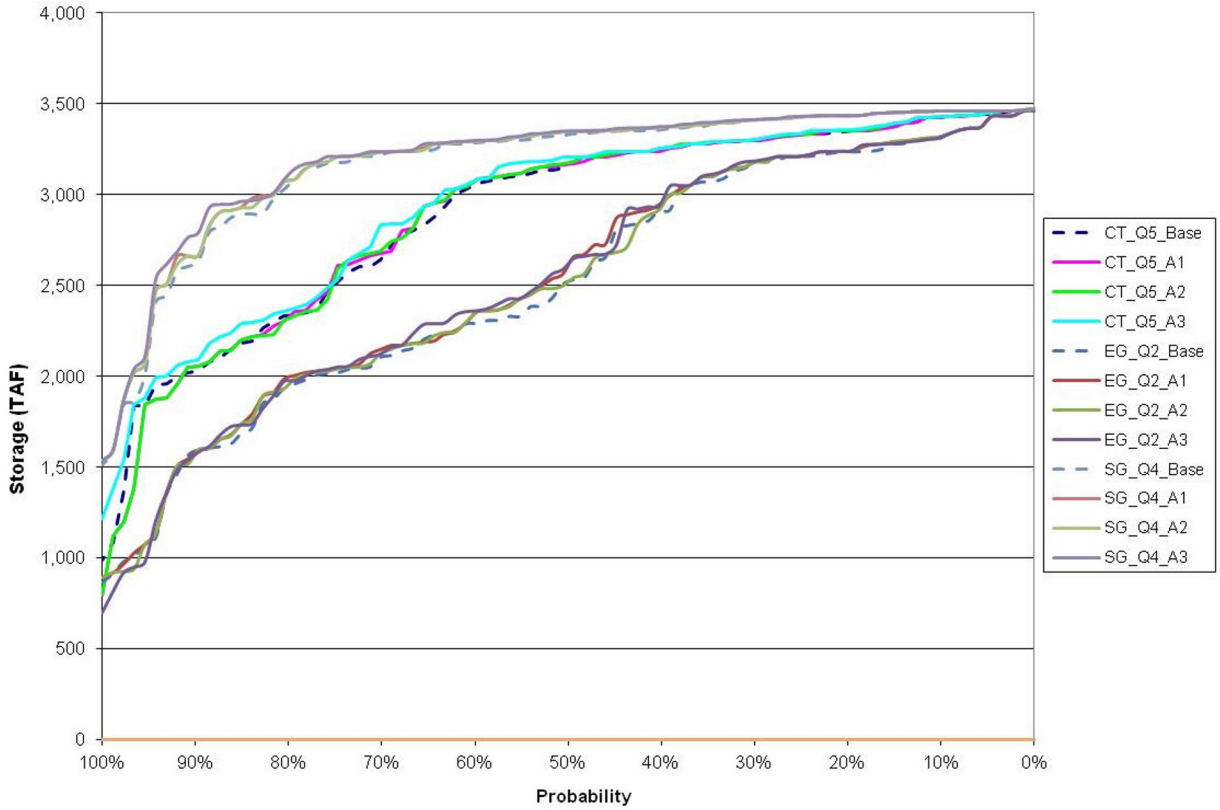

Figure 7-24. Exceedance of Lake Oroville End-of-May Storage in Portfolio A

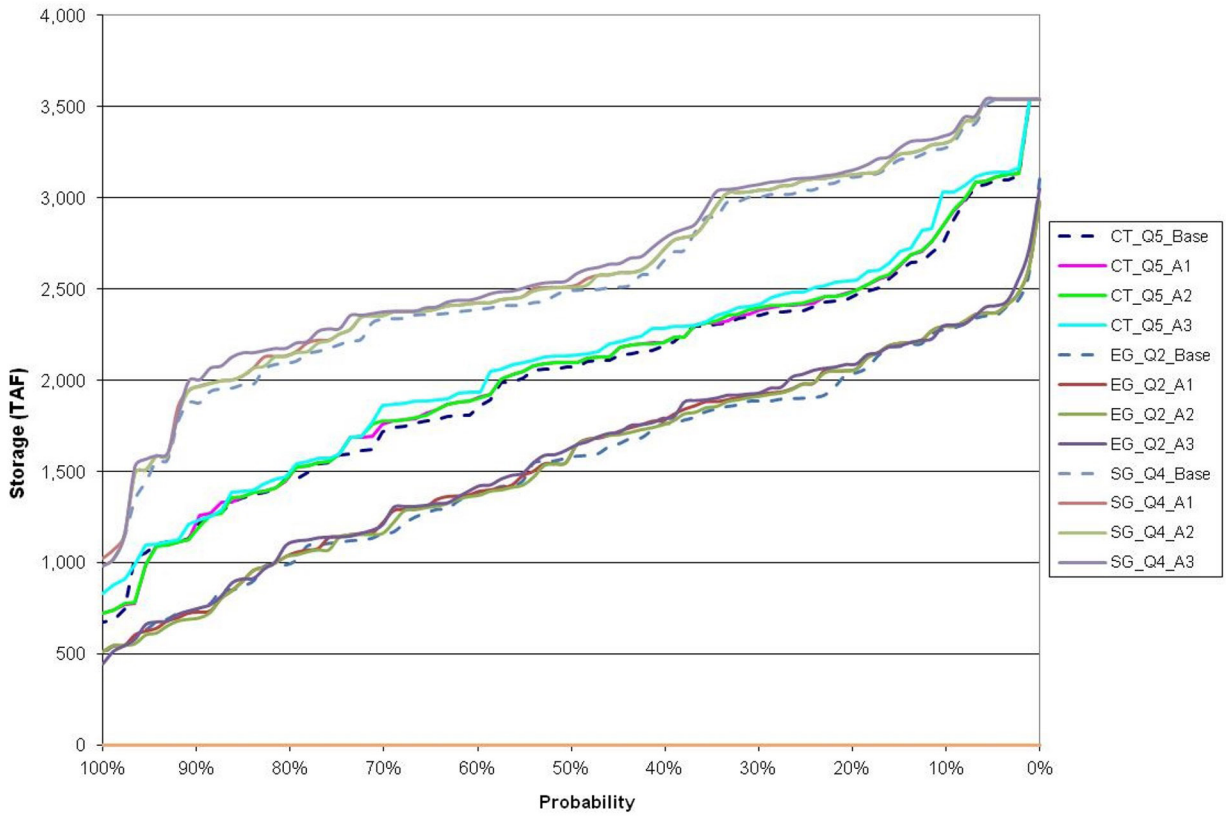

Figure 7-25. Exceedance of Lake Oroville End-of-September Storage in Portfolio A

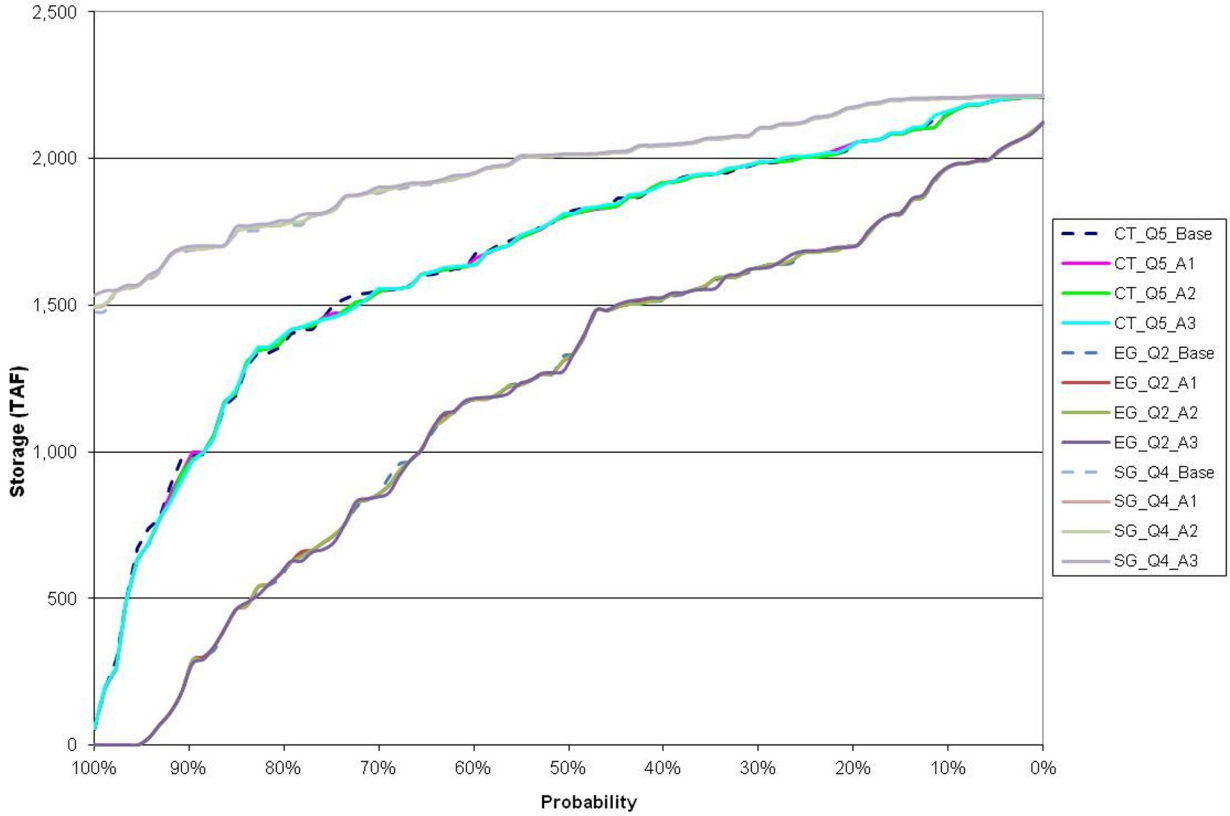

Figure 7-26. Exceedance of New Melones Reservoir End-of-May Storage in Portfolio A

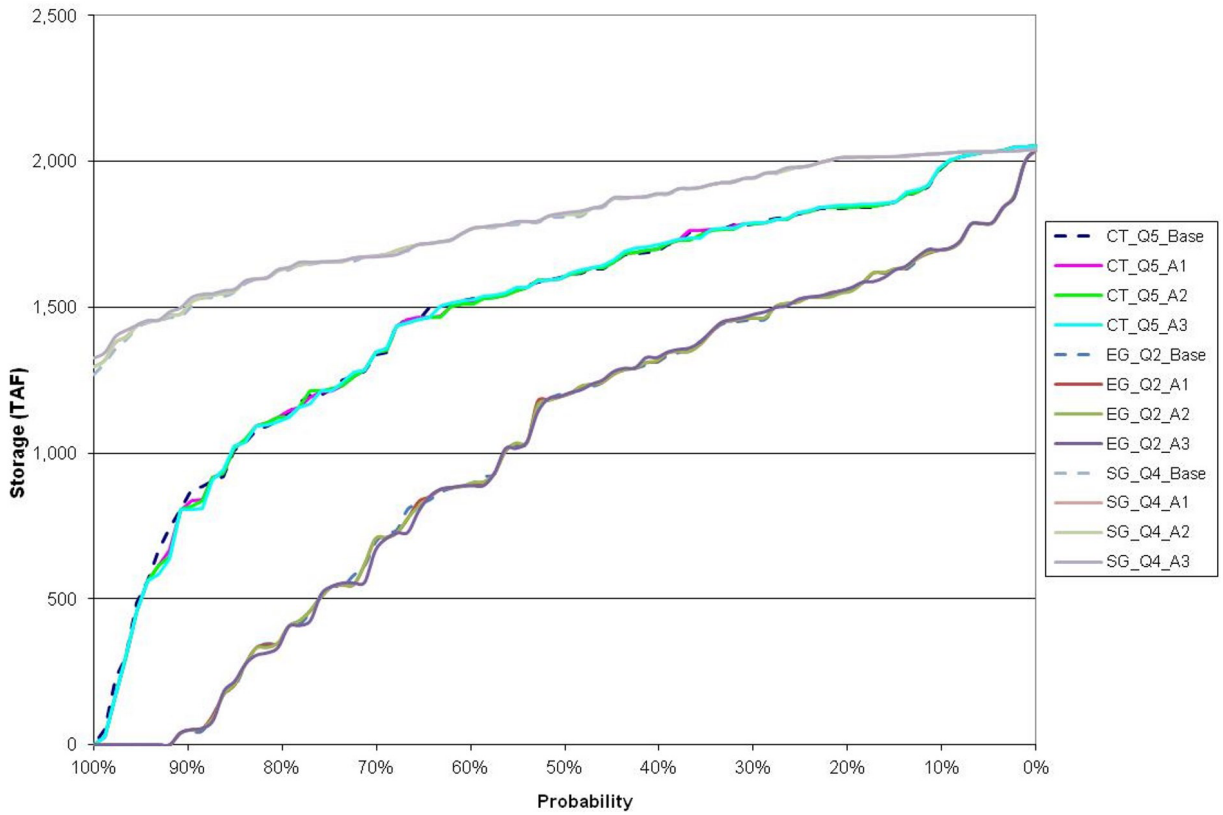

Figure 7-27. Exceedance of New Melones Reservoir End-of-September Storage in Portfolio A

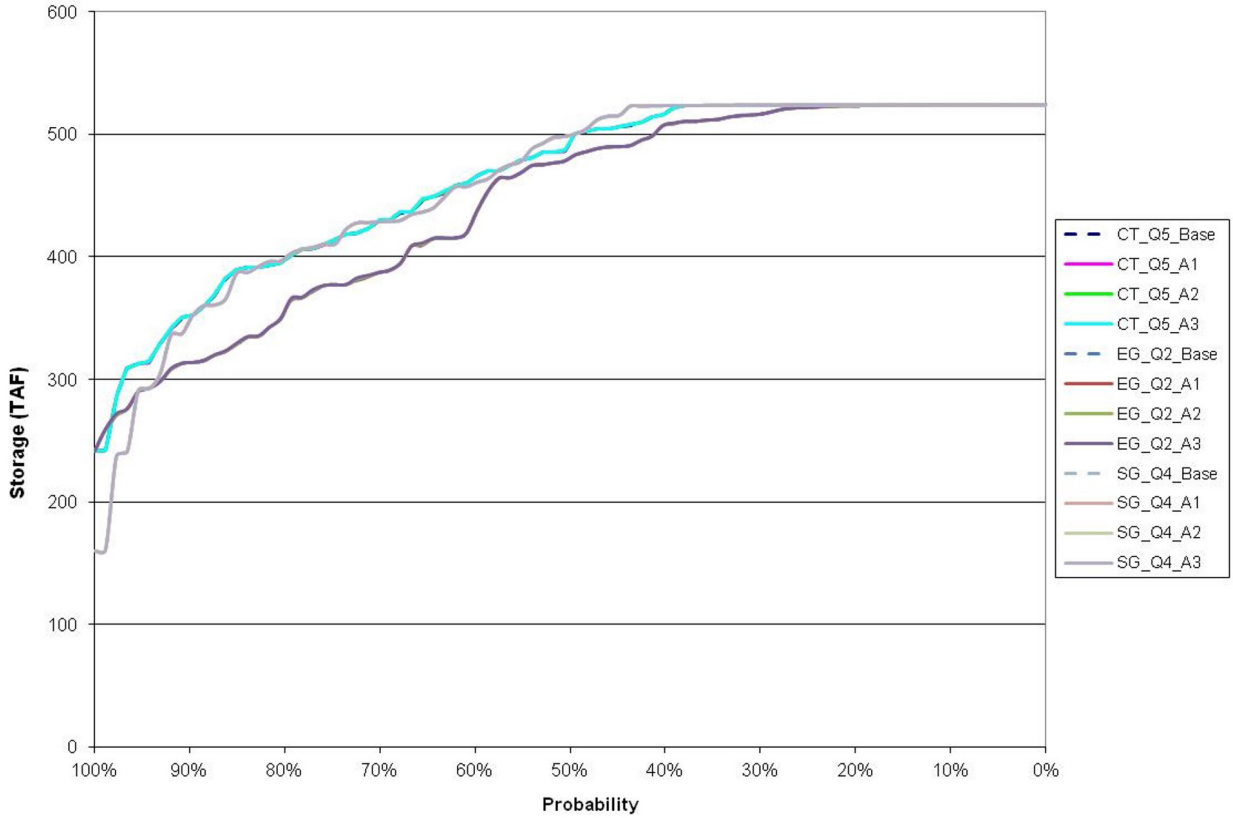

Figure 7-28. Exceedance of Millerton Lake End-of-May Storage in Portfolio A

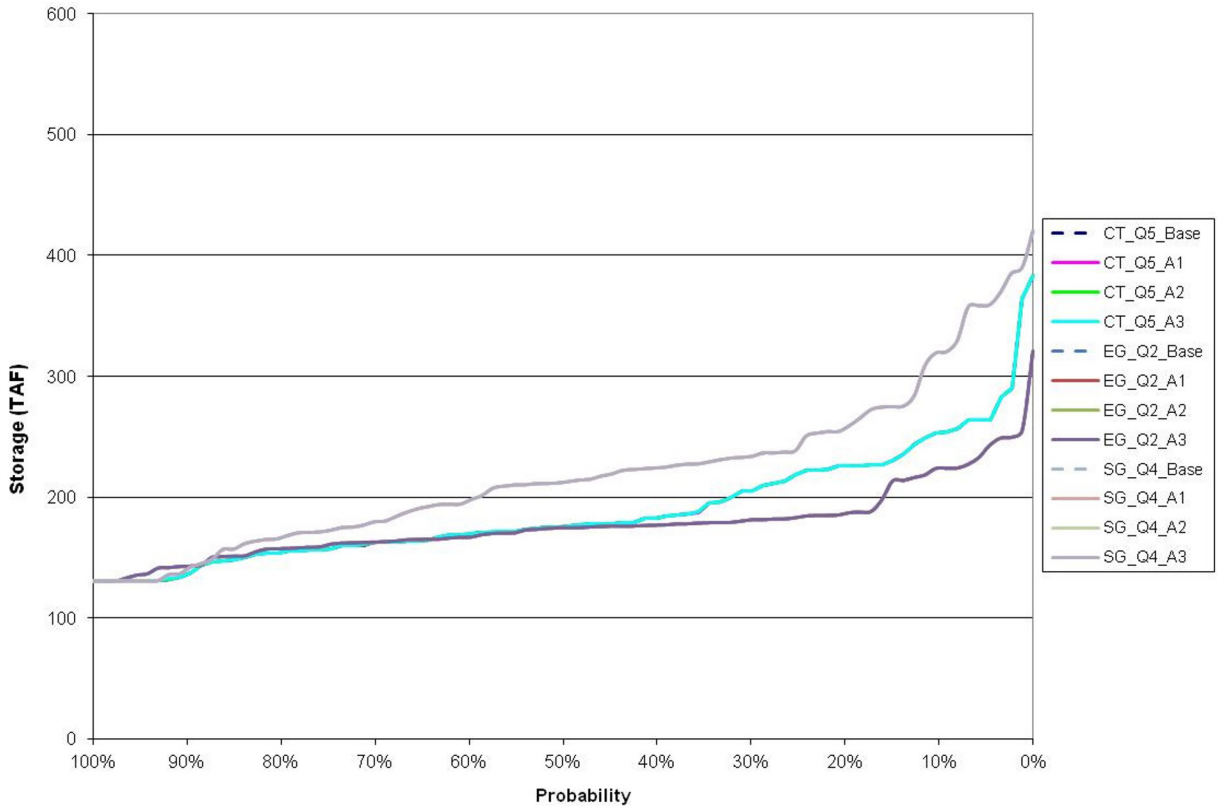

Figure 7-29. Exceedance of Millerton Lake End-of-September Storage in Portfolio A

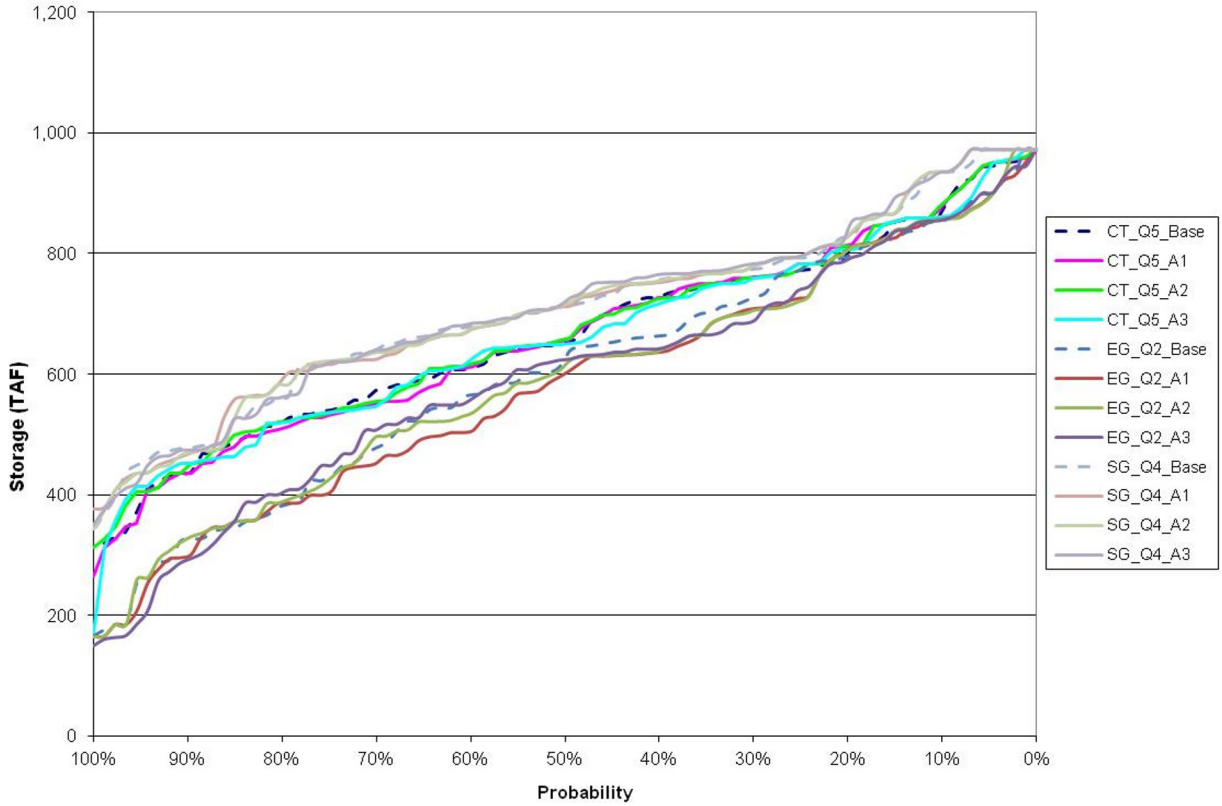

Figure 7-30. Exceedance of CVP San Luis End-of-May Storage in Portfolio A

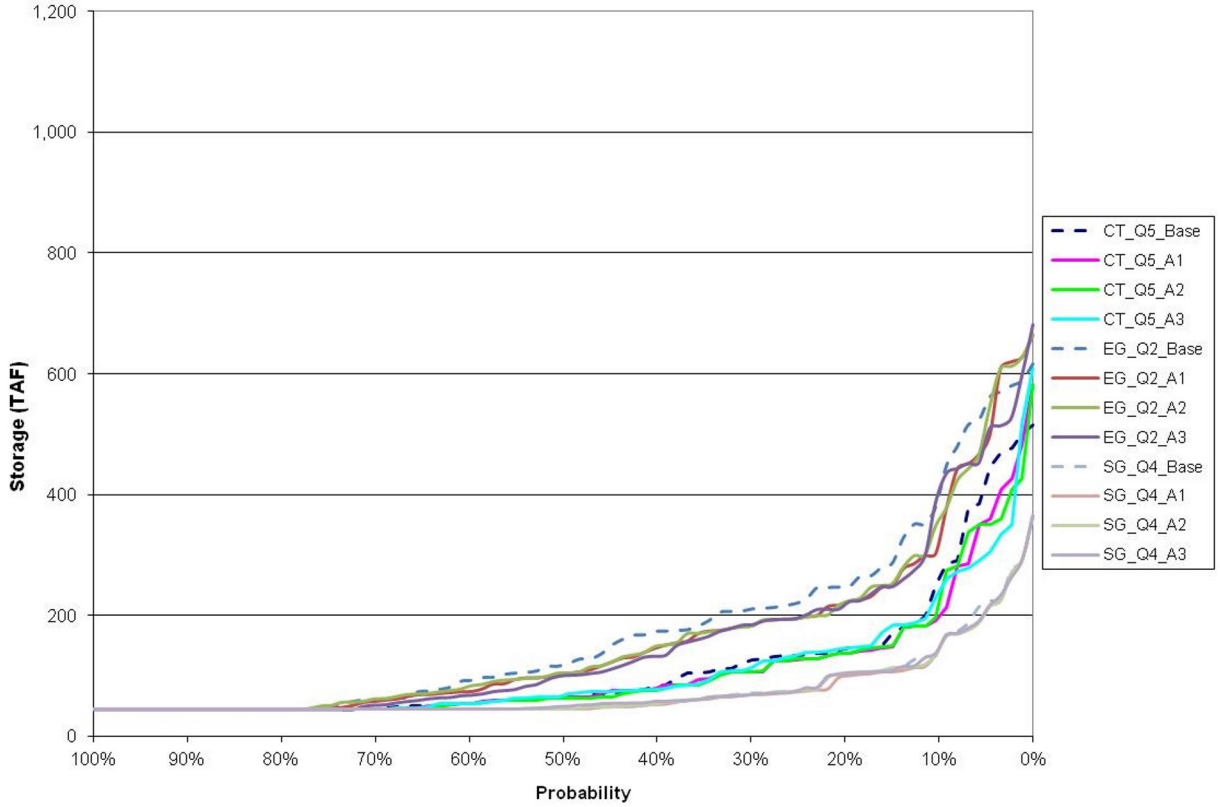

Figure 7-31. Exceedance of CVP San Luis End-of-September Storage in Portfolio A

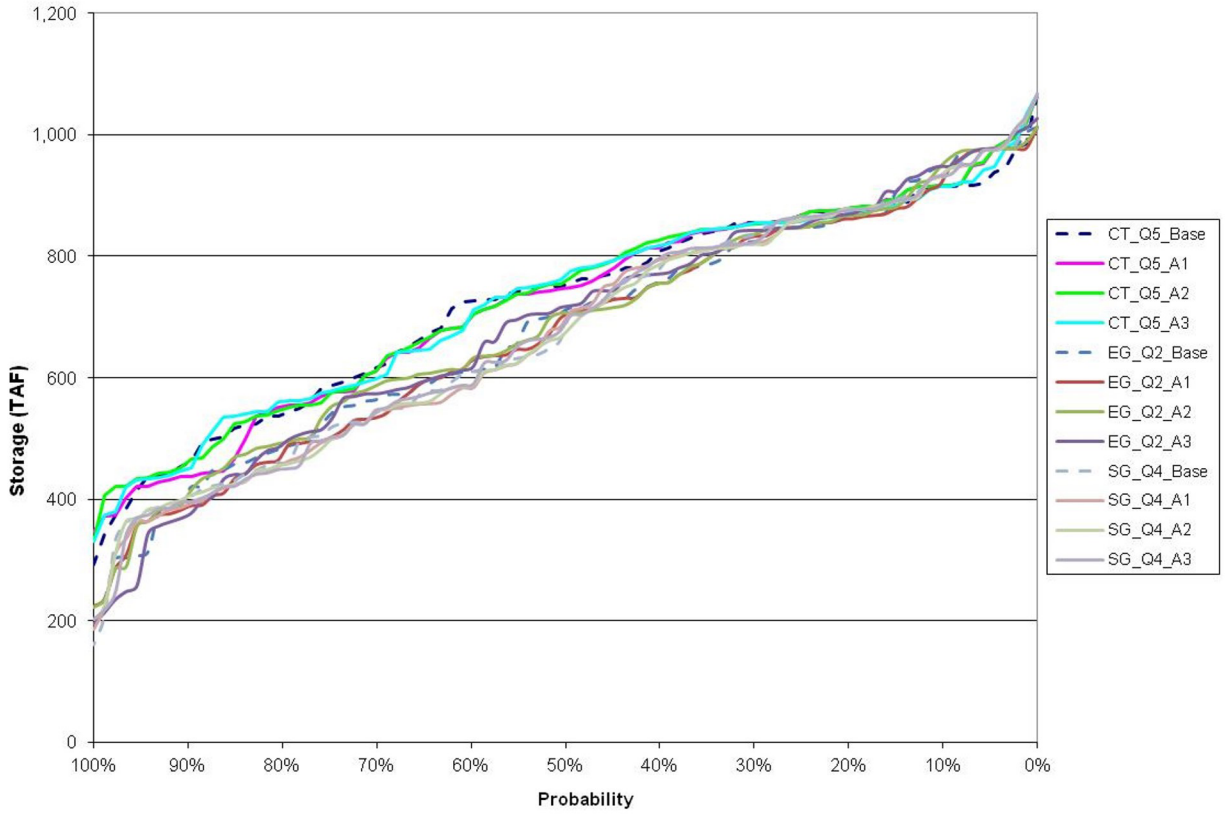

Figure 7-32. Exceedance of SWP San Luis End-of-May Storage in Portfolio A

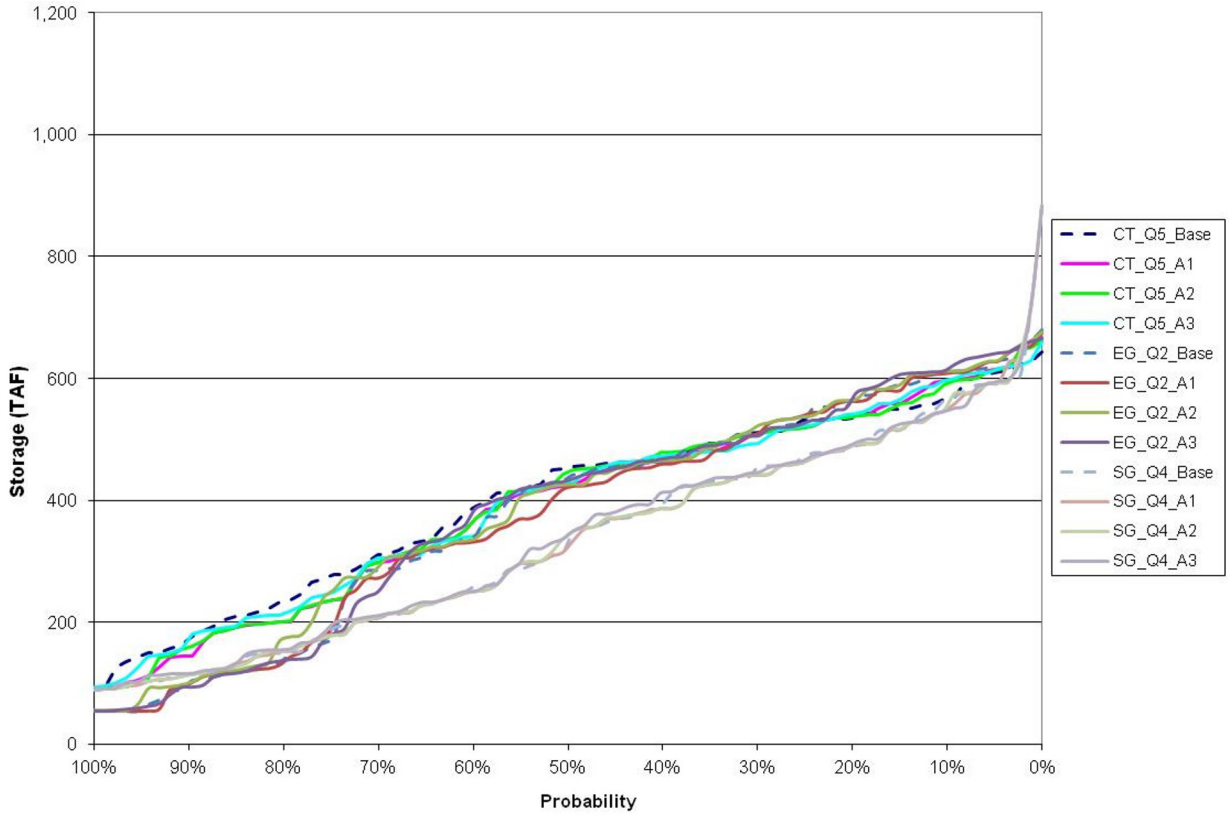

Figure 7-33. Exceedance of SWP San Luis End-of-September Storage in Portfolio A

scenario, the CT-Q5 scenario was intermediate, and the EG-Q2 scenario was the lowest. For each socioeconomic-climate scenario, the storage results for A1, A2, and A3 suites showed small increases in storage levels relative to their corresponding Baseline conditions. Storage levels increases for Suite A3 were the highest, reflecting the effects of the greater reduction in CVP demands associated with this suite of combined actions.

7.1.2.2 Delta Exports and Delta Outflow

Figures 7-34 through 7-39 show annual exceedance plots of Delta exports at the Banks PP and Jones PP, and total export pumping for the CT Q5, EG-Q2, and SG Q4 scenarios, and the change in annual average flows relative to the Baseline at these locations for all 18 socioeconomic-climate scenarios. Figures 7-40 and 7-41 show the same information for Delta outflow. Total average annual Delta exports were similar with the modest conservation A1 actions and with the addition of local water supply actions in A2, with increases ranging from 0 to 65 TAF/year in A1 and A2 across the range of scenarios. There were larger increases relative to the Baseline with addition of aggressive conservation actions in the A3 suite. They ranged from 22 to 117 TAF/year across the range of scenarios. These increases in exports occurred because of reduced CVP demands in the Sacramento Valley, which made more water available for exports. The increases in exports tended to be greater at the Banks PP than at the Jones PP, because greater incremental pumping capacity exists at Banks than at Jones relative to pumping already occurring in the Baseline.

The greatest increases in exports occurred with the drier climate scenarios (Q1 and Q2) because the lower export levels in the Baseline in these scenarios allowed for more incremental pumping under the Portfolio A actions. Conversely, the smallest increases in exports occurred with the wetter climate scenarios (Q3 and Q4) where pumping was already at the maximum in many years in the Baseline, leaving less capacity for additional exports under Portfolio A.

Delta outflows also increased in A1, A2, and A3 by amounts that were much greater than the increases in Delta exports. Consistent with the changes in exports, the greatest increases occurred with the

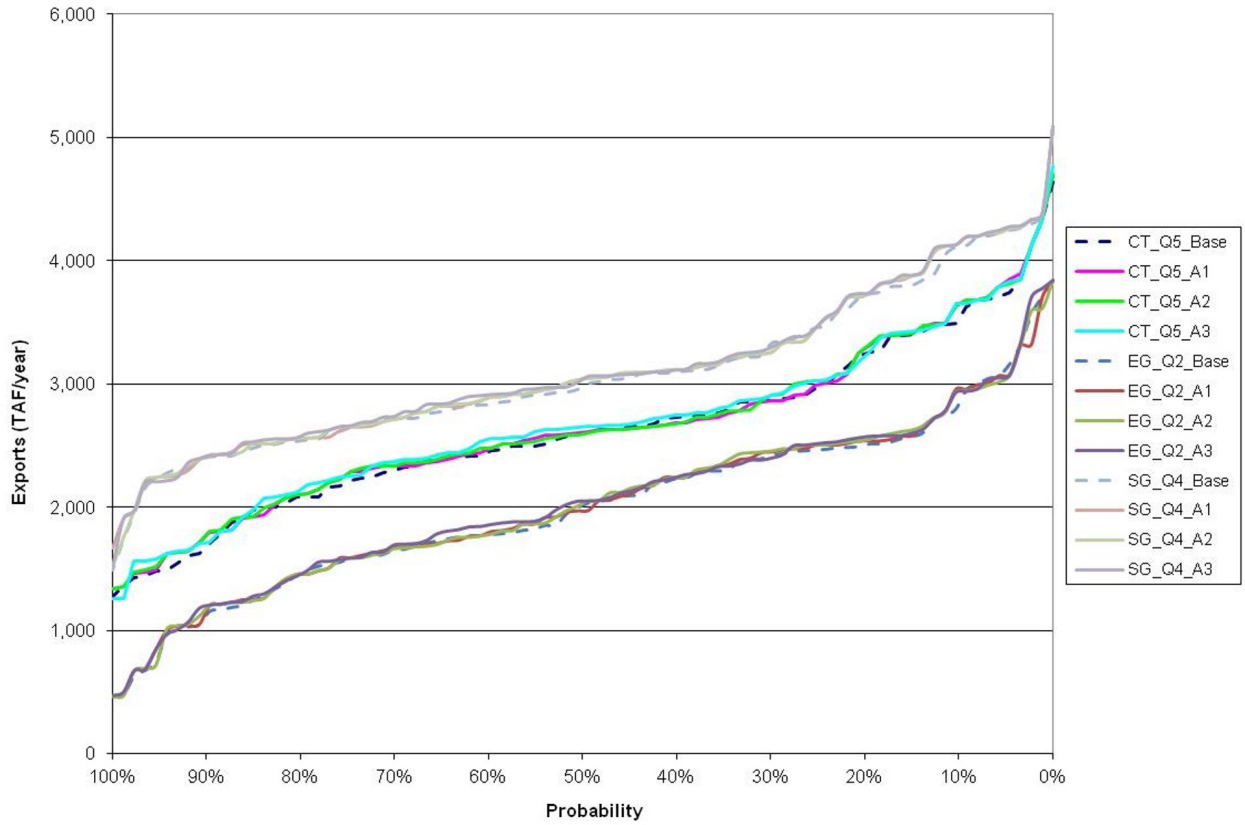

Figure 7-34. Annual Exceedance of Banks Pumping in Portfolio A

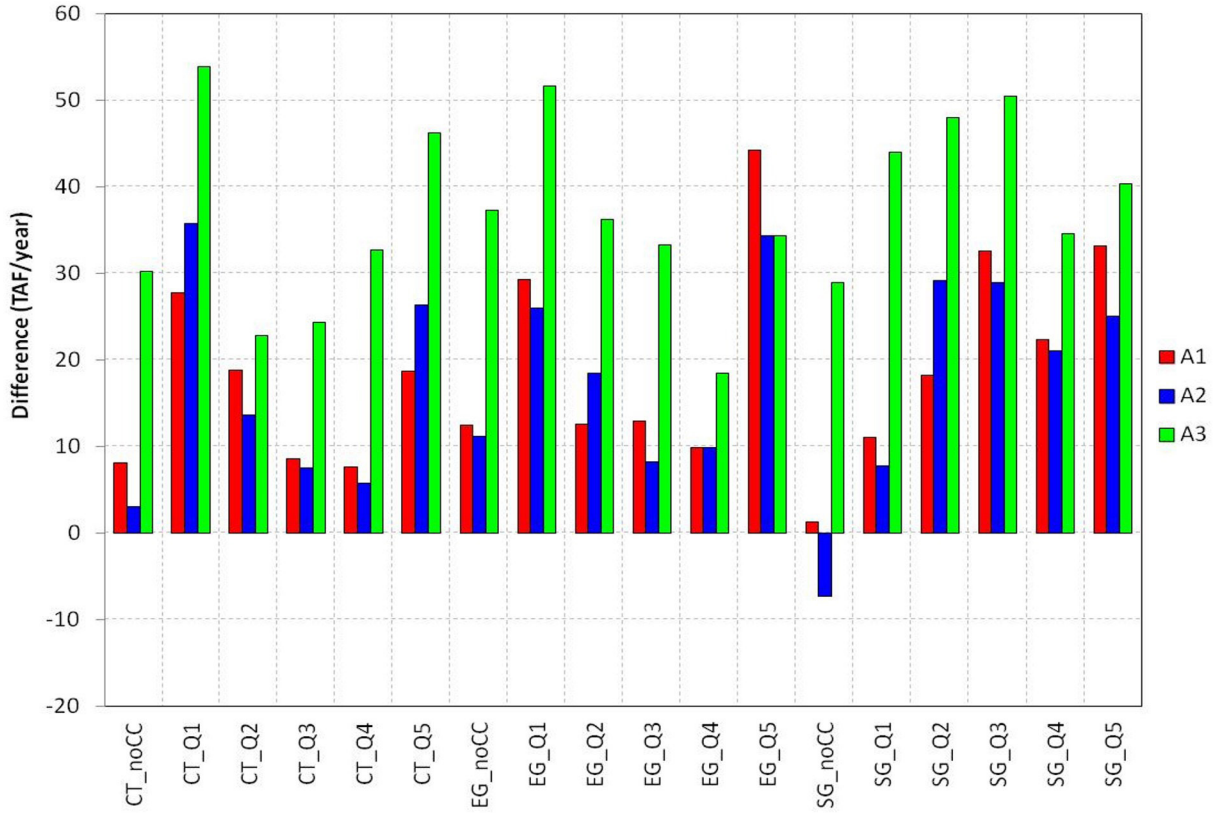

Figure 7-35. Average Annual Change in Banks Pumping for Portfolio A Relative to the Baseline in Each Scenario

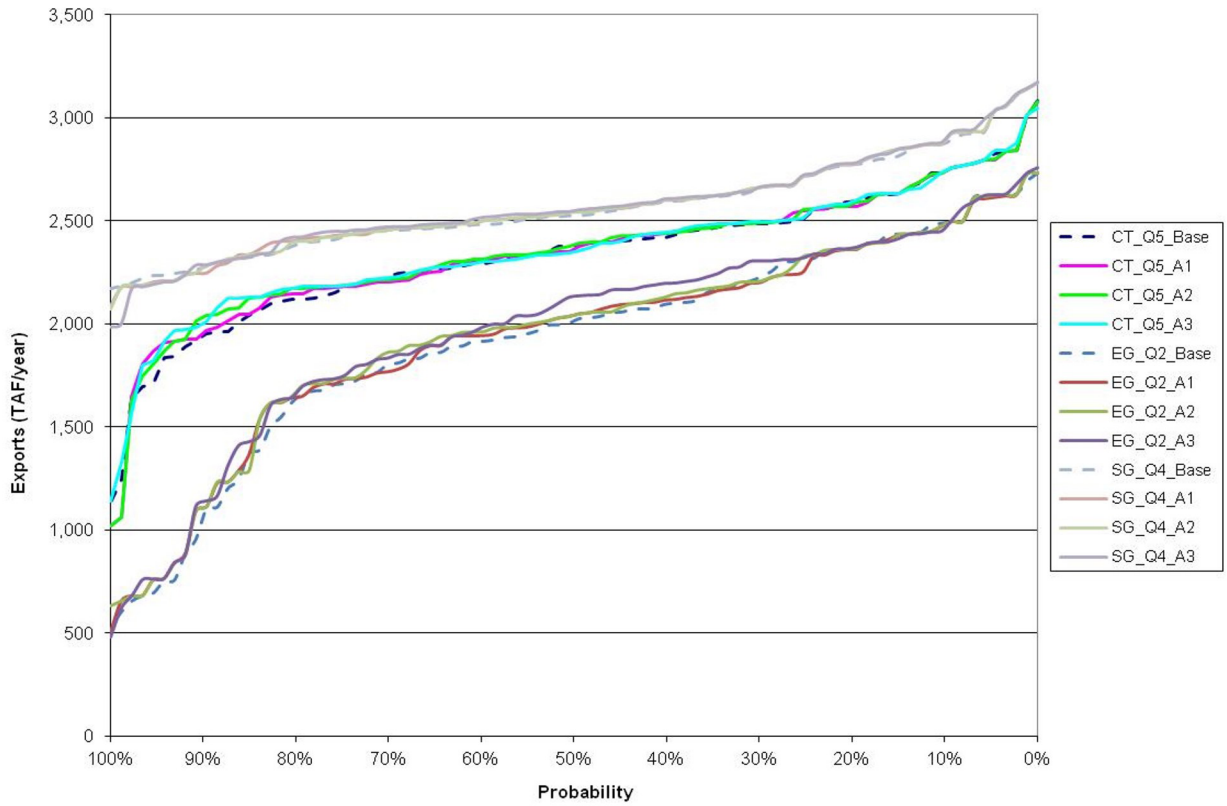

Figure 7-36. Annual Exceedance of Jones Pumping in Portfolio A

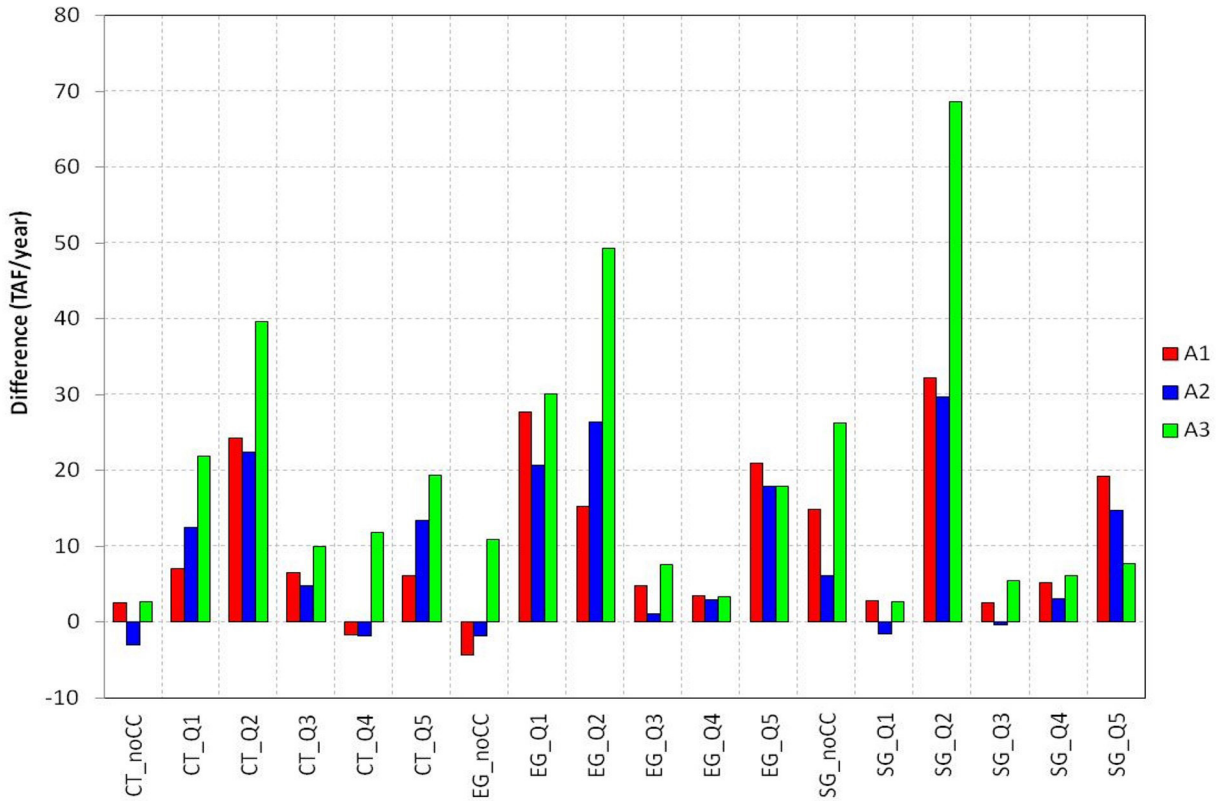

Figure 7-37. Average Annual Change in Jones Pumping for Portfolio A Relative to the Baseline in Each Scenario

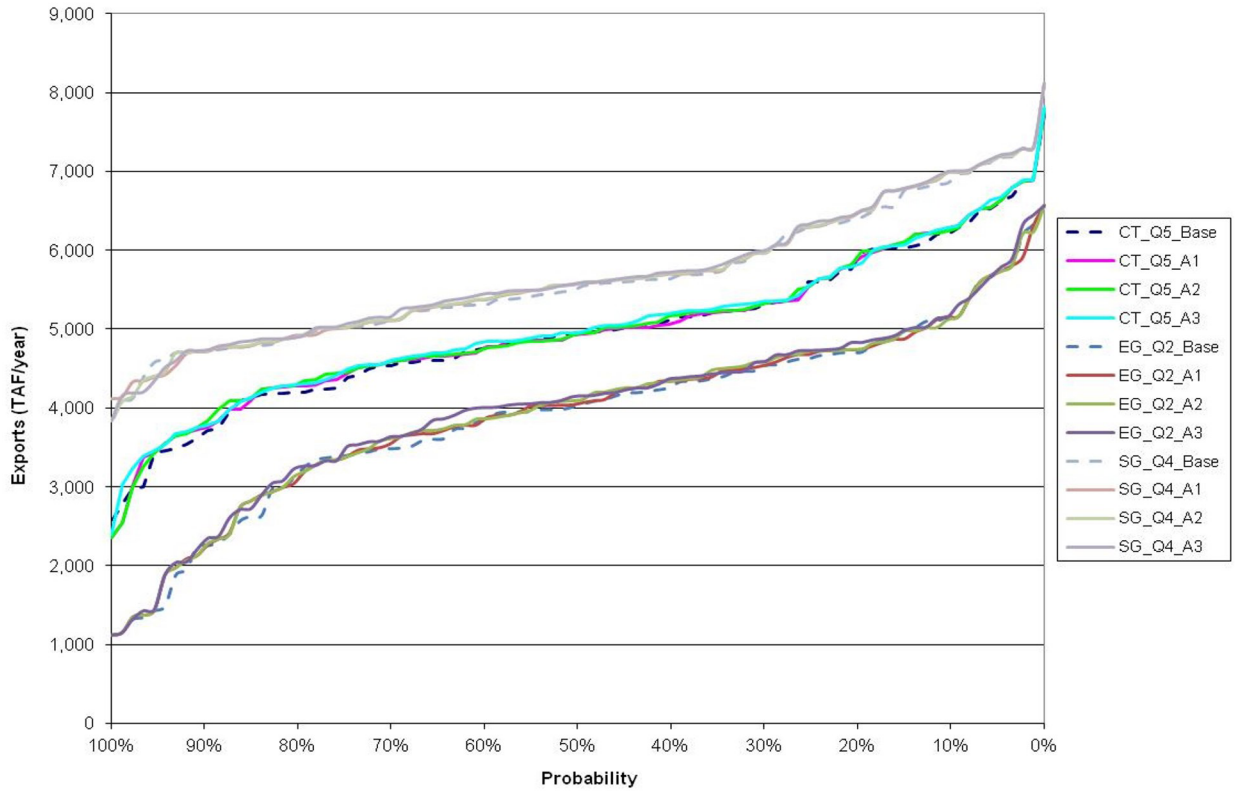

Figure 7-38. Annual Exceedance of Total Delta Exports in Portfolio A

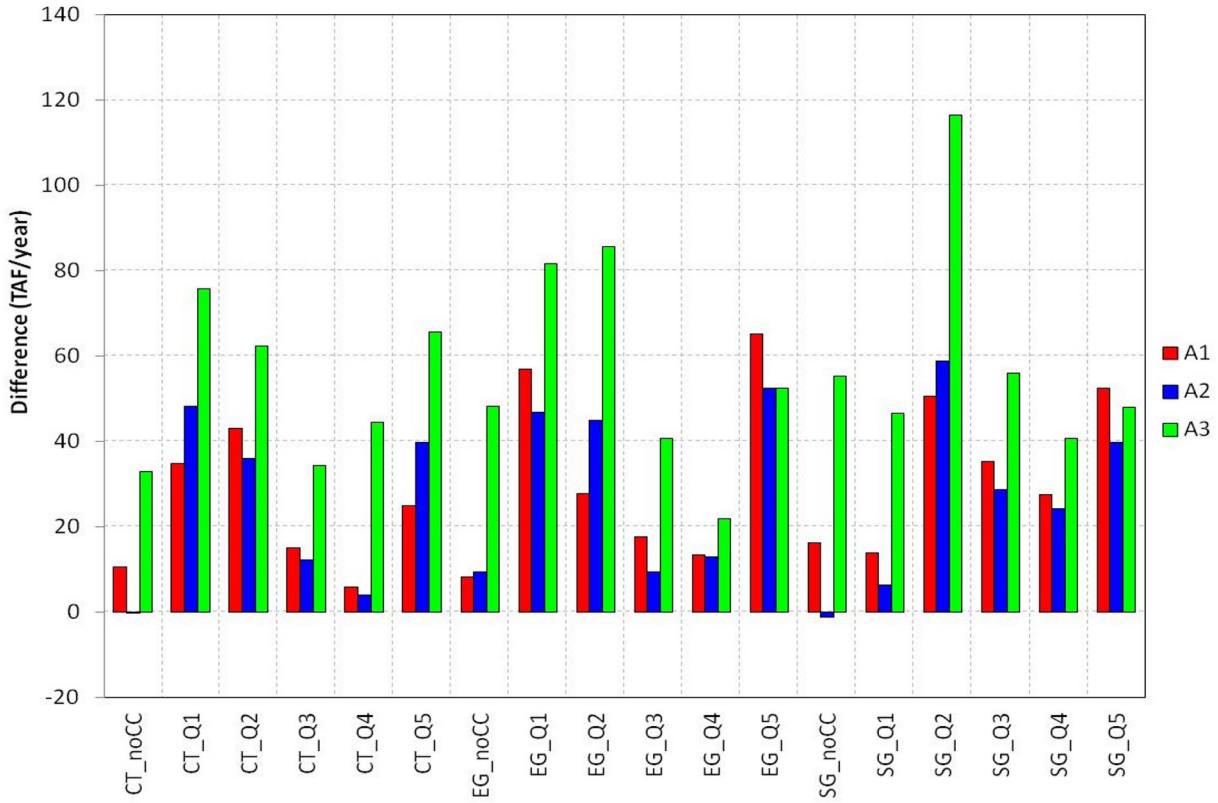

Figure 7-39. Average Annual Change in Total Delta Exports for Portfolio A Relative to the Baseline in Each Scenario

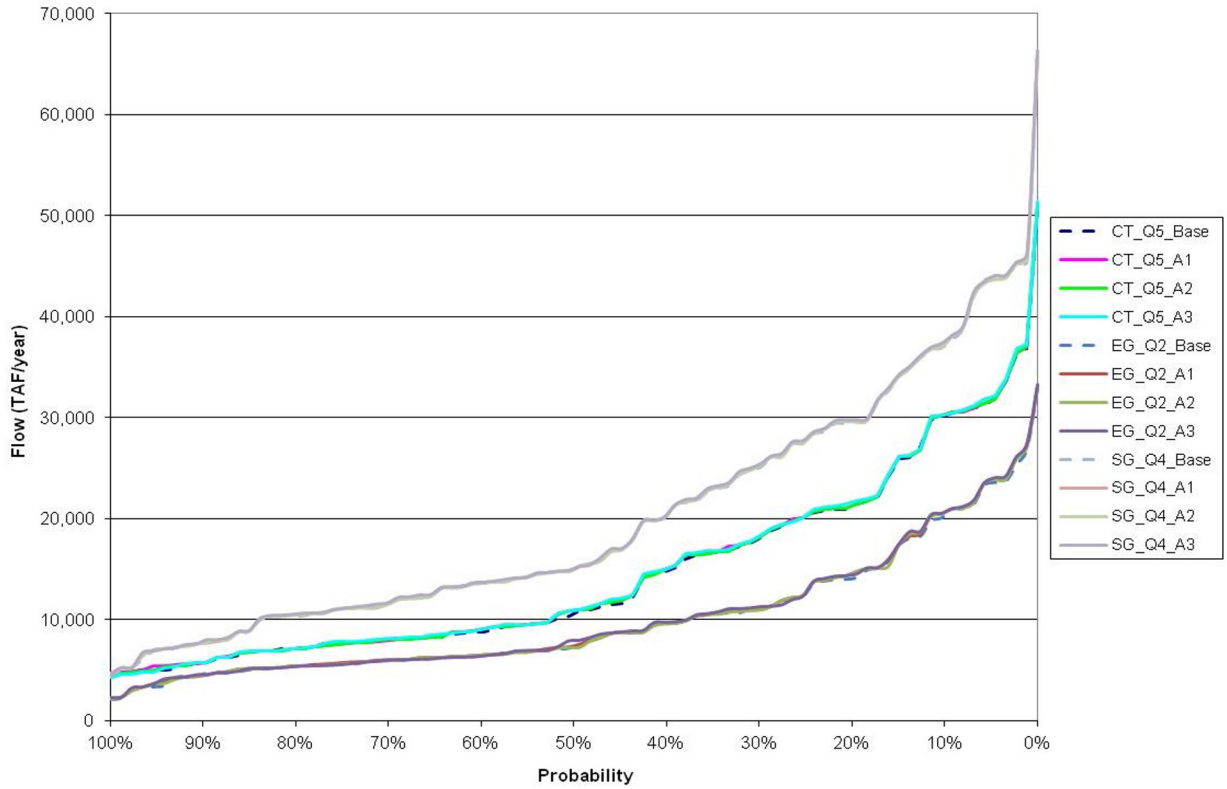

Figure 7-40. Annual Exceedance of Delta Outflow in Portfolio A

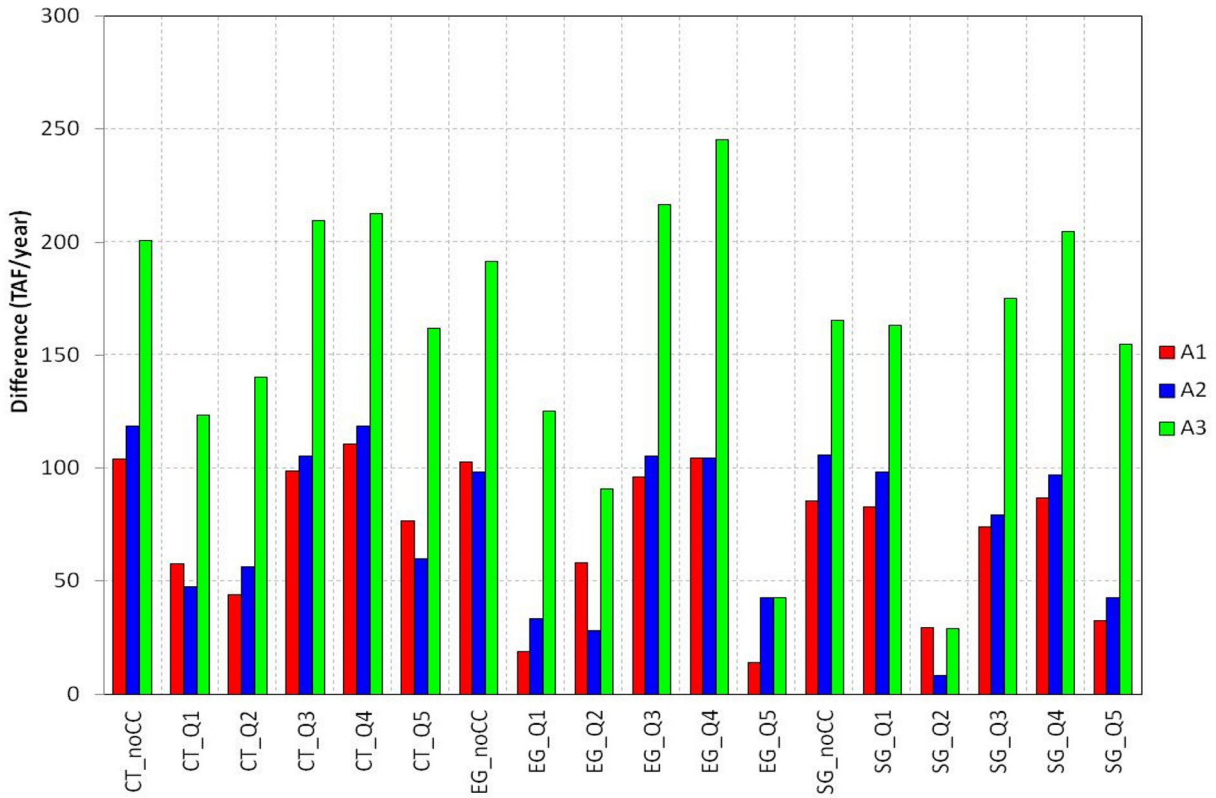

Figure 7-41. Average Annual Change in Delta Outflow for Portfolio A Relative to the Baseline in Each Scenario

wetter climate scenarios (Q3 and Q4), and the smallest increases occurred with the drier climate scenarios (Q1 and Q2). Thus, in the wetter climate scenarios, only a very small amount of the extra flow that was made available by reduced demands in the Sacramento Valley was able to be exported.

7.1.2.3 Delta Salinity

Figure 7-42 shows the average X2 position from February through June in each scenario with Portfolio A actions. Figure 7-43 is an exceedance plot of the average X2 position from February through June under CT-Q5, EG-Q2, and SG Q4 scenarios. The changes in X2 position were relatively small, reflecting the relatively small changes in Portfolio A Delta flows relative to the Baseline conditions.

7.1.3 Other Performance Assessments

7.1.3.1 Economics

Figures 7-44 through 7-47 show the improvement in net water supply system costs from the urban economic models LCPSIM and OMWEM; the net improvement in avoided cost from the water quality economic model SBWQM; and the improvement in net agricultural revenue from SWAP for each of the Portfolio A simulation suites under the CT-Q5, EG-Q2, and SG-Q4 scenarios at the 2025, 2055, and 2085 LODs.

The South Bay urban economic model results from LCPSIM showed almost no change in economic values in the SG-Q4 scenario, small economic benefits of up to about $10 million per year in the CT-Q5 scenario, and somewhat larger economic benefits of up to about $60 million per year in scenario EG-Q2. These benefits resulted from the reductions in shortage costs due to the increased deliveries to the South Bay region, and were larger in EG-Q2 because the South Bay has very high unmet demands and, therefore, high marginal shortage costs in the Baseline under EG-Q2 due to the increased population in the Expansive Growth socioeconomic scenario and reduced water supplies in the Q2 climate scenario.

Figure 7-48 shows the long-term average salinity at the CCWD and SBA diversion locations in Portfolio A. SBA water quality costs simulated by SBWQM were mixed for Portfolio A. In each simulation, the export amounts increased, but the salinity at the export locations decreased relative to the Baseline. Because these effects counteracted each other in the determination of salinity costs, each simulation had a small increase or decrease in water quality costs relative to the Baseline. In Suite A3, there was a small incremental benefit in avoided salinity cost of about $2–3 million under CT-Q5 assumptions; increased salinity costs of about $3–5 million in EG-Q2; and changes of less than $1 million in SG-Q4.

The changes in Central Valley agricultural economic model results from SWAP and urban economic results from OMWEM showed only small differences as compared to the Baseline (see Figure 7-47), reflecting the small changes in CVP and SWP deliveries in the Central Valley with the implementation of local water management actions. The average annual economic changes across the different scenarios and LODs ranged from a cost of about $14 million per year to a benefit of about $4 million per year for SWAP, and from a cost of about $14 million per year to a benefit of about $4 million per year for OMWEM.

7.1.3.2 Water Temperature

Figures 7-49 through 7-52 show exceedance plots and average changes of daily water temperatures from July through September at the Sacramento River at Keswick and at Jelly's Ferry in Portfolio A suites relative to the Baseline for CT Q5, EG-Q2, and SG-Q4 scenarios. In all three Portfolio A suites, the mean daily water temperatures in the Sacramento River at Keswick were about 0–0.3°F lower than in the Baseline; and the mean daily water temperatures at Jelly's Ferry were about 0–0.2°F lower than the Baseline across the range of scenarios. These small changes in water temperature occurred because of the increased storage and available coldwater pool in Shasta Lake due to the demand reduction actions. As observed in the Baseline, the SG-Q4 (less warming, wetter) scenario had the lowest water temperatures; and the EG-Q2 (more warming, drier) scenario had the highest water temperatures, with CT-Q5 (consensus projection) falling between them.

Figures 7-53 through 7-58 show exceedance plots and average changes in daily water temperatures for Portfolio A suites relative to the Baseline in the San Joaquin River at Lost Lake, at Gravelly Ford, and at Vernalis from August through November. There were minimal changes in mean daily water

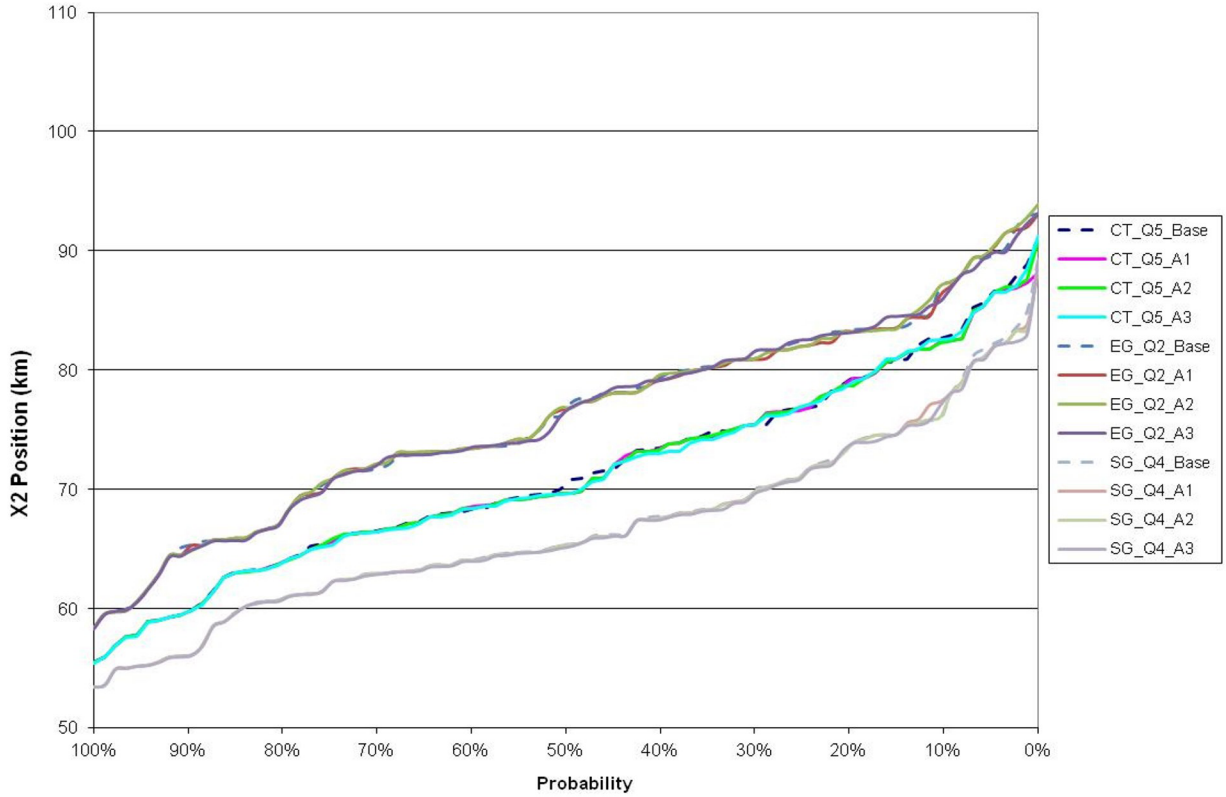

Figure 7-42. Exceedance of Average February-to-June X2 Position in Portfolio A

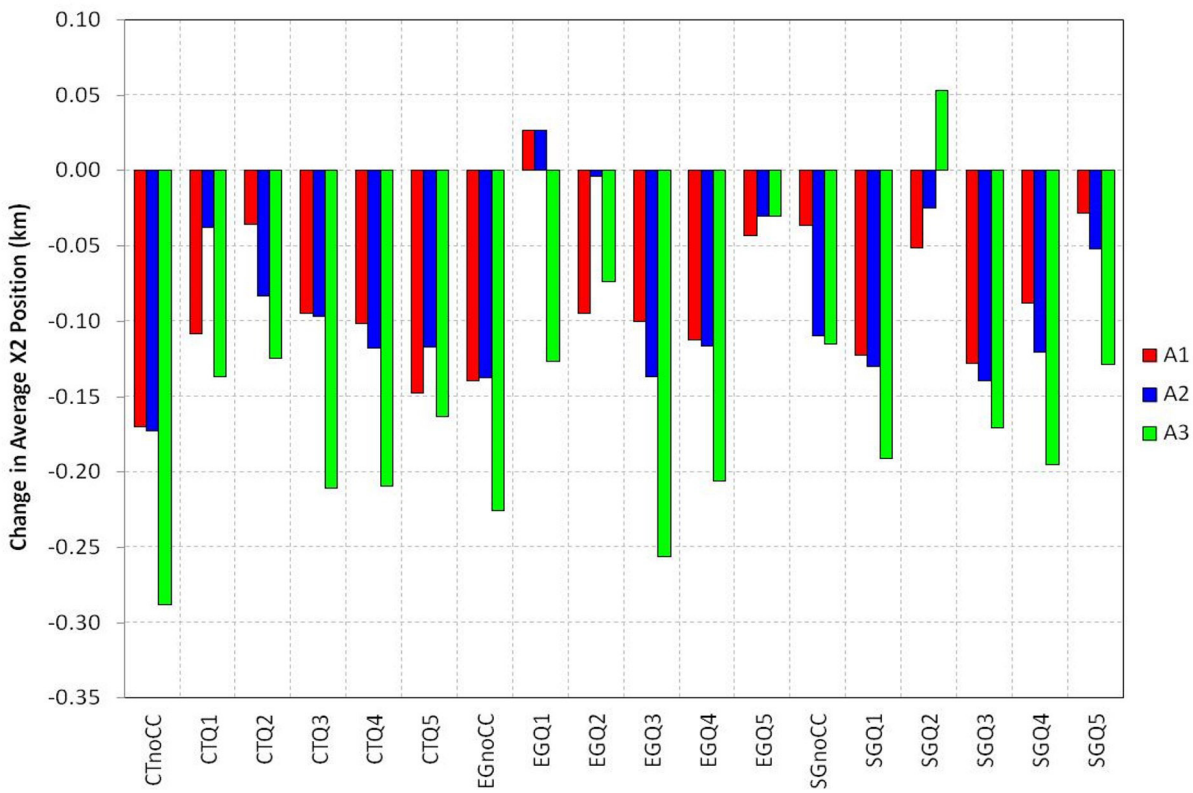

Figure 7-43. Change in Average February-to-June X2 Position for Portfolio A Relative to the Baseline in Each Scenario

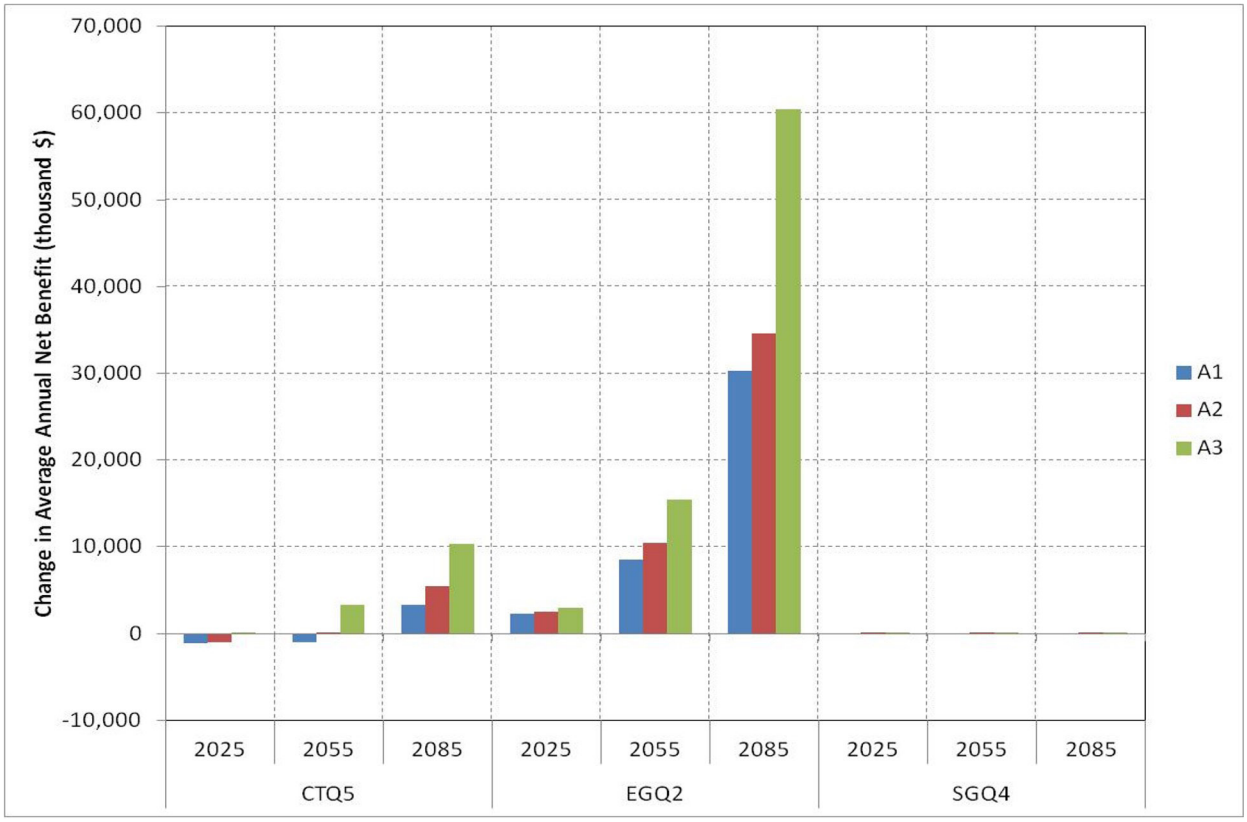

Figure 7-44. Improvement in Average Annual Urban Net Water Supply System Costs in South Bay Region from LCPSIM in Portfolio A

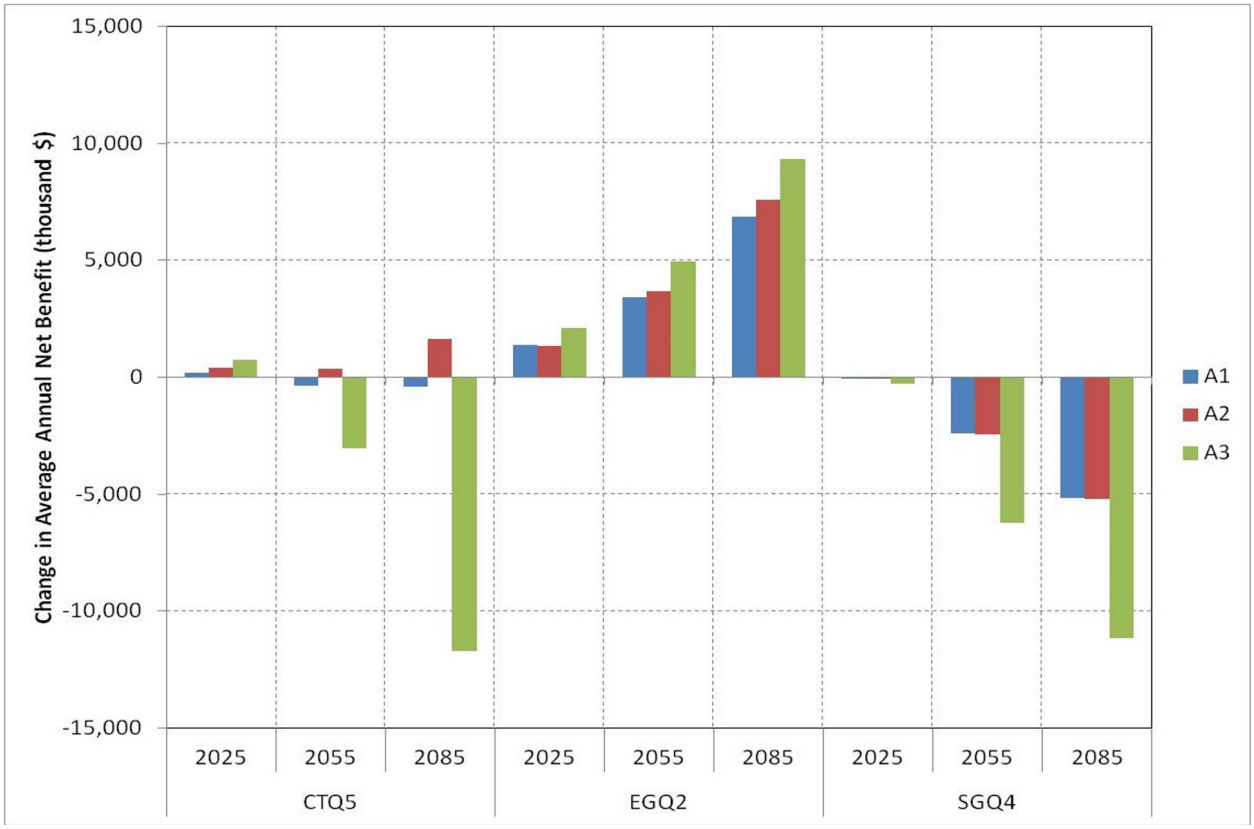

Figure 7-45. Improvement in Average Annual Urban Net Water Supply System Costs in Central Valley from OMWEM in Portfolio A

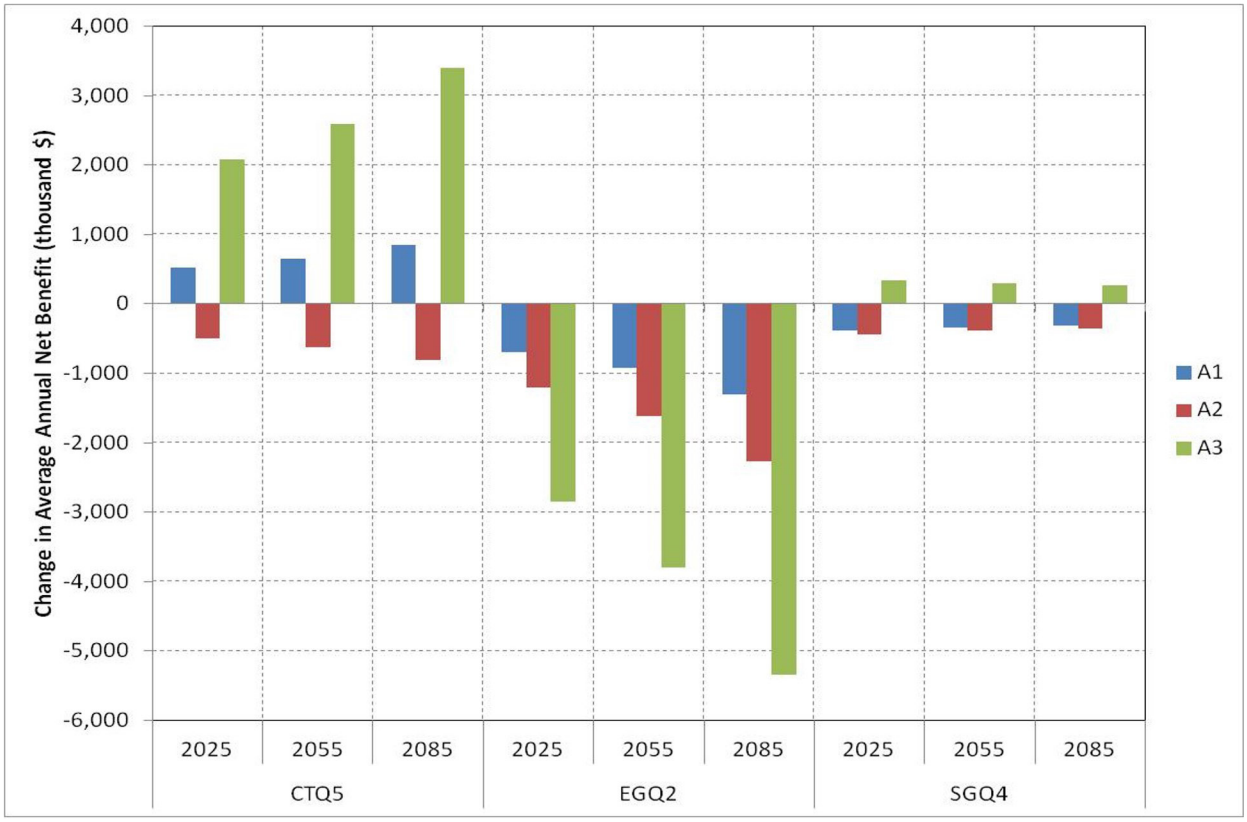

Figure 7-46. Improvement in Average Annual Avoided Water Quality Costs in South Bay Region from SBWQM in Portfolio A

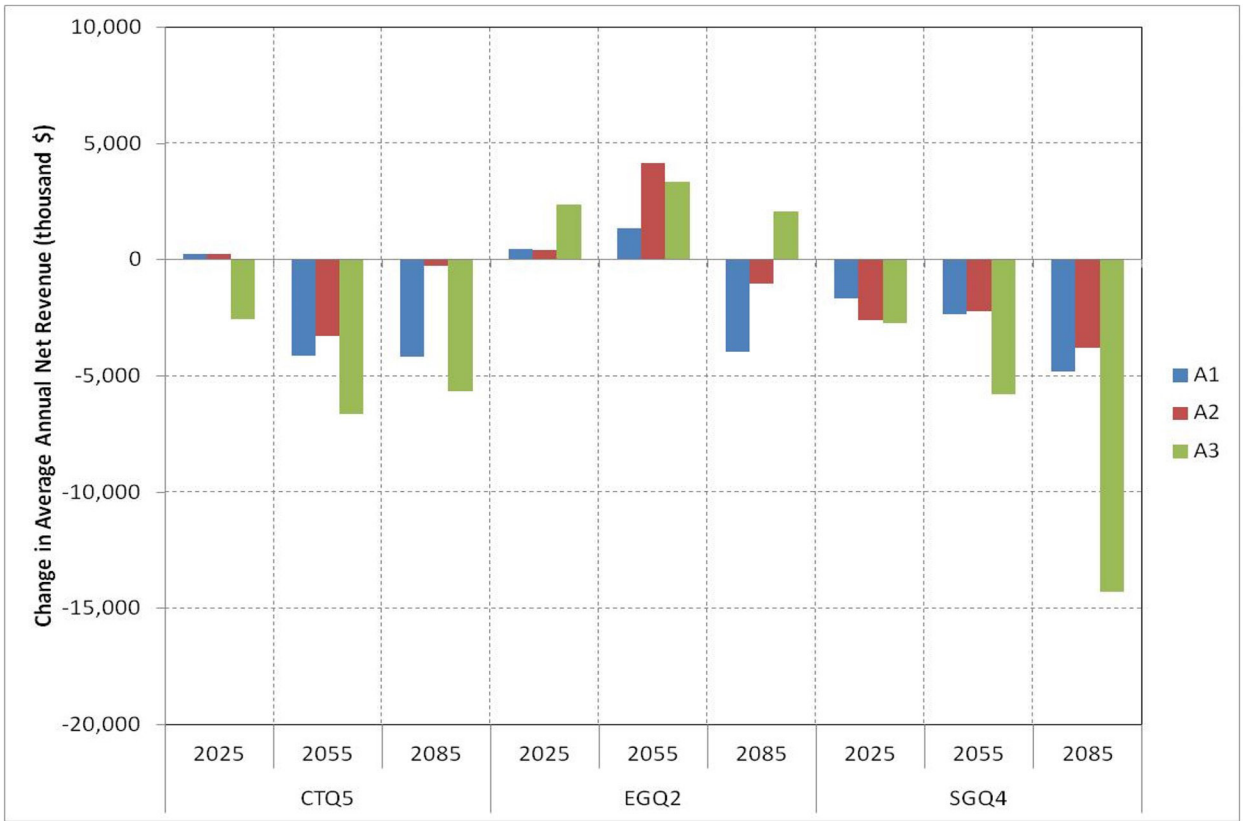

Figure 7-47. Improvement in Average Annual Agricultural Net Revenue in Central Valley from SWAP in Portfolio A

Figure 7-48. Long-Term Average Salinity at CCWD and SBA Diversion Locations in Portfolio A

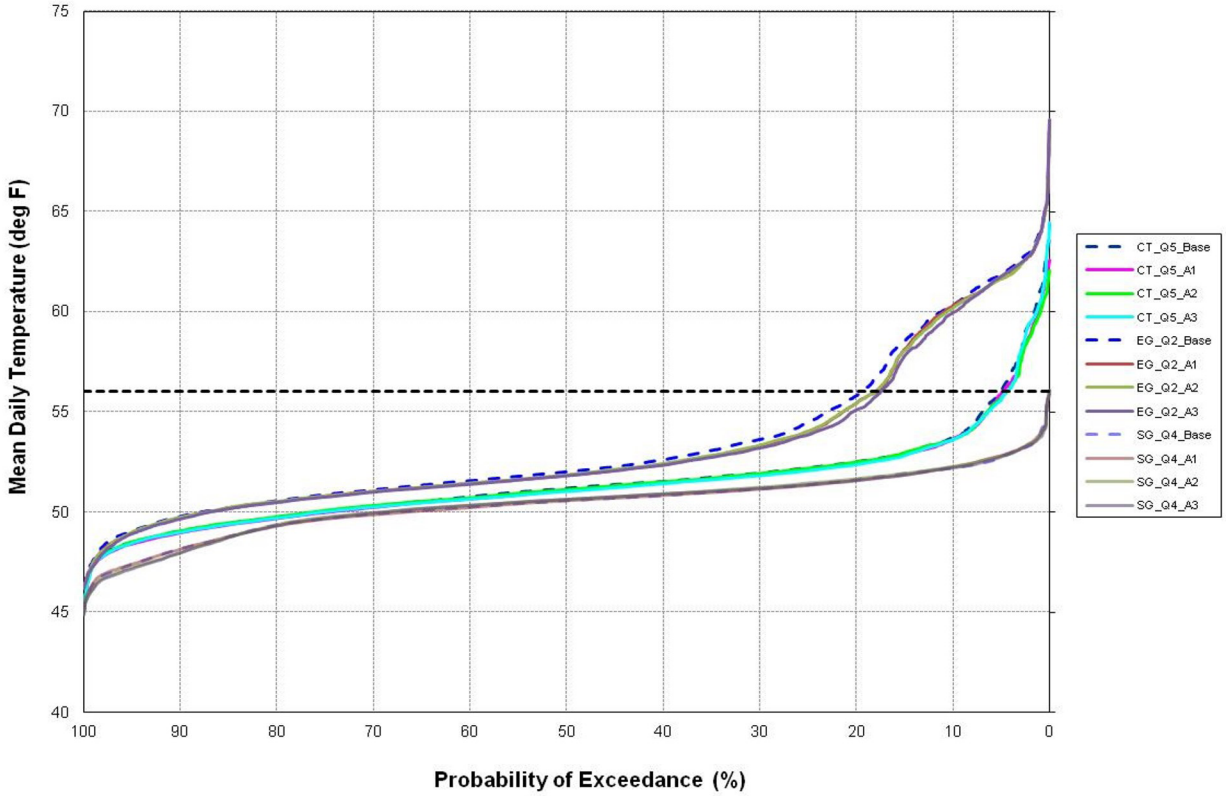

Figure 7-49. Exceedance of Mean Daily Temperature on Sacramento River at Keswick from July to September in Portfolio A

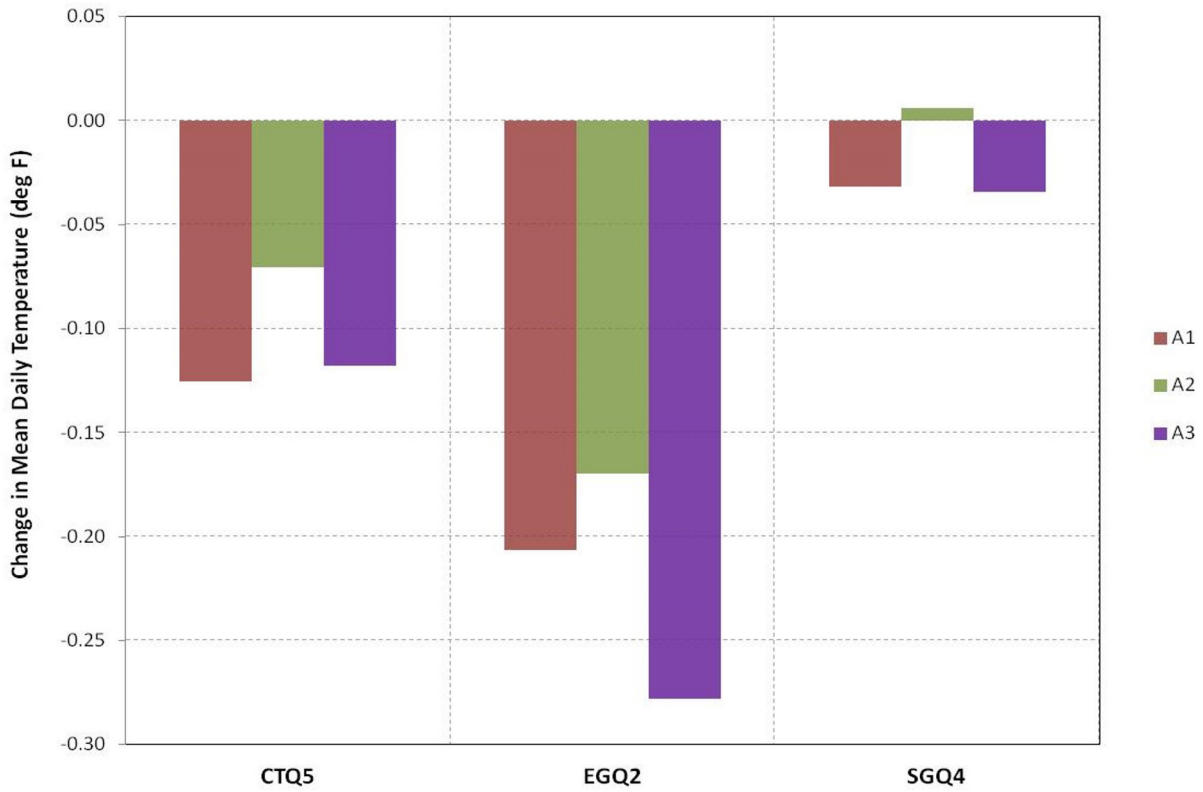

Figure 7-50. Change in Mean Daily Temperature on Sacramento River at Keswick from July to September in Portfolio A

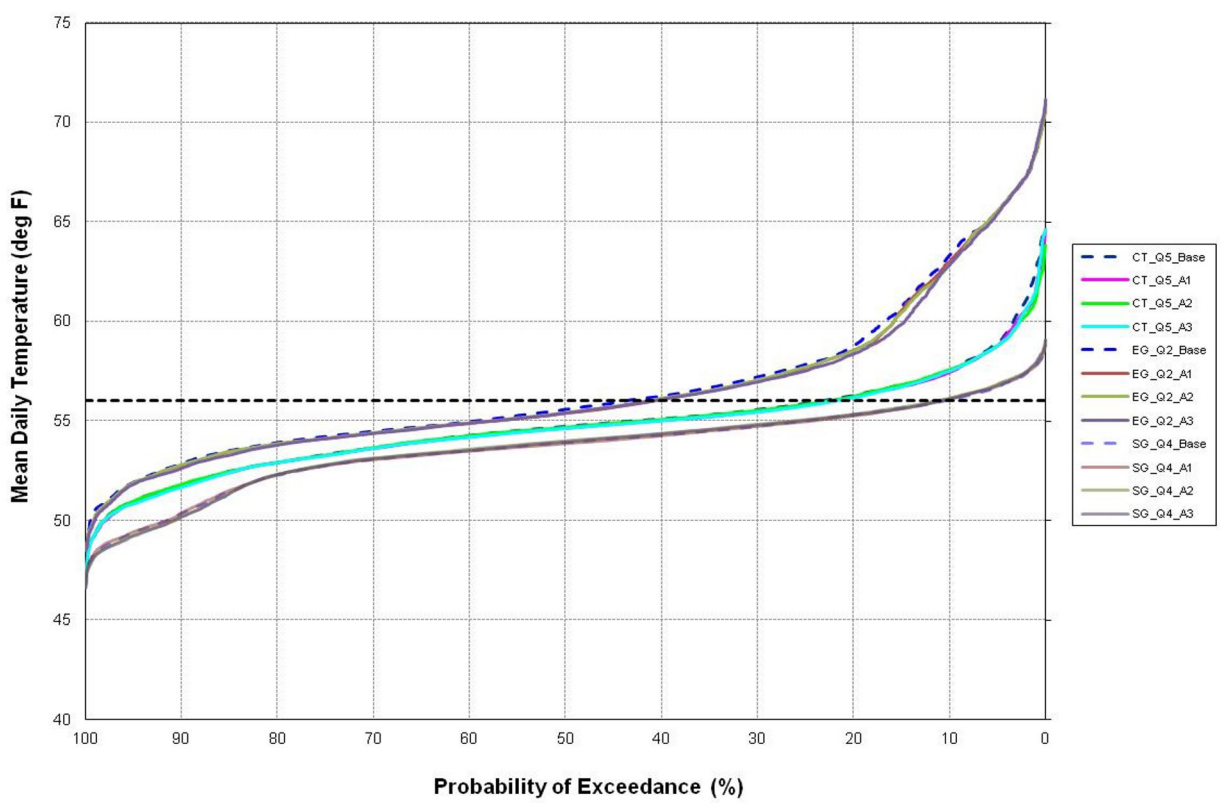

Figure 7-51. Exceedance of Mean Daily Temperature on Sacramento River at Jelly's Ferry from July to September in Portfolio A

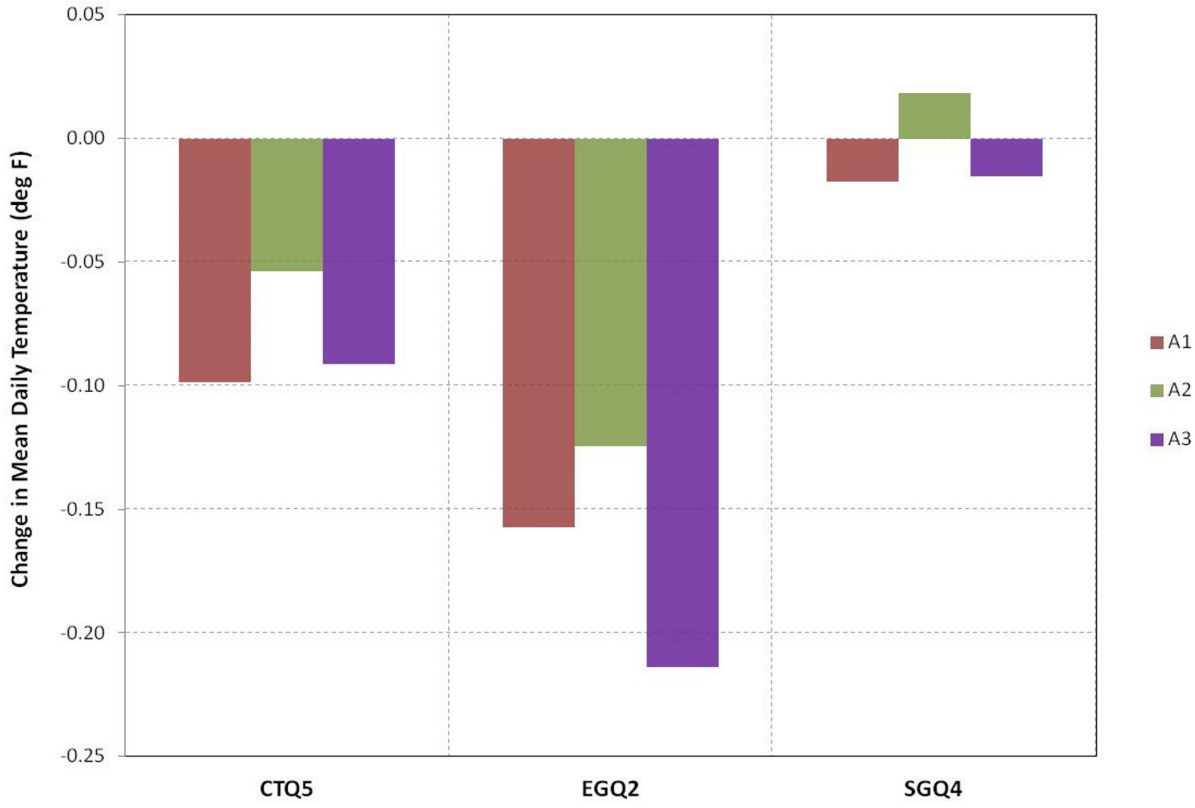

Figure 7-52. Change in Mean Daily Temperature on Sacramento River at Jelly's Ferry from July to September in Portfolio A

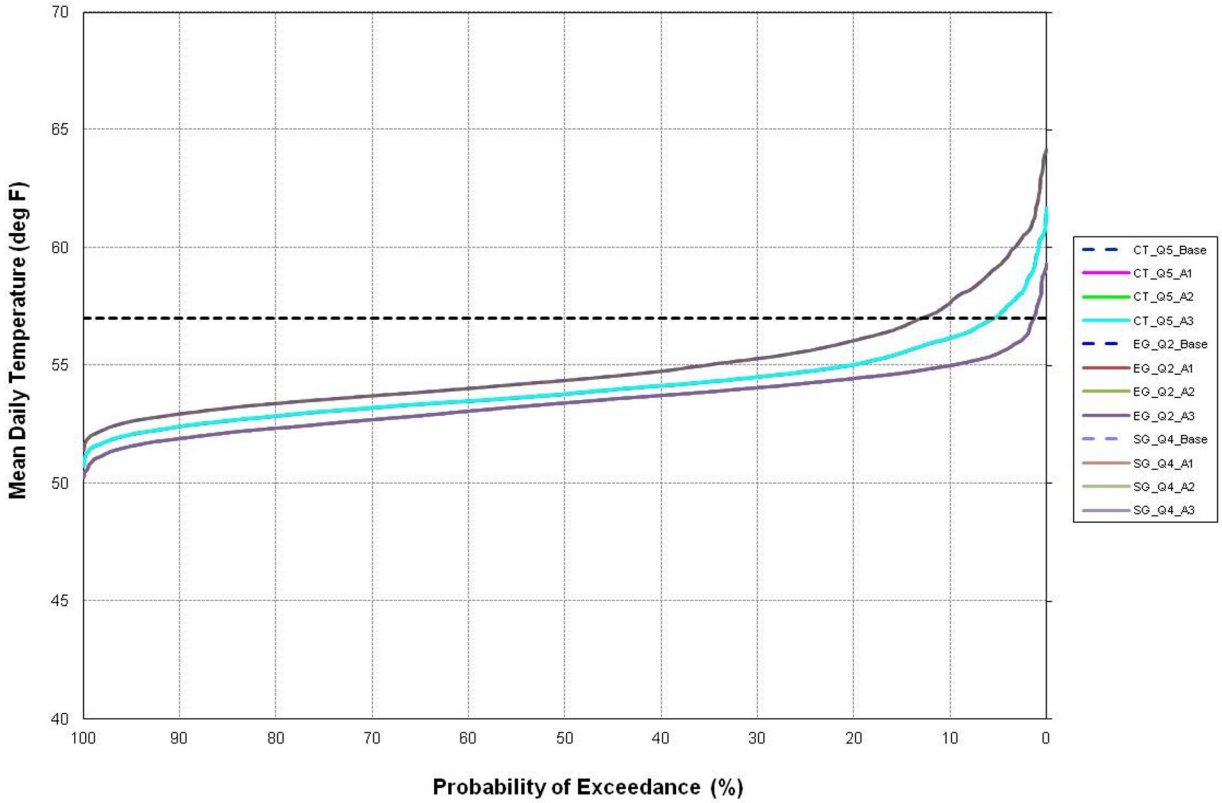

Figure 7-53. Exceedance of Mean Daily Temperature on San Joaquin River at Lost Lake from August to November in Portfolio A

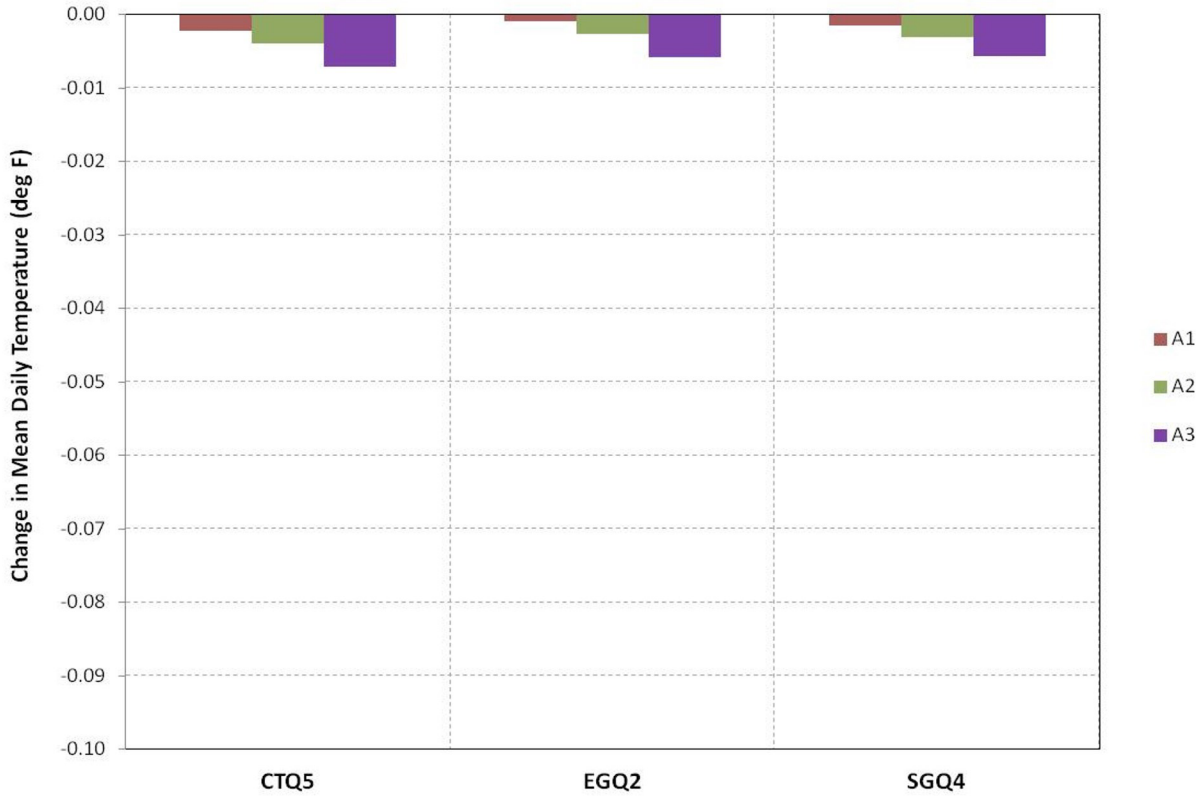

Figure 7-54. Change in Mean Daily Temperature on San Joaquin River at Lost Lake from August to November in Portfolio A

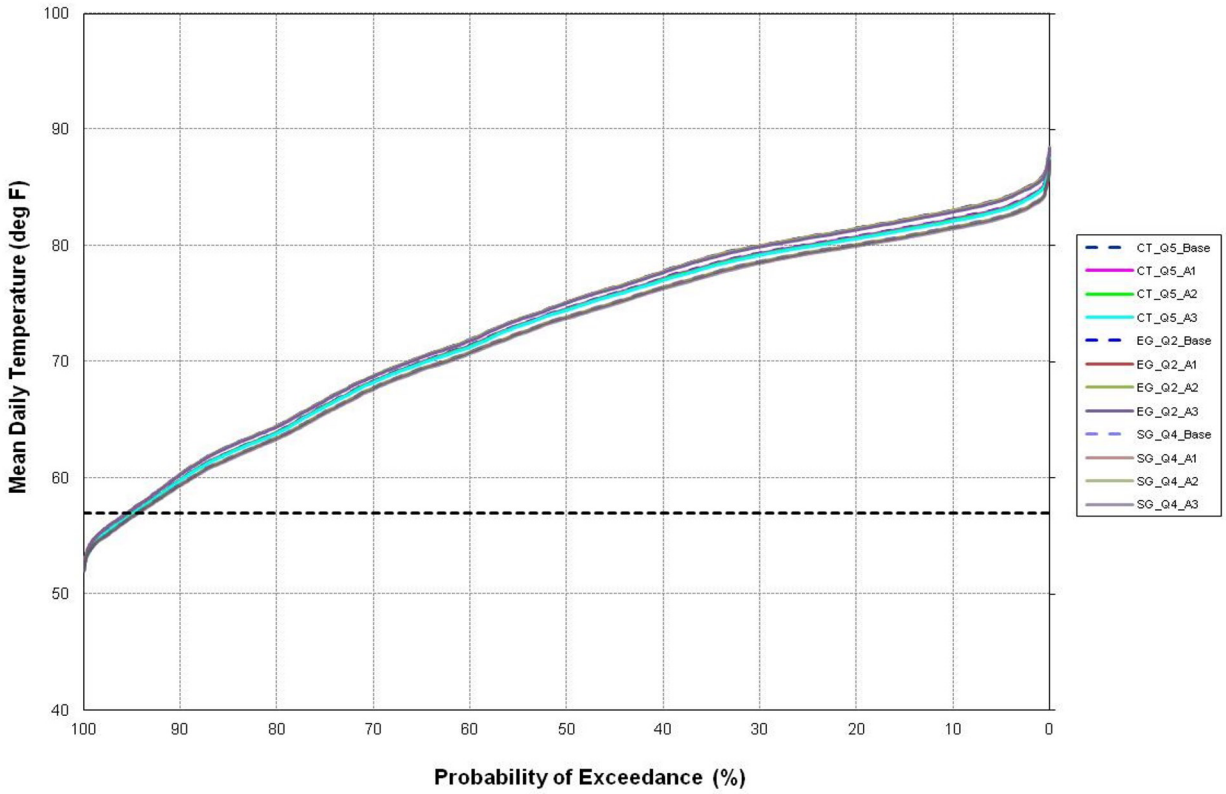

Figure 7-55. Exceedance of Mean Daily Temperature on San Joaquin River at Gravelly Ford from August to November in Portfolio A

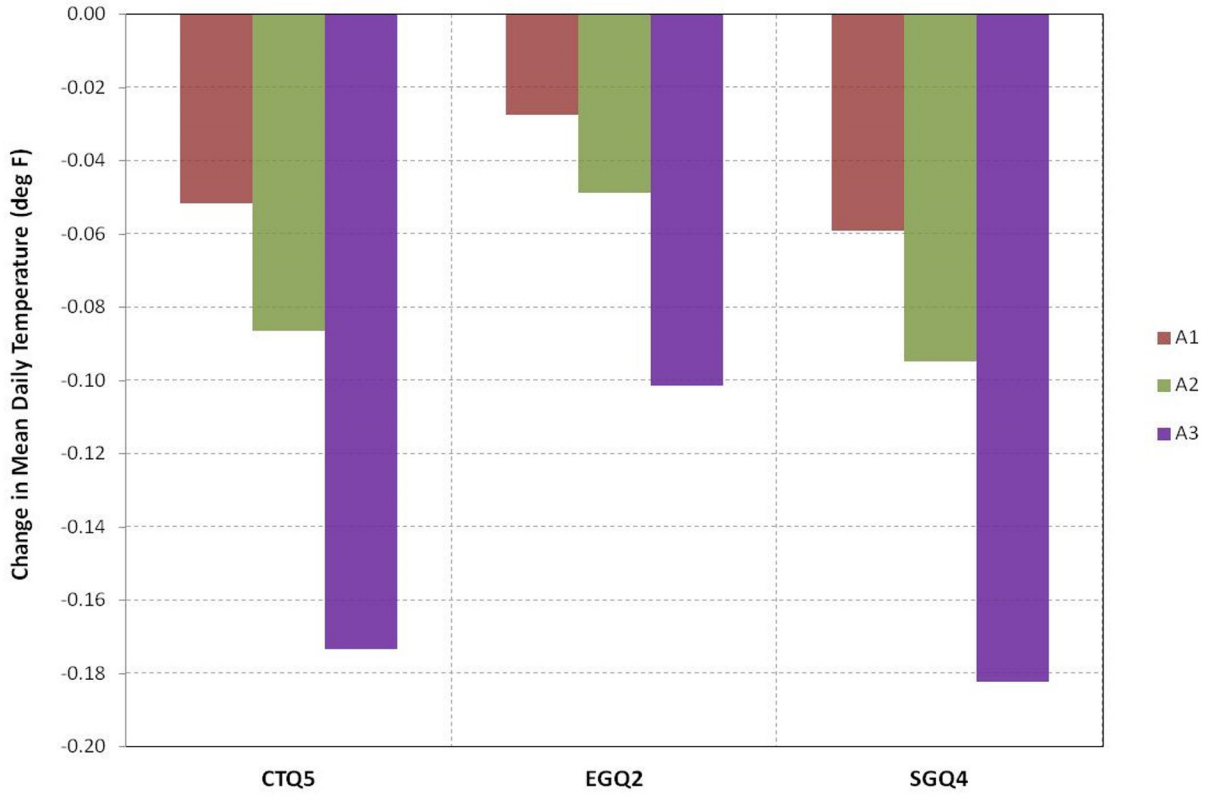

Figure 7-56. Change in Mean Daily Temperature on San Joaquin River at Gravelly Ford from August to November in Portfolio A

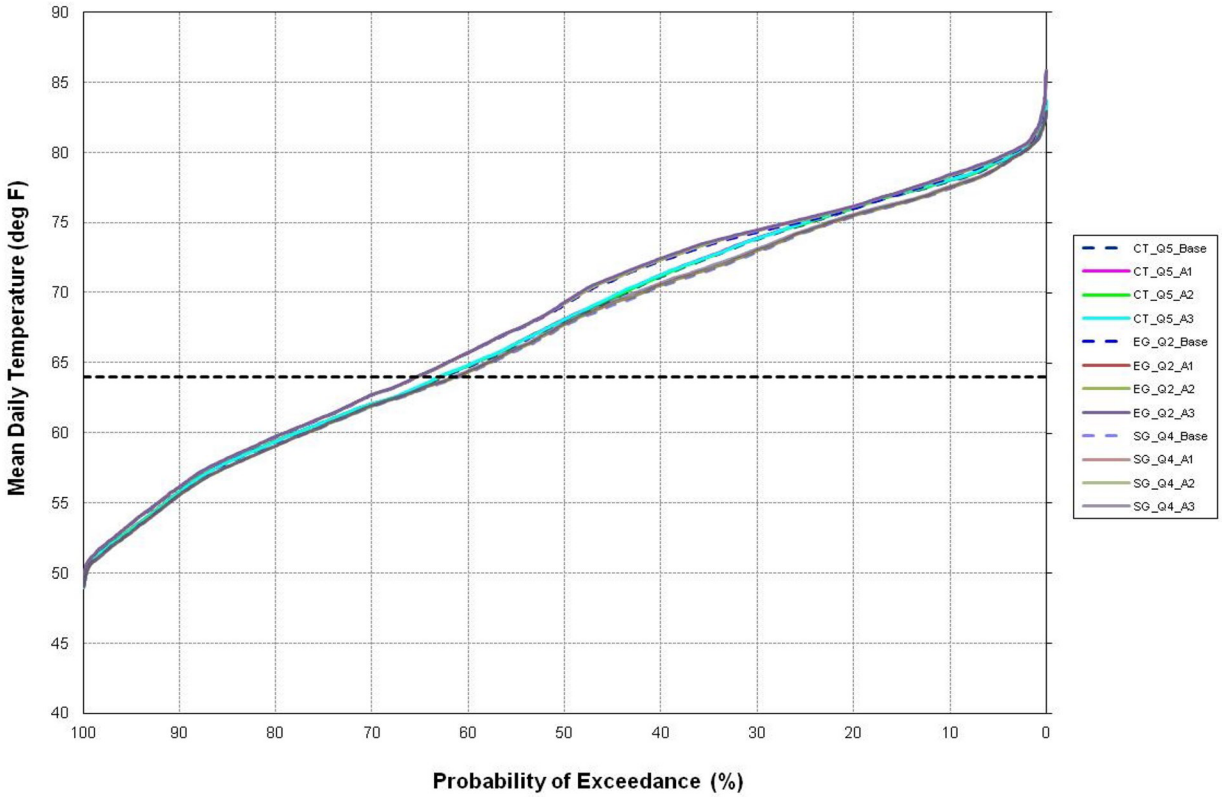

Figure 7-57. Exceedance of Mean Daily Temperature on San Joaquin River at Vernalis from August to November in Portfolio A

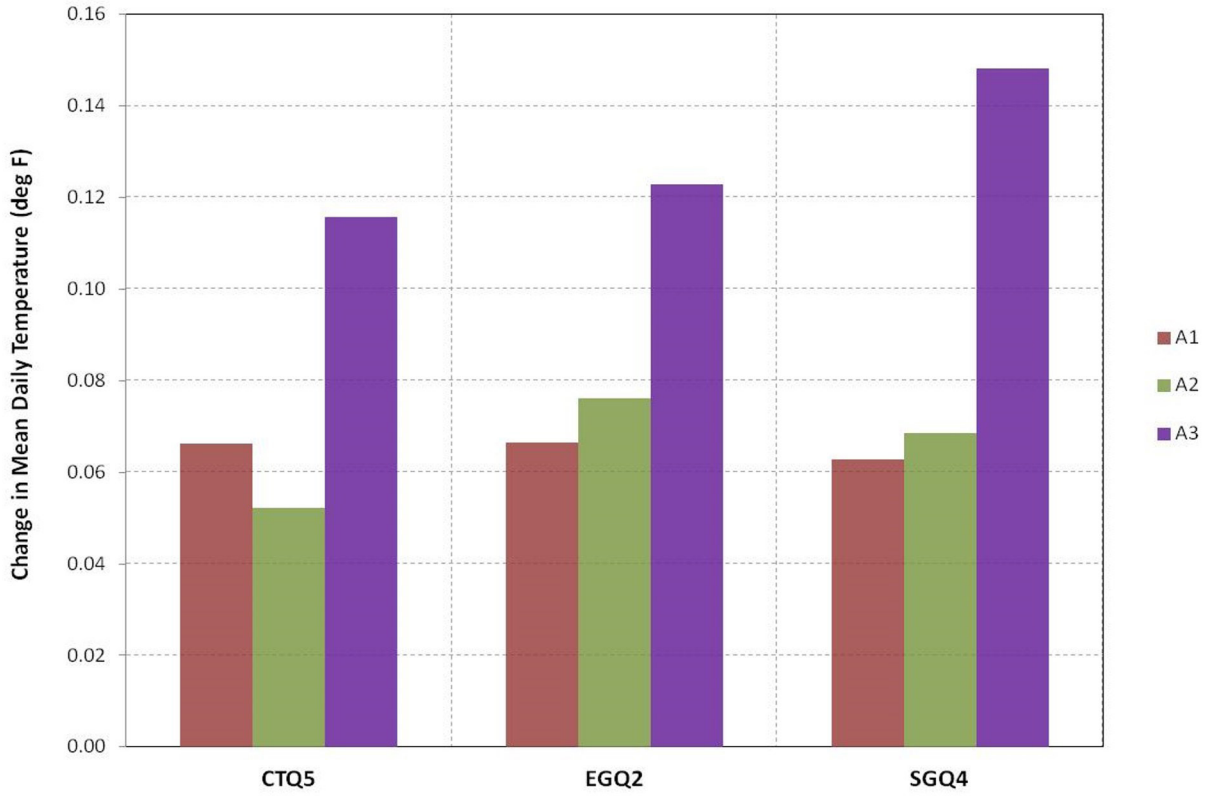

Figure 7-58. Change in Mean Daily Temperature on San Joaquin River at Vernalis from August to November in Portfolio A

temperatures at Lost Lake, and small reductions in mean daily water temperatures of about 0–0.2°F at Gravelly Ford due to increased flows on the river caused by the reduction in diversions off the river. At Vernalis, there were small increases in mean daily water temperatures of about 0.05–0.15°F due to the warming because of the meteorological changes and limited ability of the cold water from the reservoirs to affect the river water temperatures in the farther downstream locations.

7.1.3.3 Hydropower and Greenhouse Gas Emissions

Figures 7-59 and 7-60 show the changes in net generation and in GHG emissions (that is, increase in GHG emissions in the SWP system or reduction in potential GHG offsets in the CVP system) in the CVP and SWP systems in Portfolio A relative to the Baseline. In the CVP system, there was very little change in net generation or in potential GHG offsets in Portfolio A. In the SWP system, there was a reduction in net generation and an increase in GHG emissions in all three socioeconomic-climate scenarios, which was caused by the increase in Delta export levels under the Portfolio A actions relative to the Baseline. In A3, the SWP's reduction in net generation was about 70–100 gigawatt hours per year (GWh/year), and the GHG emissions increased by about 6,000–8,000 metric tons of CO2 equivalents (mTCO2e) across the three scenarios.

7.2 Portfolio B: North-of-Delta Surface Storage

The North-of-Delta Surface Storage Portfolio B was designed to investigate potential improvements in CVP-SWP water supply reliability related to increasing storage capacity through the NODOS and SLWRI Enlarged Shasta surface water storage projects. The NODOS project includes a new offstream storage reservoir and pipeline located approximately 10 miles to the west of the town of Maxwell, California. As simulated in this study, the Sites Reservoir alternative would have a storage capacity of 1.81 MAF, and diversion and release capacities of up to 5,900 and 1,500 cfs, respectively. The SLWRI study examined the effects of increasing the storage capacity of the existing Shasta Lake Reservoir from the current

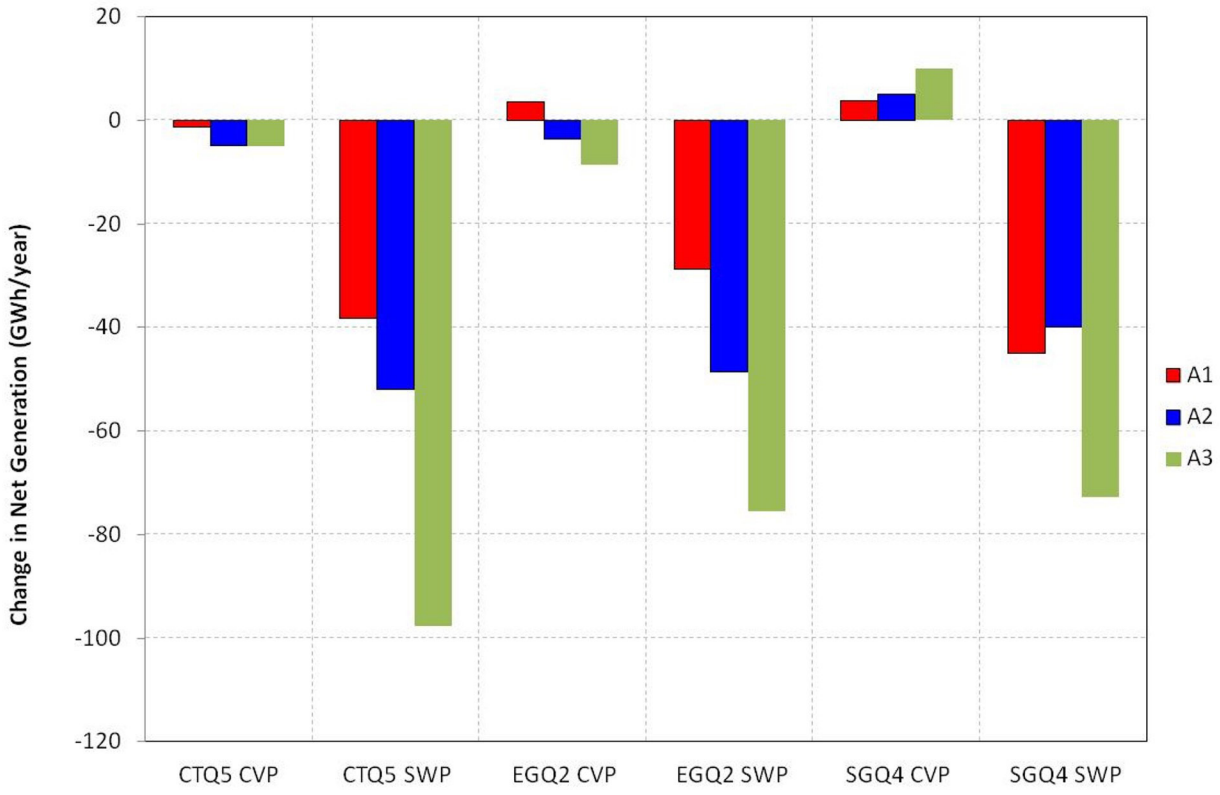

Figure 7-59. Change in Average Annual Net Energy Generation for the CVP and SWP Systems in Portfolio A

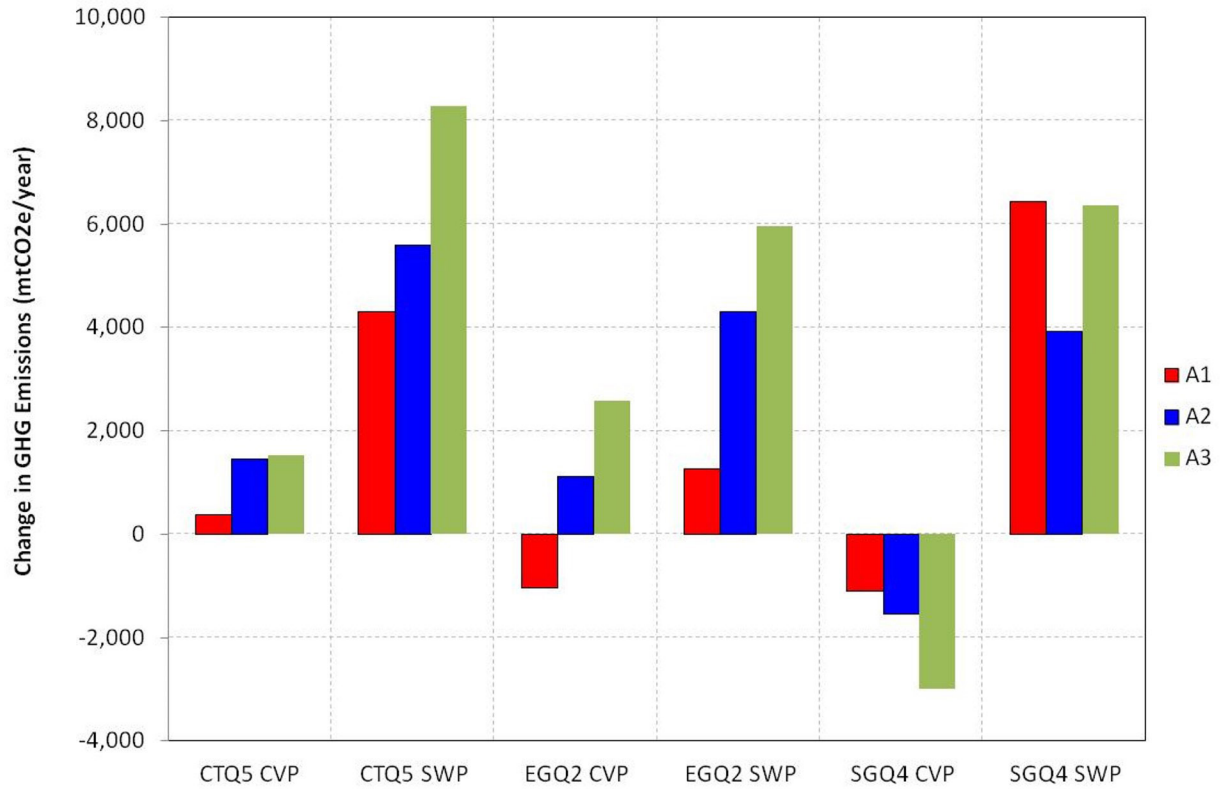

Figure 7-60. Change in Average Annual Greenhouse Gas Emissions for the CVP and SWP Systems in Portfolio A

volume of approximately 4.5 to 5.1 MAF. Both of the projects are multi-objective (see detailed descriptions in Section 6.3). In the CVP IRP study, the evaluation focuses primarily on the effects of socioeconomic-climate changes on the water supply benefits. It is important to acknowledge that the CVP IRP CalLite model is a simplified representation of the CVP-SWP systems and proposed NODOS and Enlarged Shasta project operations and, therefore, does not fully capture their potential benefits. The two North-of-Delta Surface Storage simulation suites included the following:

1. Baseline assumptions with Enlarged Shasta (B1)
2. Baseline assumptions with Sites Reservoir (B2)

Table 7-2 shows the assumptions that are included in each simulation.

7.2.1 Supplies and Demands in CVP Divisions

Figure 7-61 shows the average reduction in unmet demand in the CVP Service Area for the Shasta Enlargement B1 and NODOS B2 actions in each socioeconomic-climate scenarios. Figures 7-62 through 7-70 show the same information for each CVP Division. The reduction in unmet demand in the CVP Service Area ranged from 5–33 TAF/year (up to 1 percent of Baseline unmet demands) for Enlarged Shasta and 15-322 TAF/year (up to 10 percent of Baseline unmet demands) for the Sites Reservoir actions across the range of scenarios. Consistent with the changes in Delta exports, the greatest reductions in unmet demand occurred in the drier Q1 and Q2 climate projections, and the smallest reductions occurred in wetter Q3 and Q4 projections.

Figures 7-71 through 7-73 show the annual time series of groundwater, surface water, and local project supplies, and the unmet demands for the CVP Service Area under the CT-Q5, EG-Q2, and SG-Q4 scenarios under Portfolio B Suite B1. Unmet demands in B1 ranged from 800 to 11,900 TAF/year in CT-Q5, from 900 to 15,700 TAF/year in EG-Q2, and from 800 to 7,600 TAF/year in SG-Q4.

Figures 7-74 through 7-76 show the same information for Suite B2. Unmet demands in B2 ranged from 800 to 12,000 TAF/year in CT-Q5, from 800 to 15,800 TAF/year in EG-Q2, and from 800 to 7,700 TAF/year in SG-Q4. In CT Q5 and EG-Q2, there were reductions in unmet demand relative to the Baseline in both B1 and B2 primarily due to increases in surface water deliveries with the addition of the storage projects. There was very little change in SG-Q4 because surface water deliveries in both B1 and B2 were very similar to the Baseline.

7.2.2 CVP and SWP System Operations

The following sections describe the results of each of these simulation suites.

7.2.2.1 CVP and SWP Project Storage

Figures 7-77 through 7-90 show the exceedance plots of reservoir storage over the twenty-first century in the Baseline and for each of the Portfolio B simulation suites at the end of May

Table 7-2. Simulation Suites and Assumptions Included in Portfolio B

	Simulation Suite B1	Simulation Suite B2
Baseline Assumptions	x	x
Local Actions		
Modest Ag and M&I Conservation		
Municipal Recycling and Desalination		
Aggressive Ag and M&I Conservation		
Systemwide Actions		
Delta Conveyance		
Shasta Lake Enlargement	x	
North-of-Delta Offstream Storage		x
South-of-Delta SW or GW Storage		
Enhanced Environmental Flows		

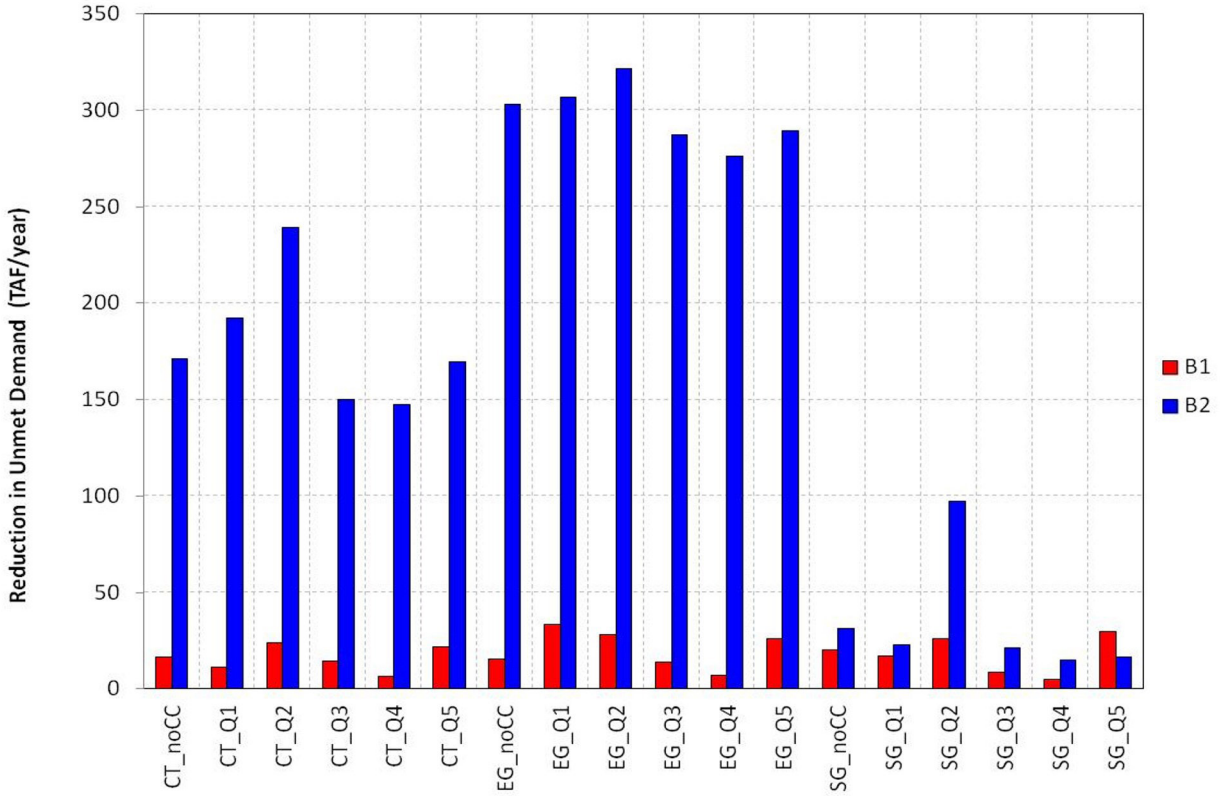

Figure 7-61. Average Annual Reduction in Unmet Demand in the CVP Service Area for Portfolio B in Each Scenario

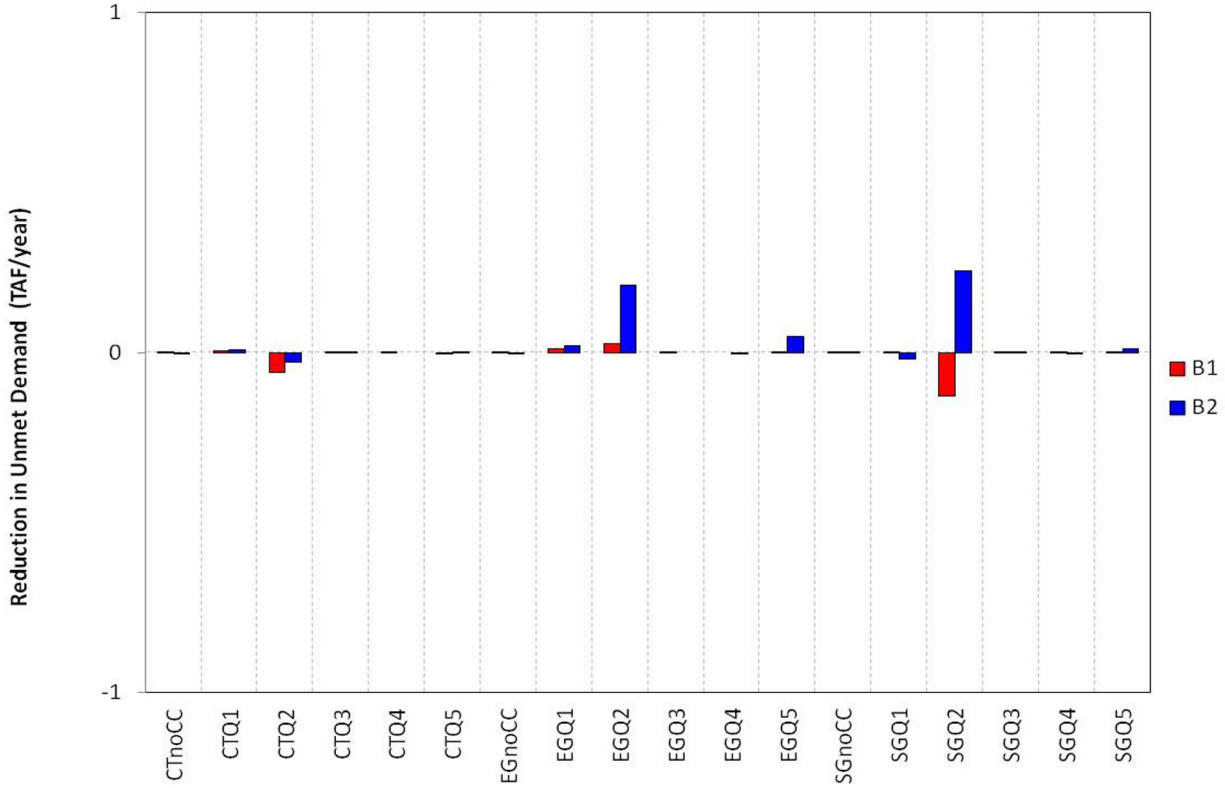

Figure 7-62. Average Annual Reduction in Unmet Demand in the American River Division for Portfolio B in Each Scenario

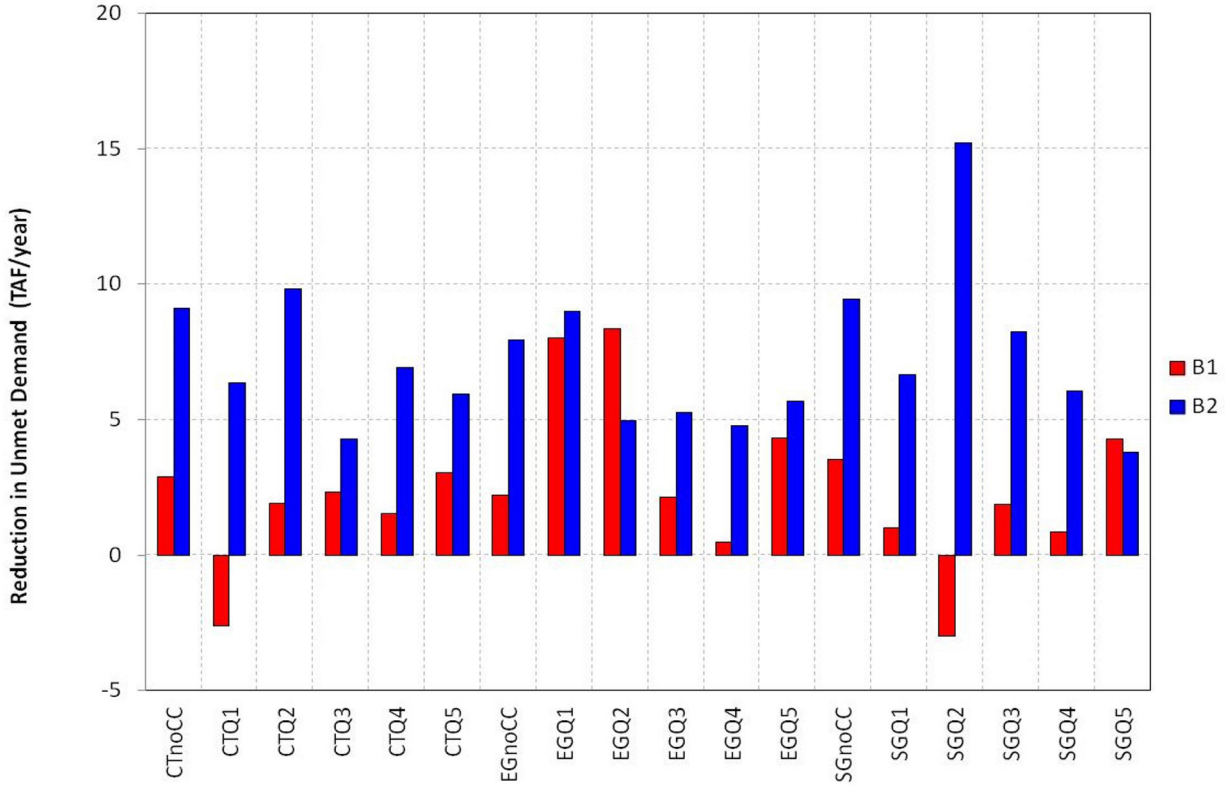

Figure 7-63. Average Annual Reduction in Unmet Demand in the Delta Division for Portfolio B in Each Scenario

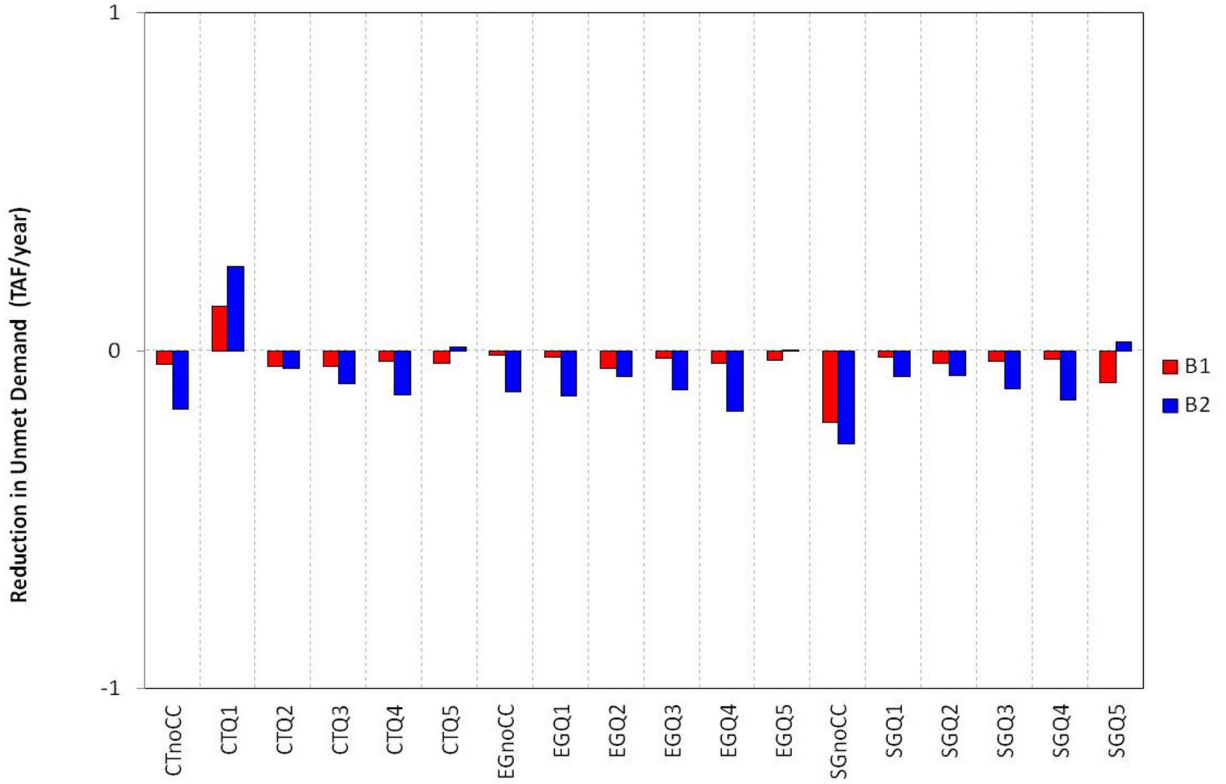

Figure 7-64. Average Annual Reduction in Unmet Demand in the East Side Division for Portfolio B in Each Scenario

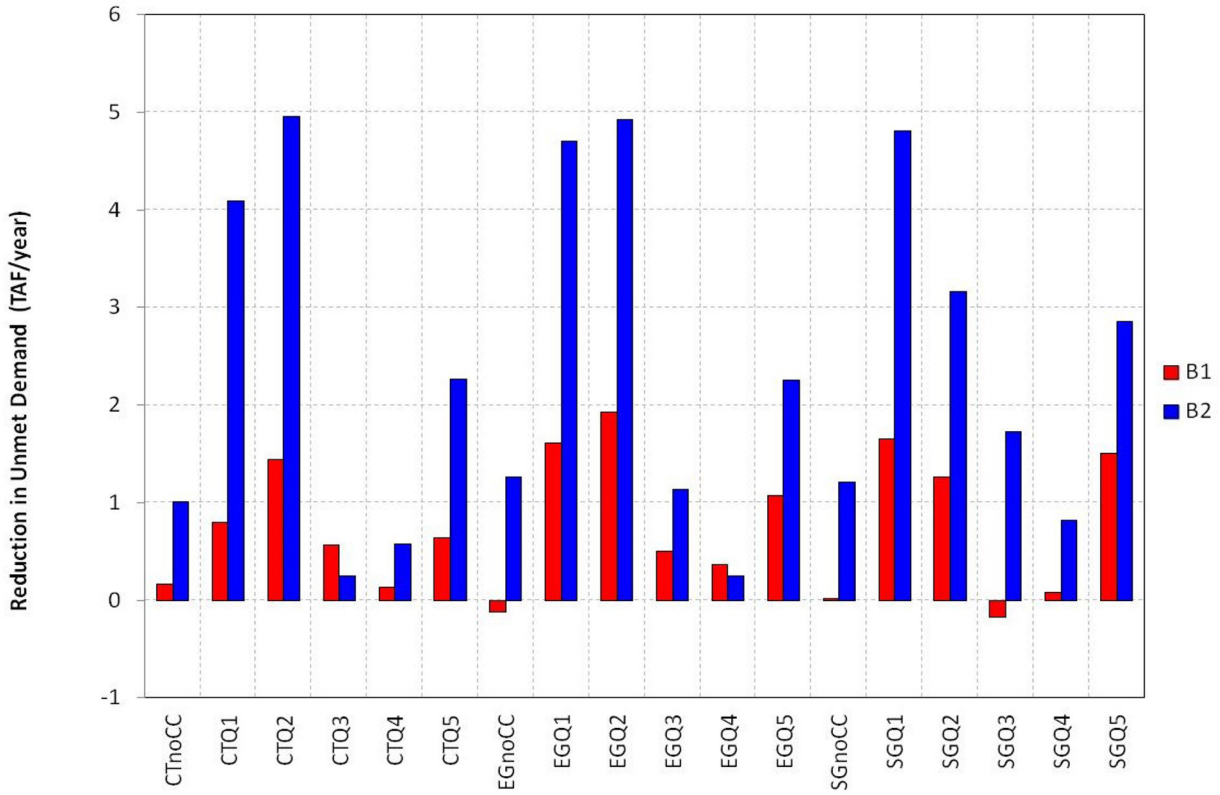

Figure 7-65. Average Annual Reduction in Unmet Demand in the Friant Division for Portfolio B in Each Scenario

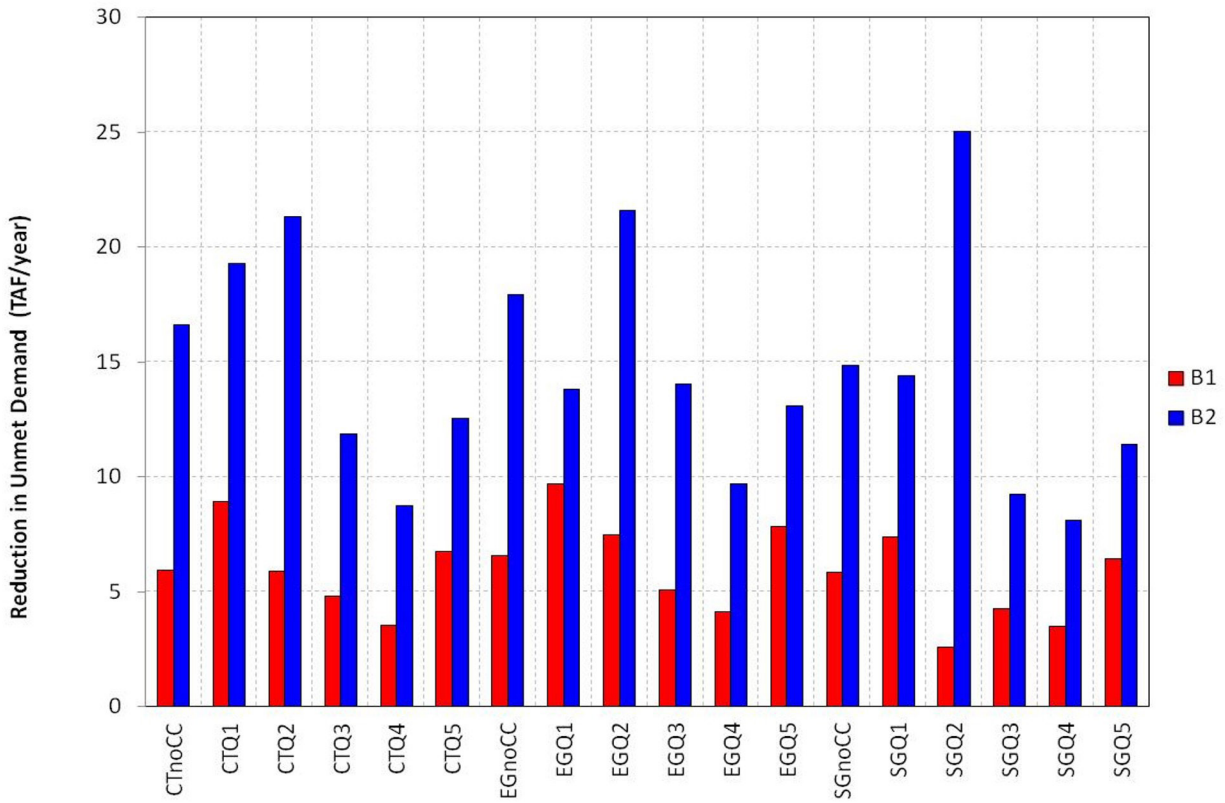

Figure 7-66. Average Annual Reduction in Unmet Demand in the Sacramento River Division for Portfolio B in Each Scenario

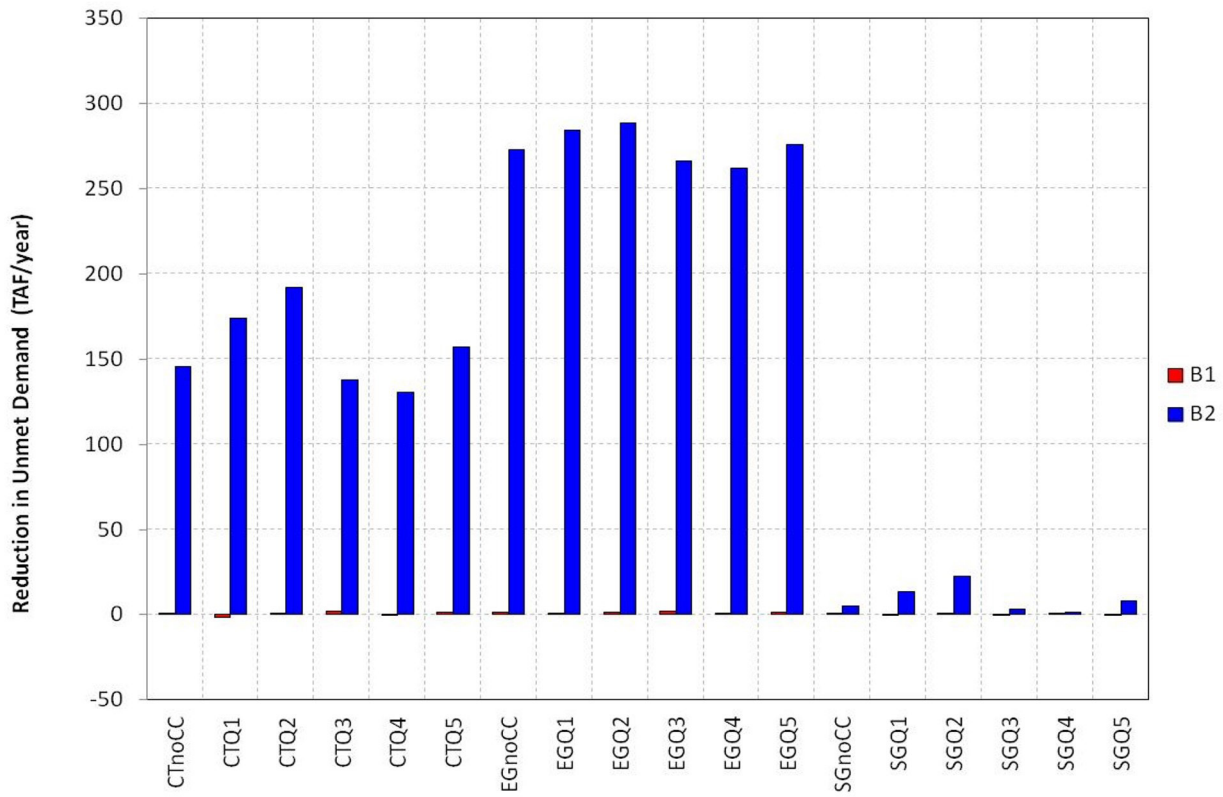

Figure 7-67. Average Annual Reduction in Unmet Demand in the San Felipe Division for Portfolio B in Each Scenario

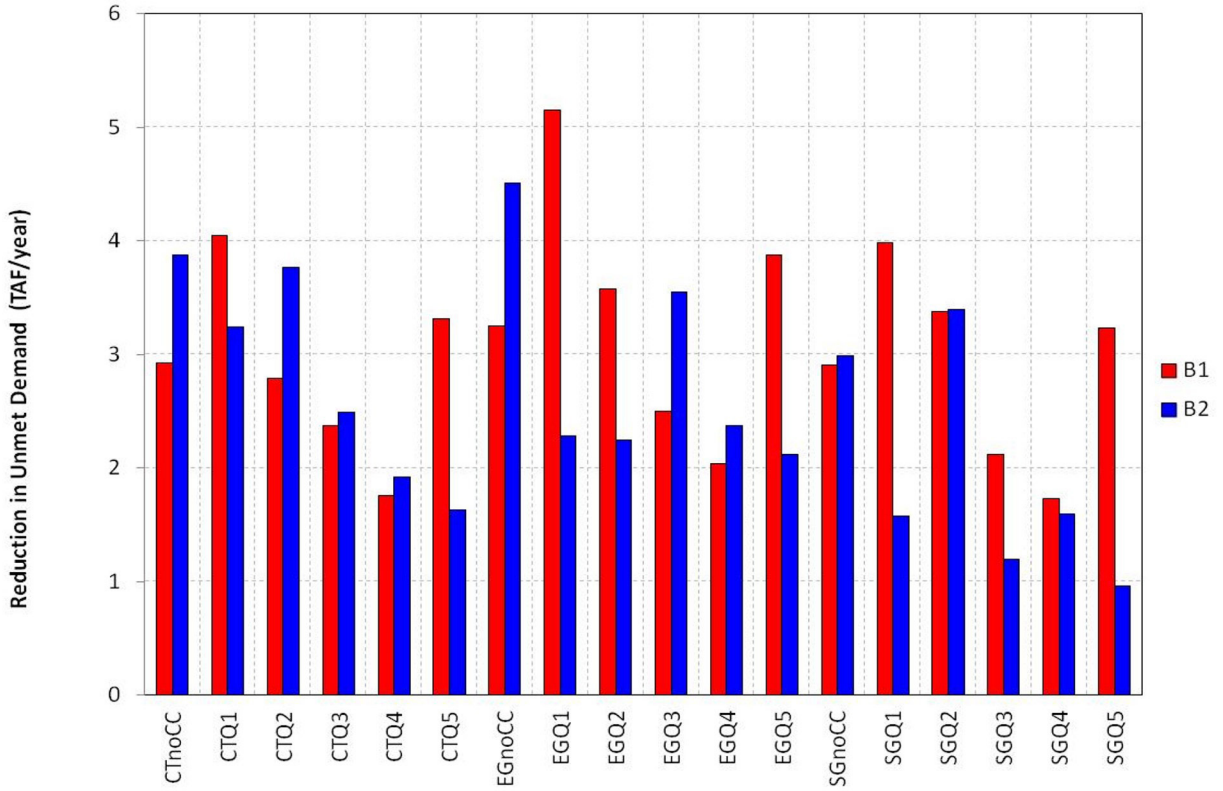

Figure 7-68. Average Annual Reduction in Unmet Demand in the Shasta Division for Portfolio B in Each Scenario

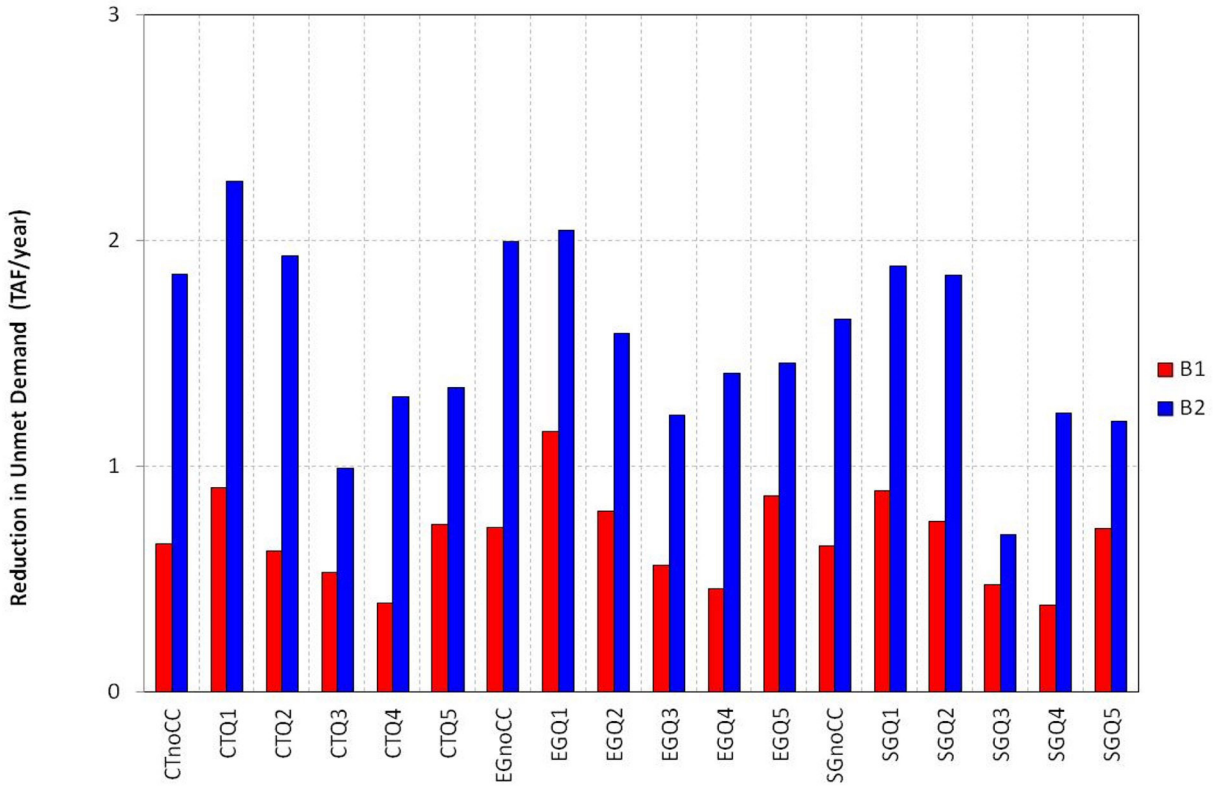

Figure 7-69. Average Annual Reduction in Unmet Demand in the Trinity Division for Portfolio B in Each Scenario

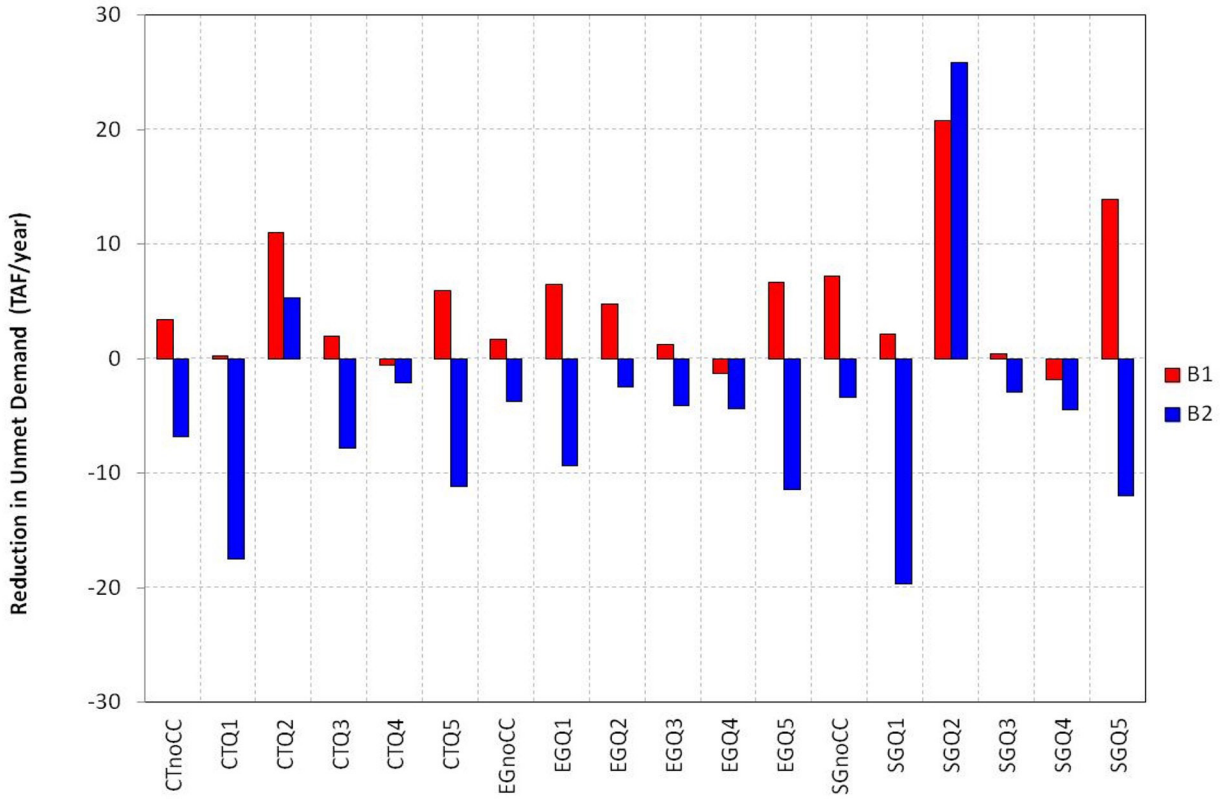

Figure 7-70. Average Annual Reduction in Unmet Demand in the West San Joaquin Division for Portfolio B in Each Scenario

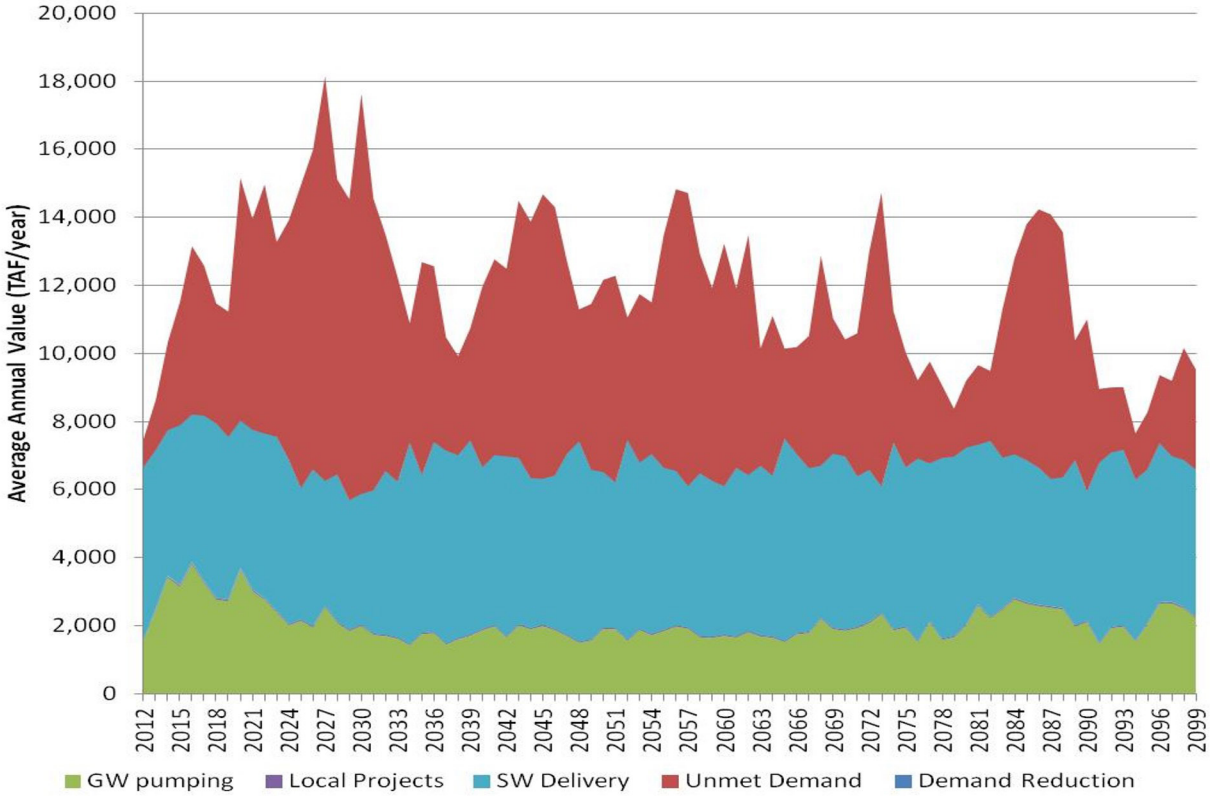

Figure 7-71. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite B1 in the CT-Q5 Scenario

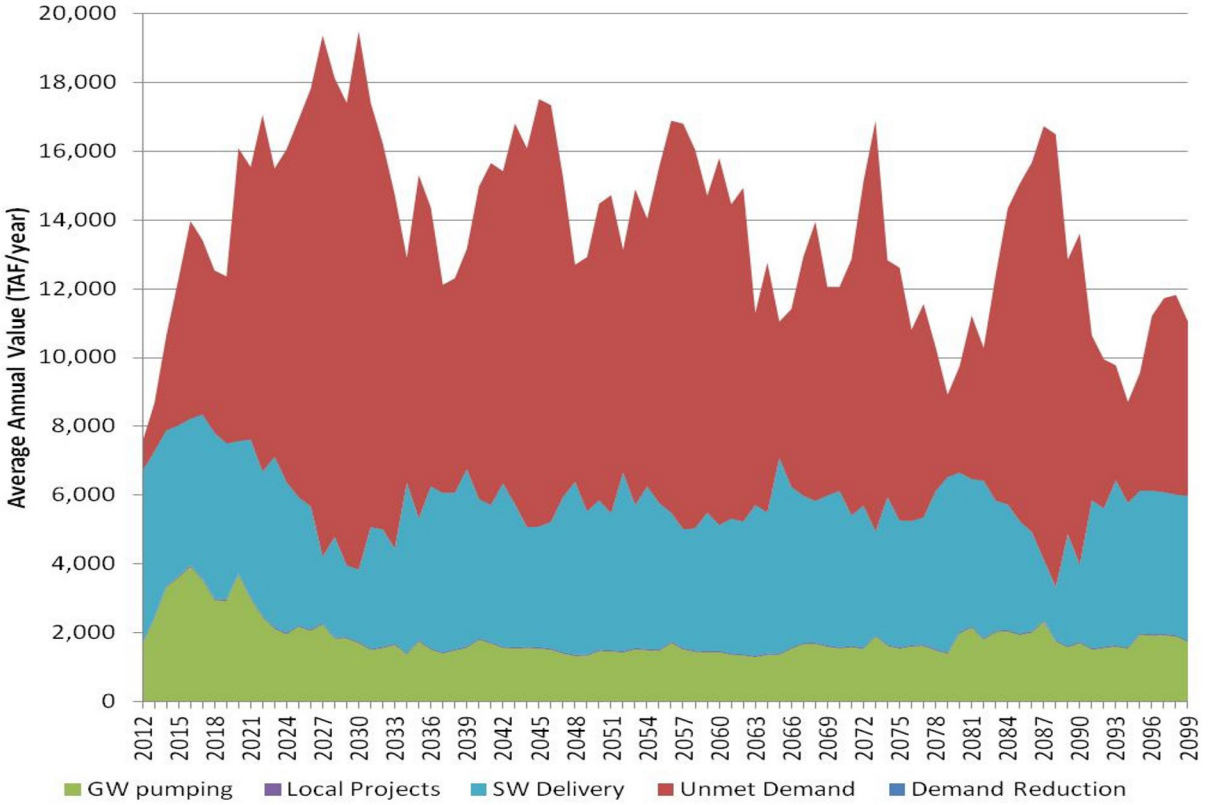

Figure 7-72. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite B1 in the EG-Q2 Scenario

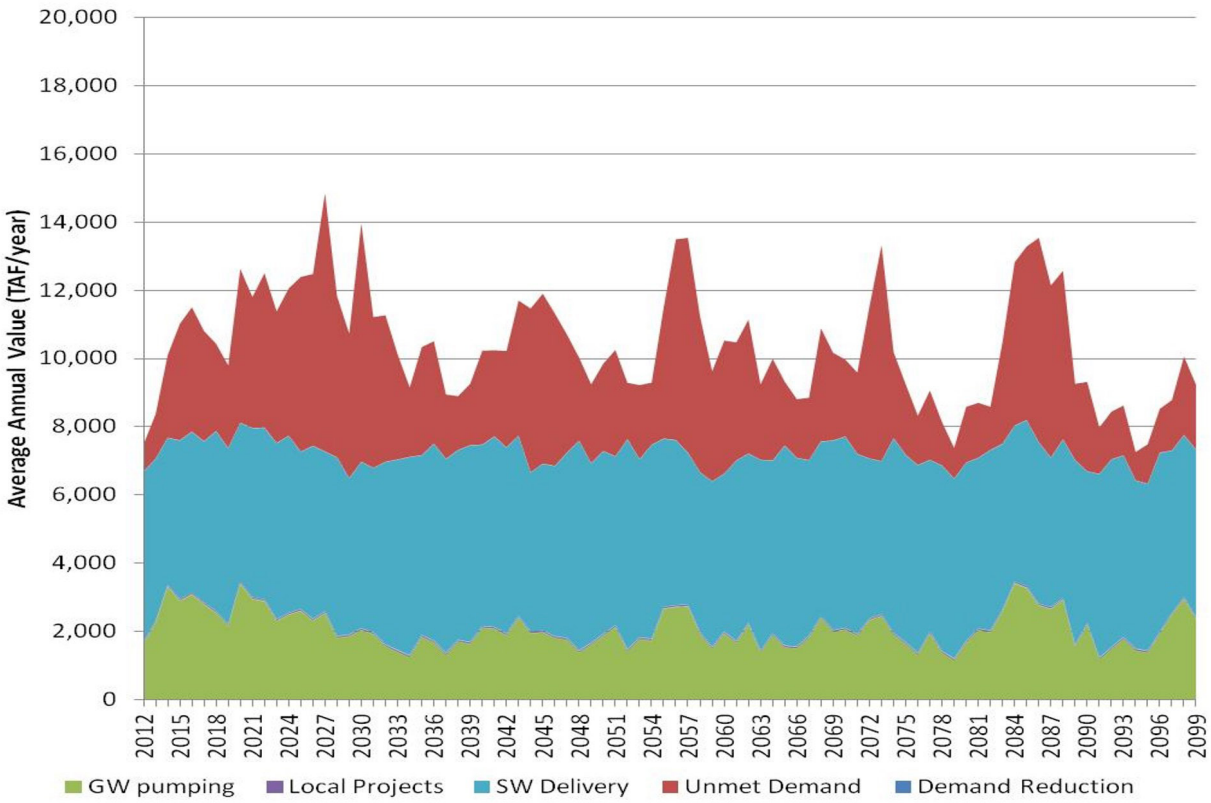

Figure 7-73. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite B1 in the SG-Q4 Scenario

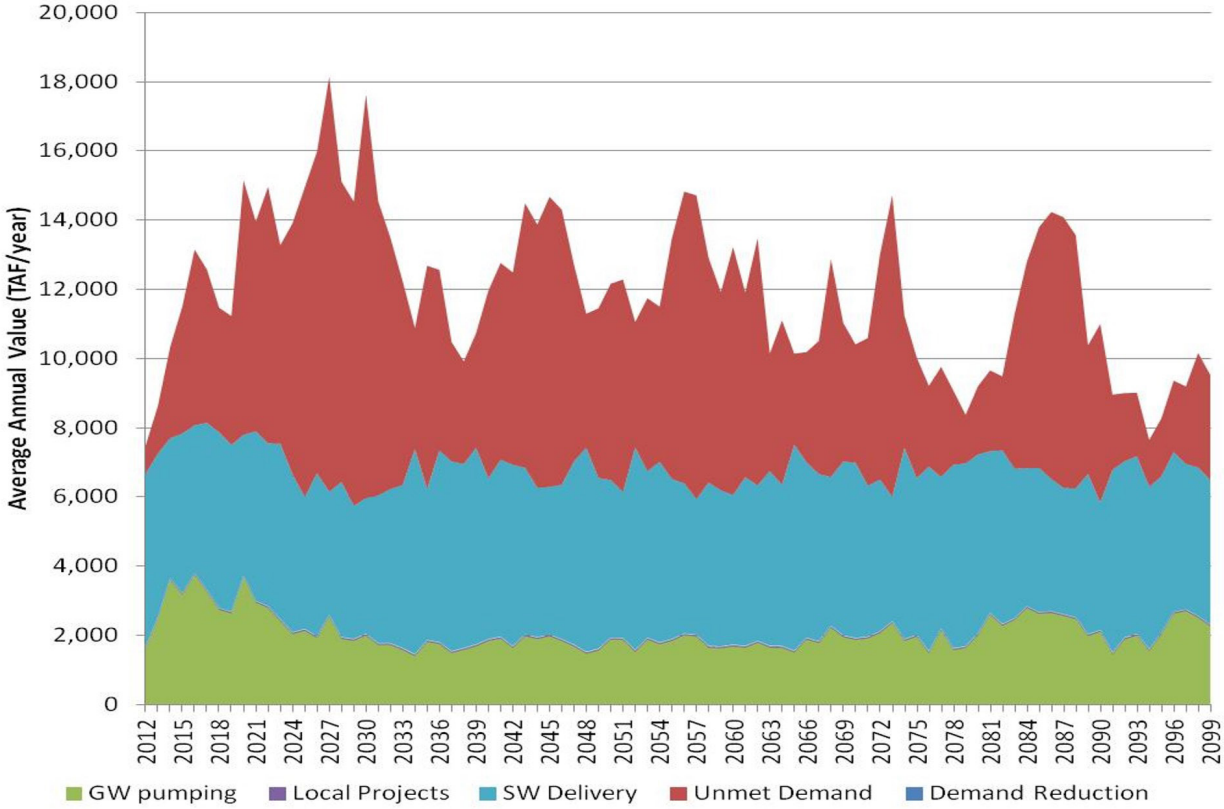

Figure 7-74. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite B2 in the CT-Q5 Scenario

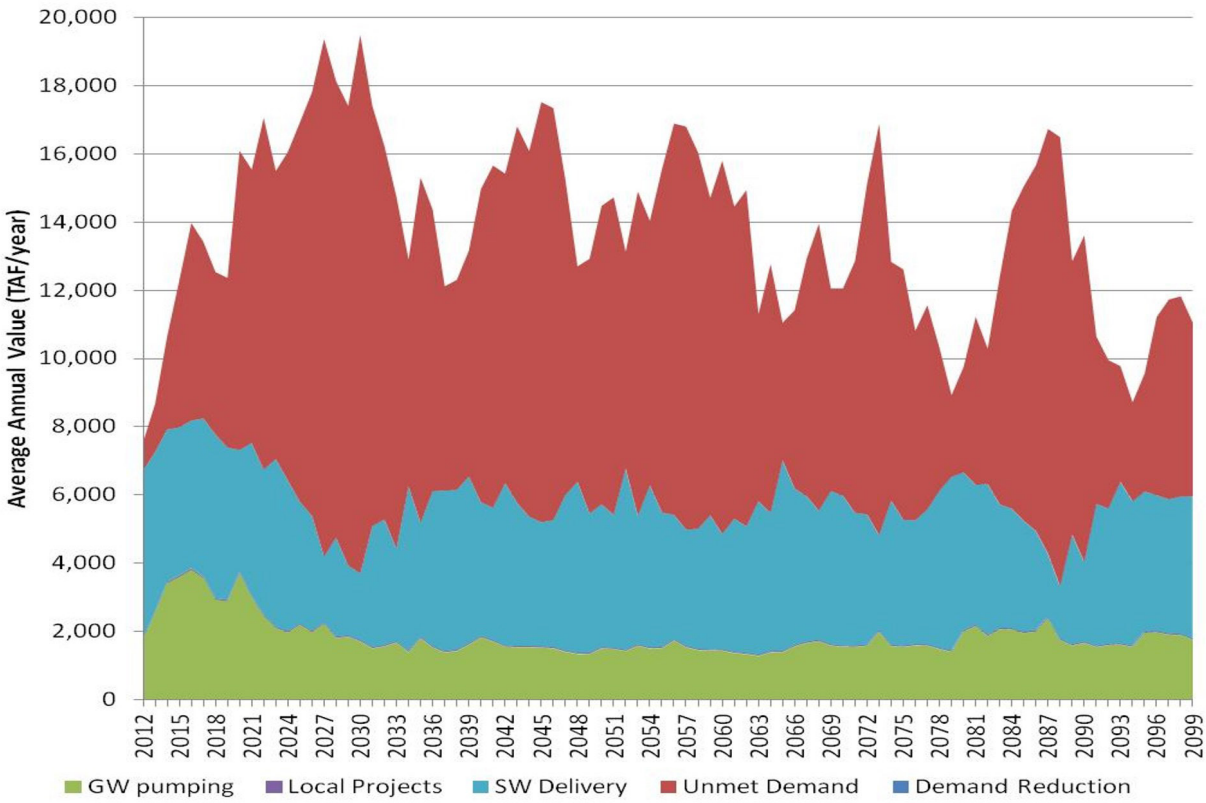

Figure 7-75. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite B2 in the EG-Q2 Scenario

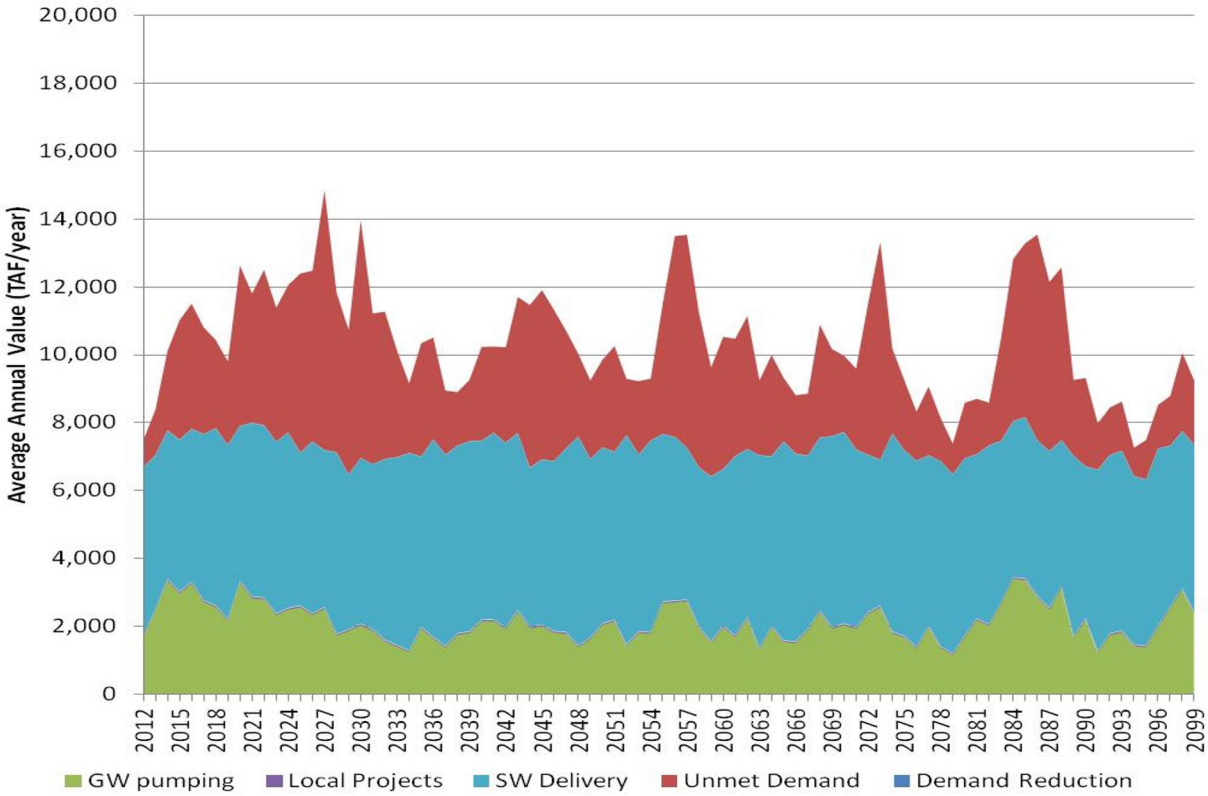

Figure 7-76. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite B2 in the SG-Q4 Scenario

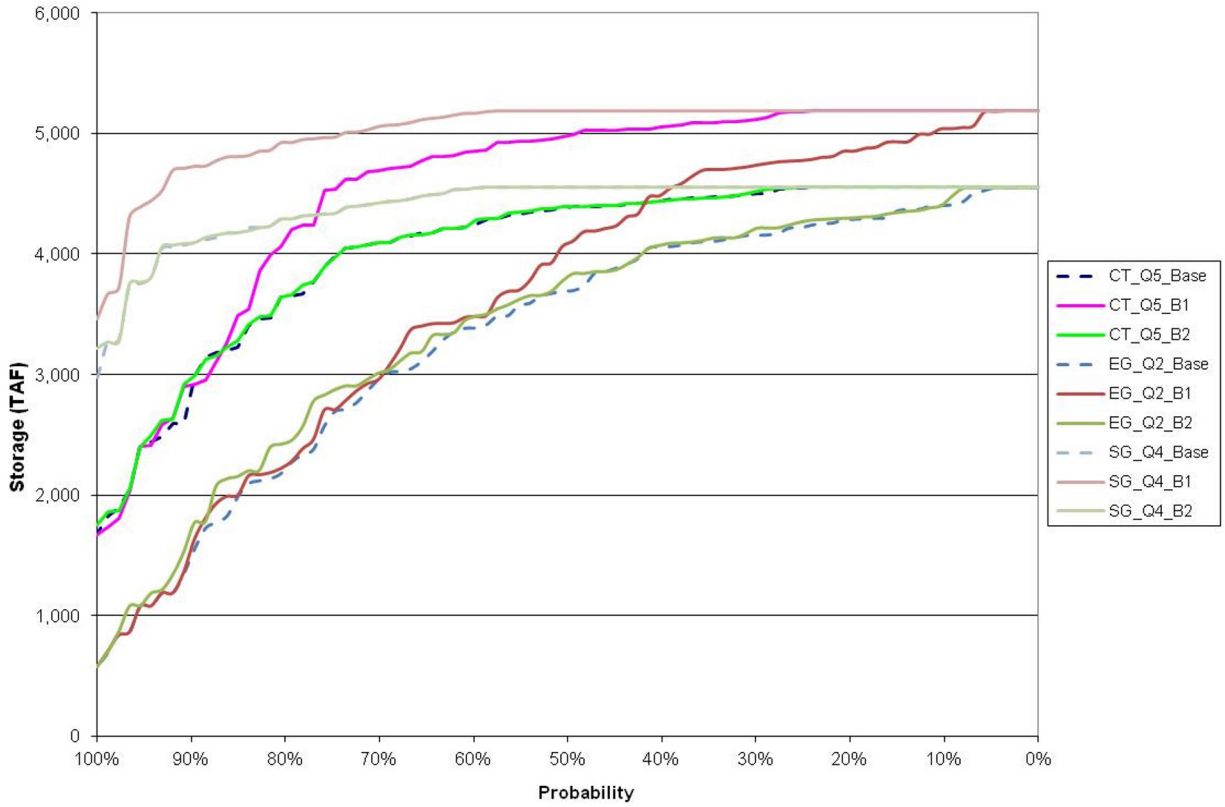

Figure 7-77. Exceedance of Lake Shasta End-of-May Storage in Portfolio B

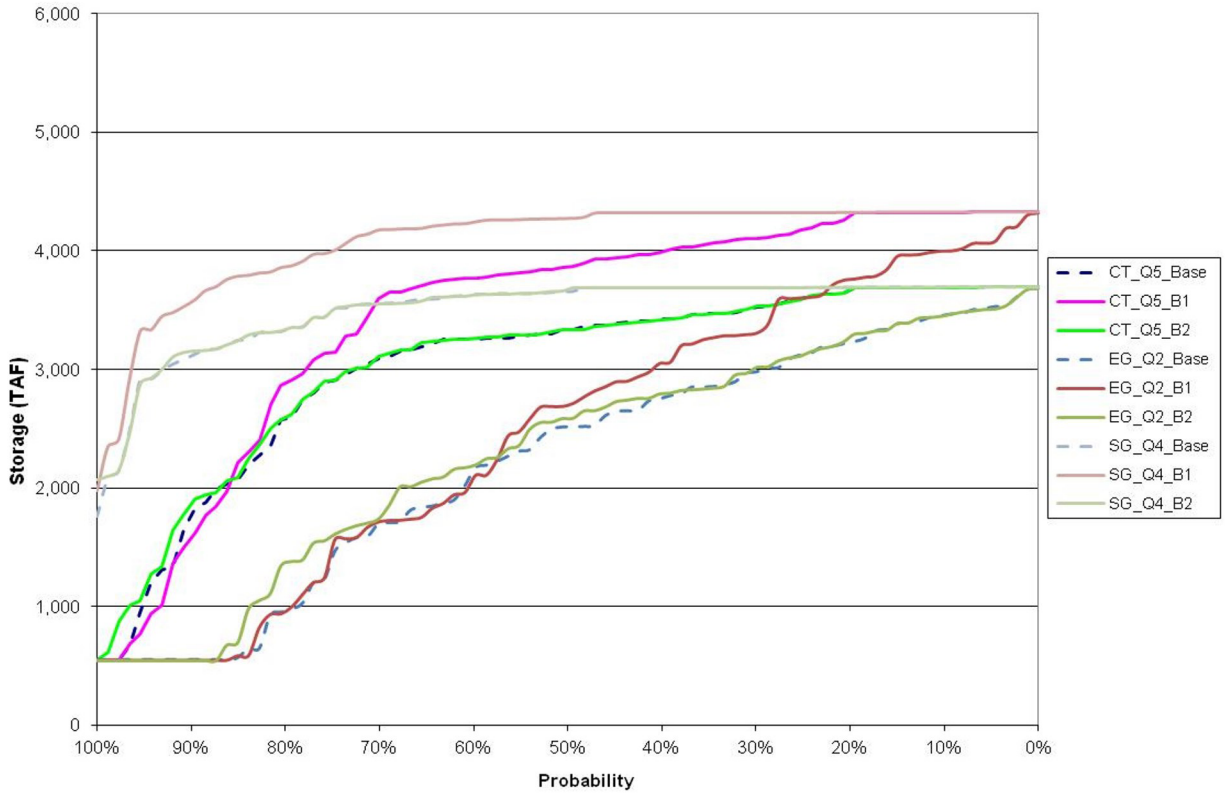

Figure 7-78. Exceedance of Lake Shasta End-of-September Storage in Portfolio B

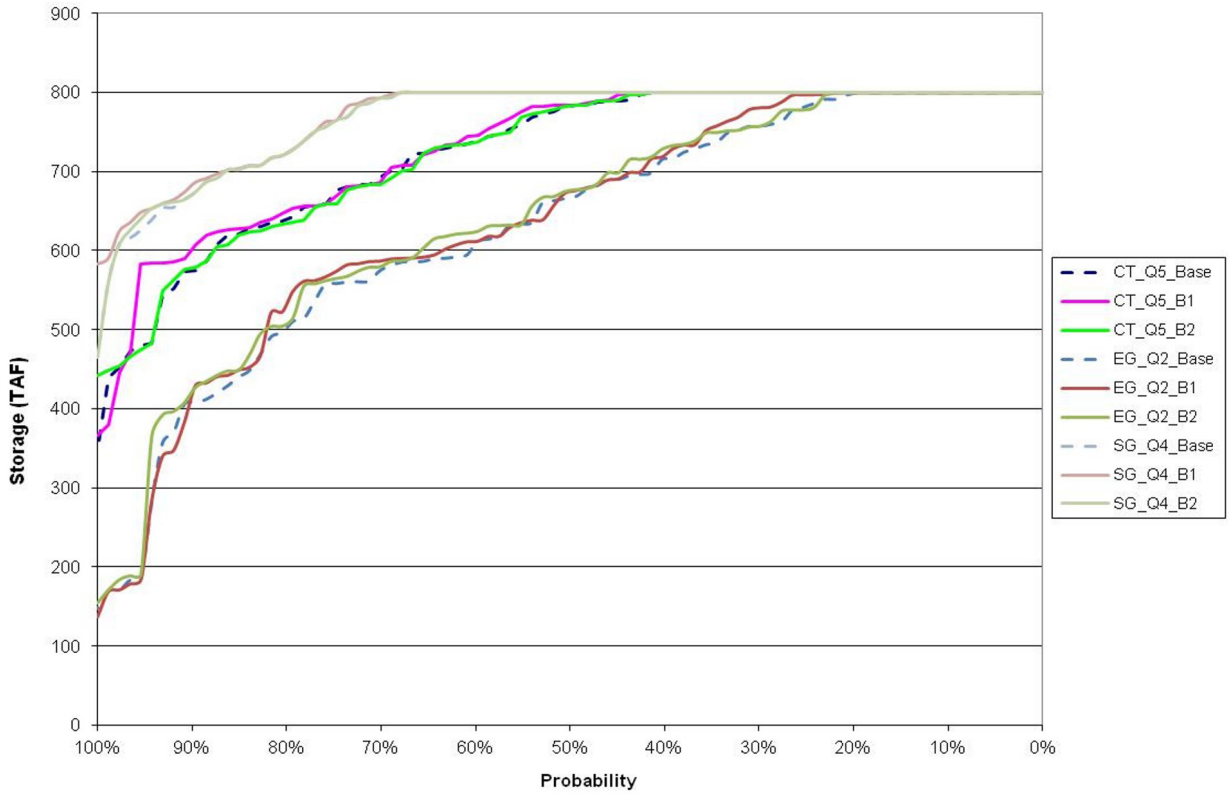

Figure 7-79. Exceedance of Folsom Lake End-of-May Storage in Portfolio B

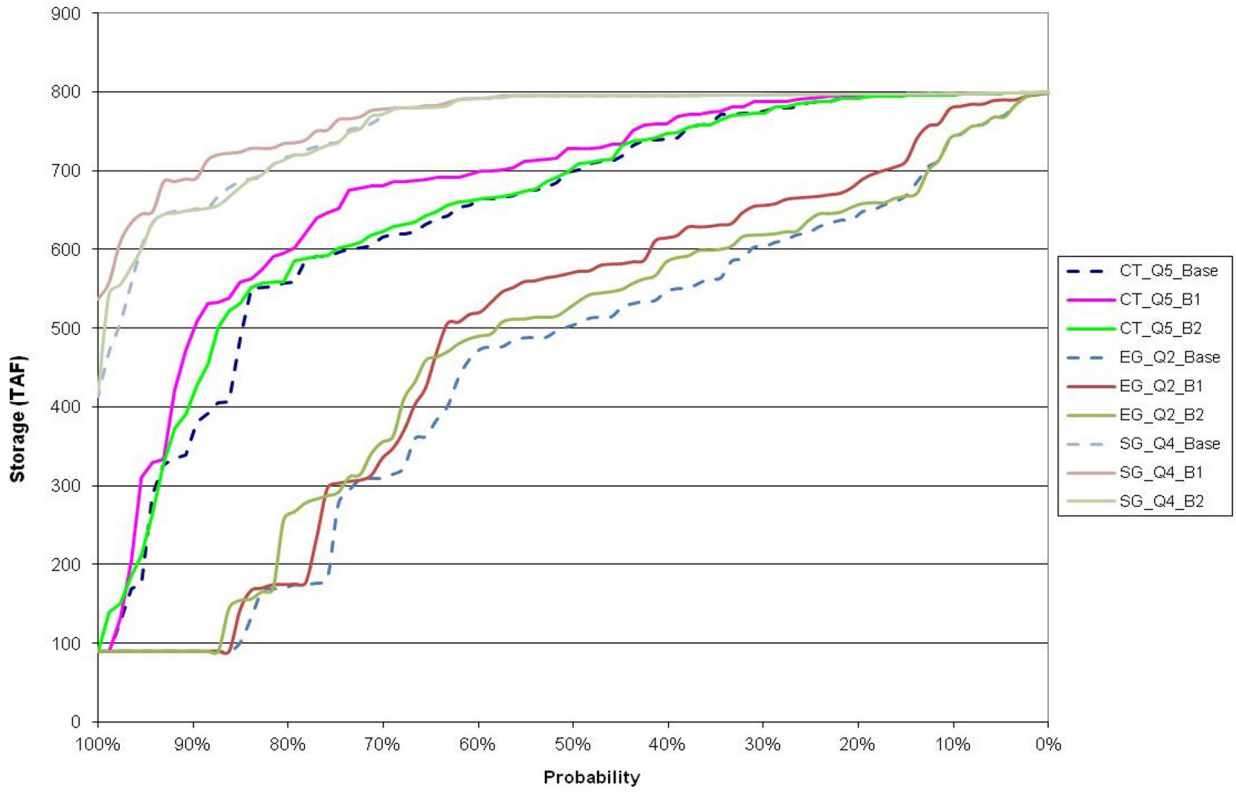

Figure 7-80. Exceedance of Folsom Lake End-of-September Storage in Portfolio B

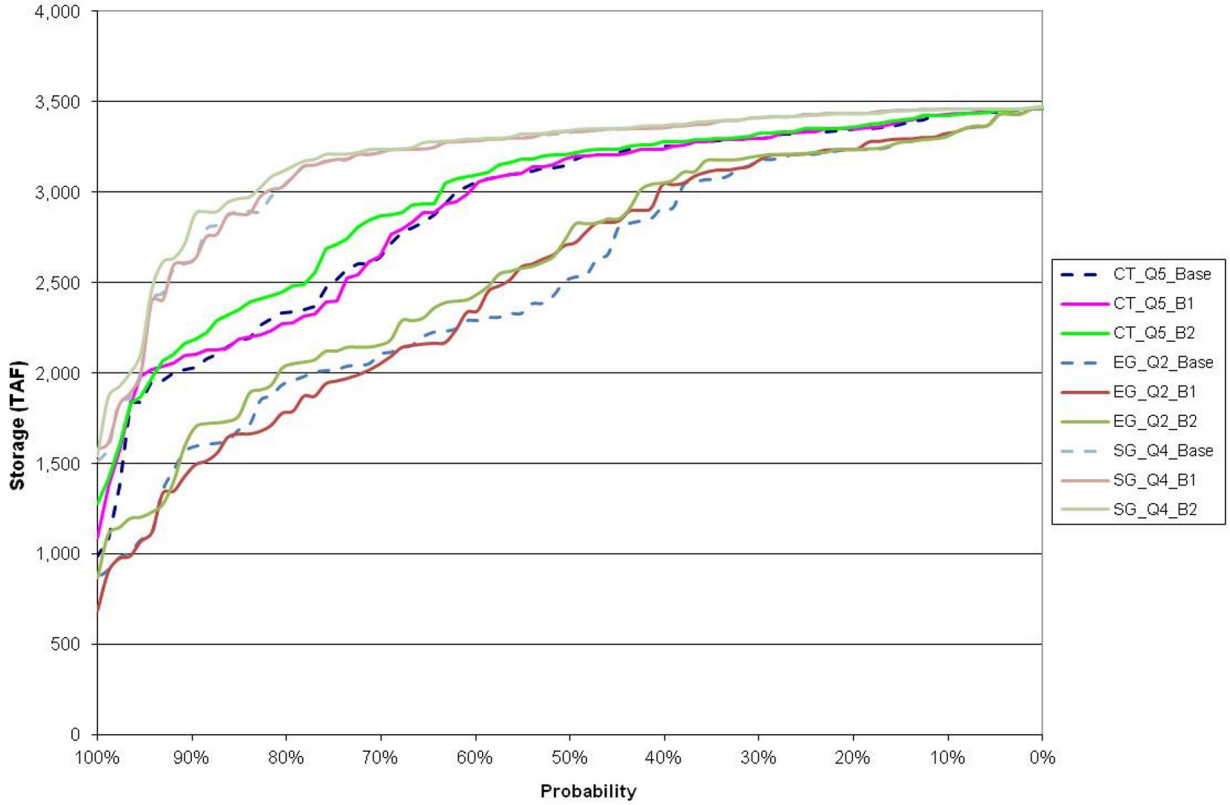

Figure 7-81. Exceedance of Lake Oroville End-of-May Storage in Portfolio B

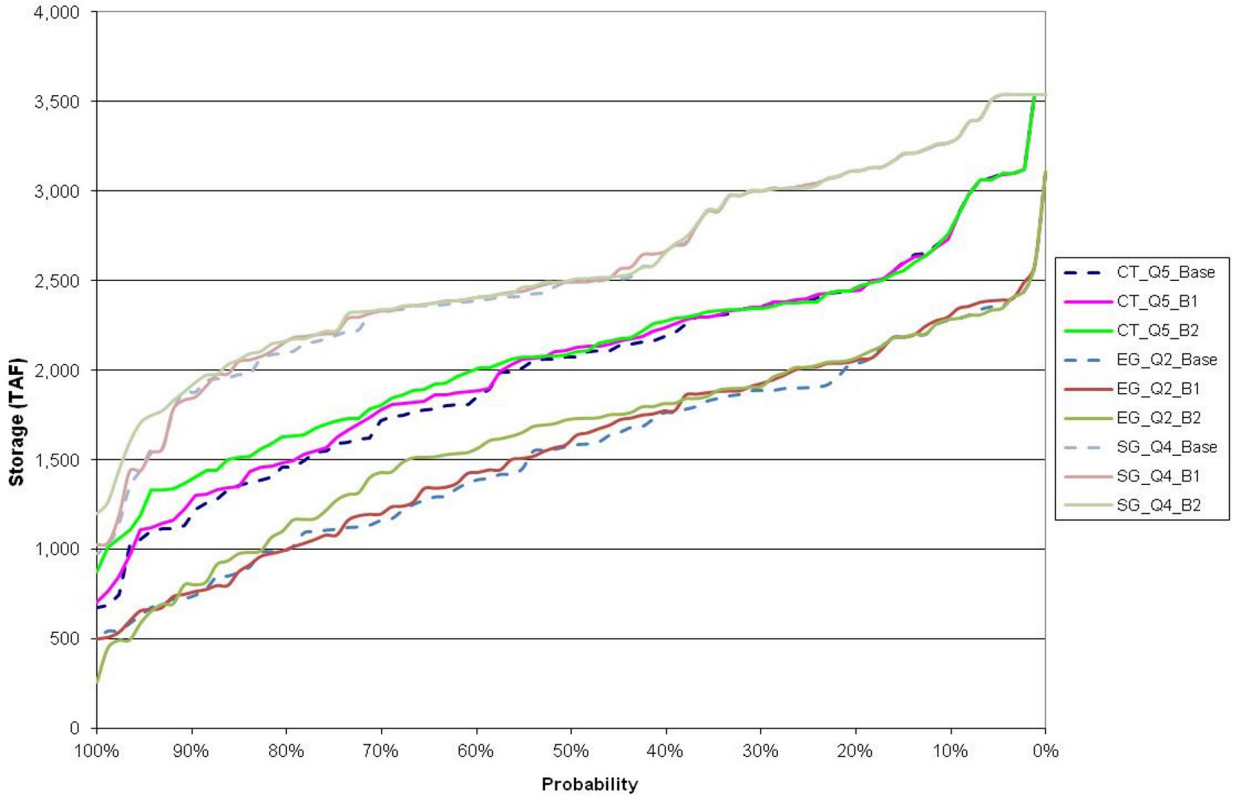

Figure 7-82. Exceedance of Lake Oroville End-of-September Storage in Portfolio B

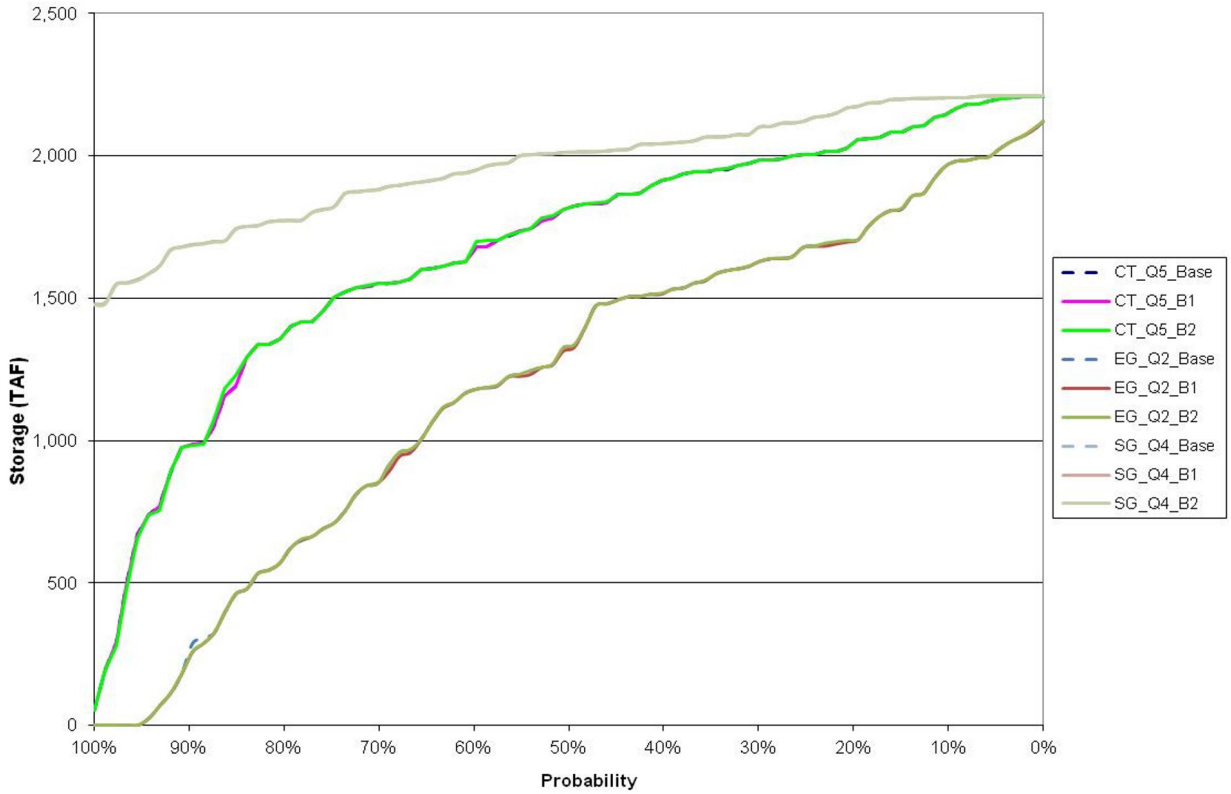

Figure 7-83. Exceedance of New Melones Reservoir End-of-May Storage in Portfolio B

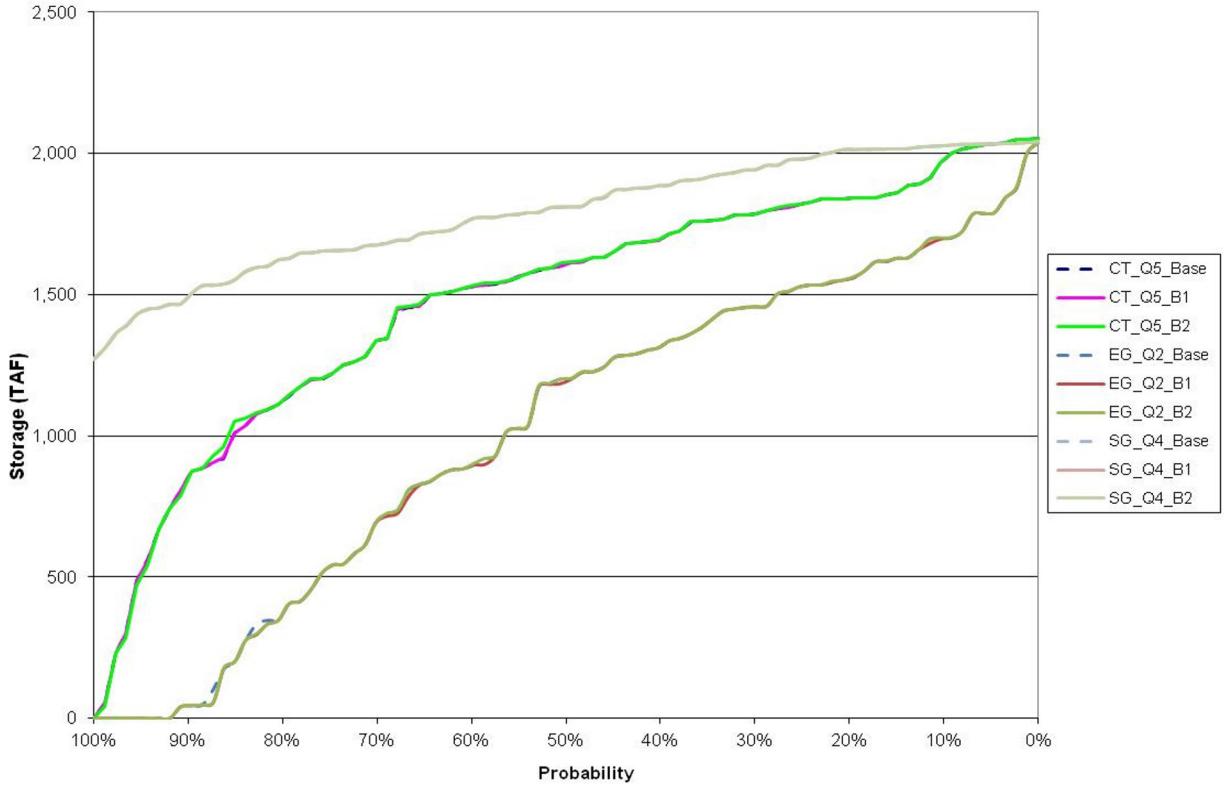

Figure 7-84. Exceedance of New Melones Reservoir End-of-September Storage in Portfolio B

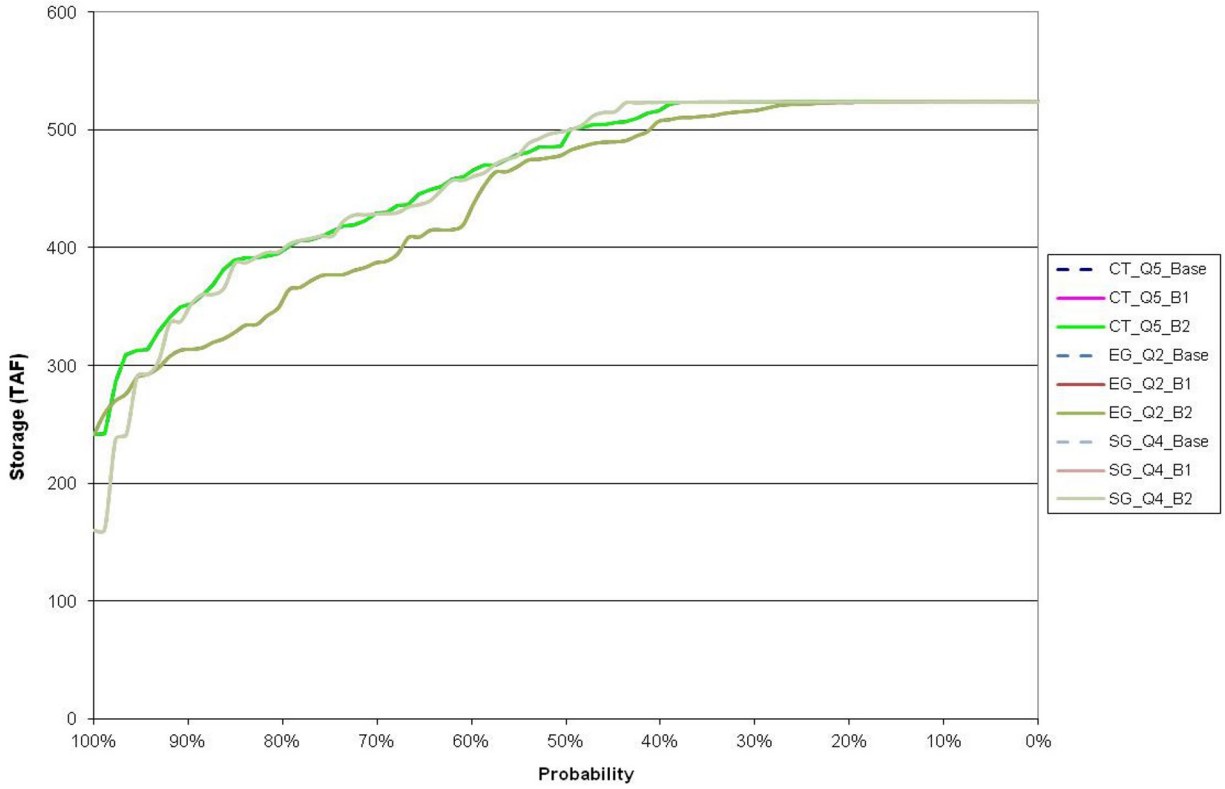

Figure 7-85. Exceedance of Millerton Lake End-of-May Storage in Portfolio B

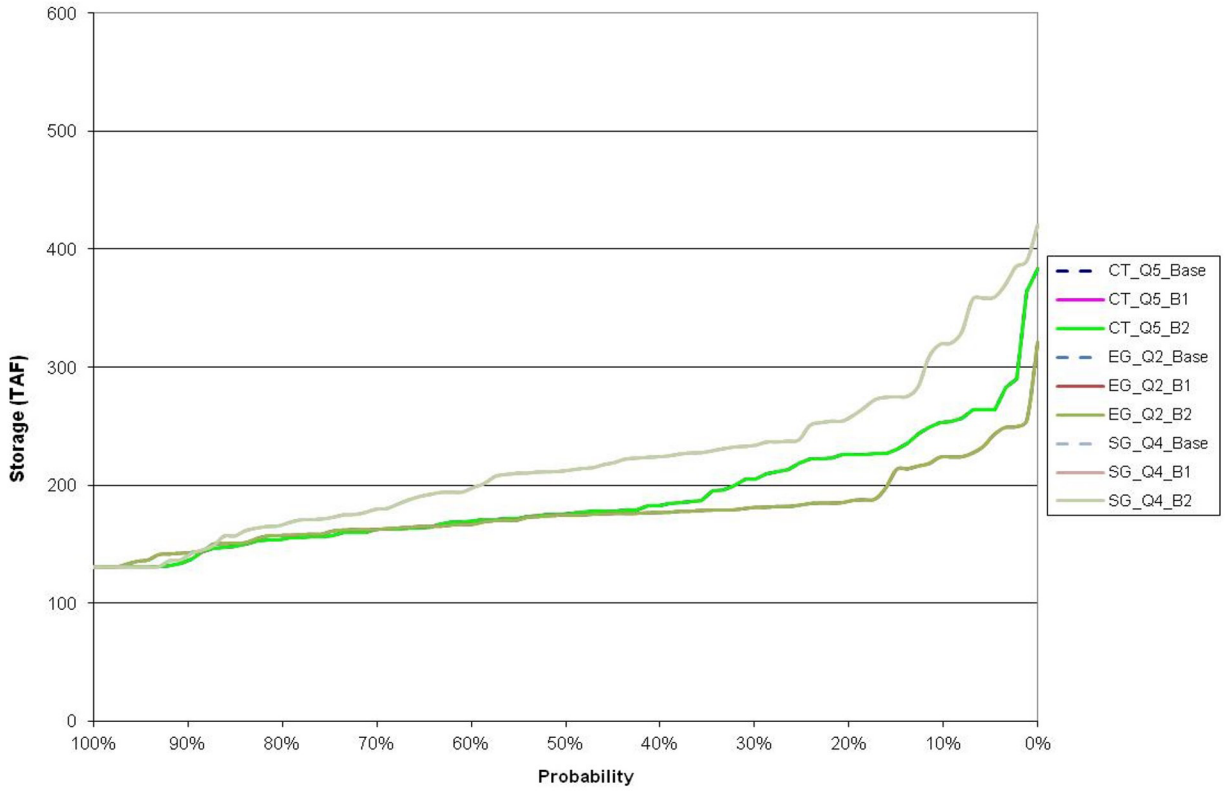

Figure 7-86. Exceedance of Millerton Lake End-of-September Storage in Portfolio B

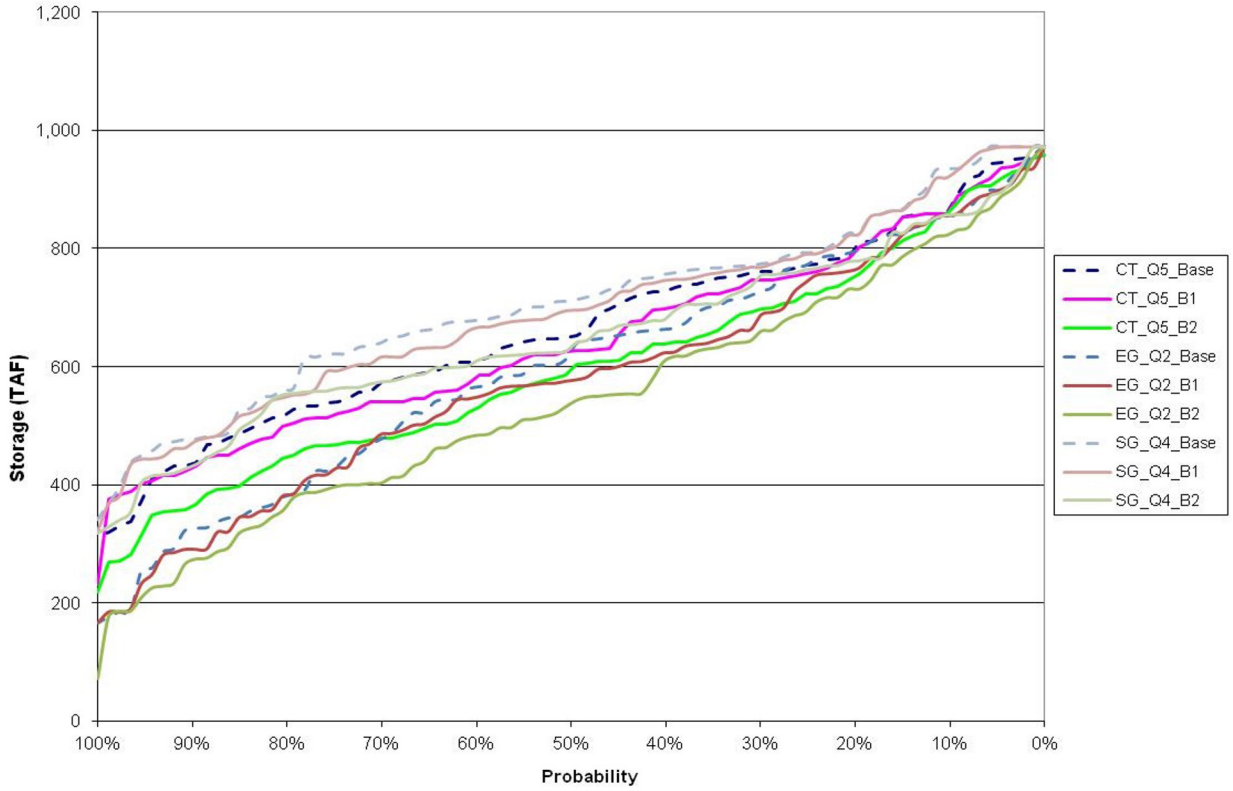

Figure 7-87. Exceedance of CVP San Luis End-of-May Storage in Portfolio B

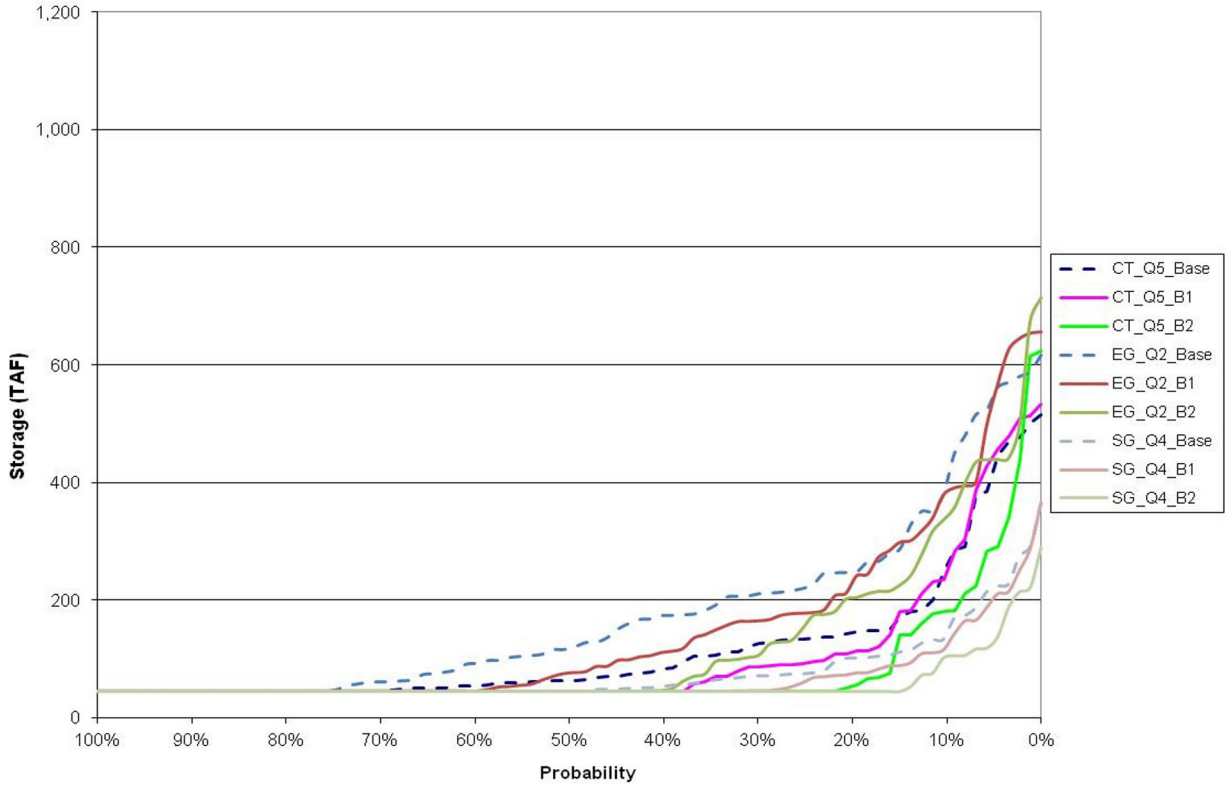

Figure 7-88. Exceedance of CVP San Luis End-of-September Storage in Portfolio B

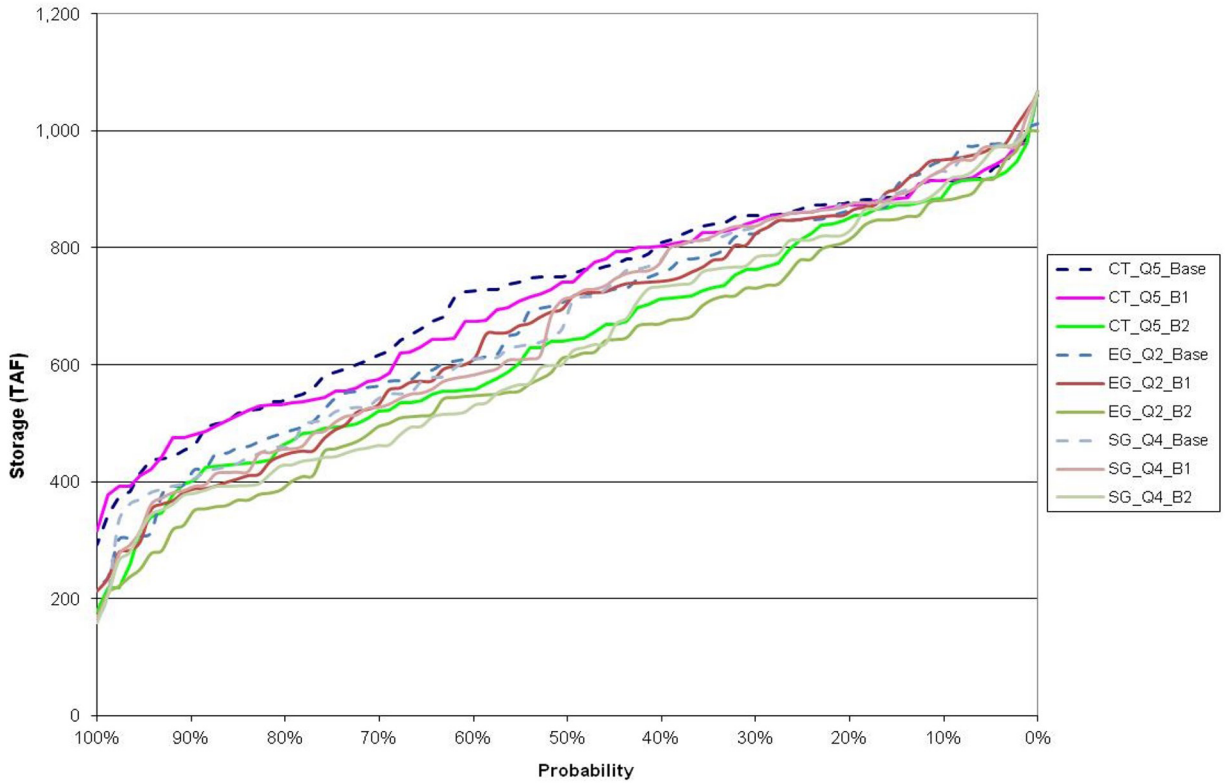

Figure 7-89. Exceedance of SWP San Luis End-of-May Storage in Portfolio B

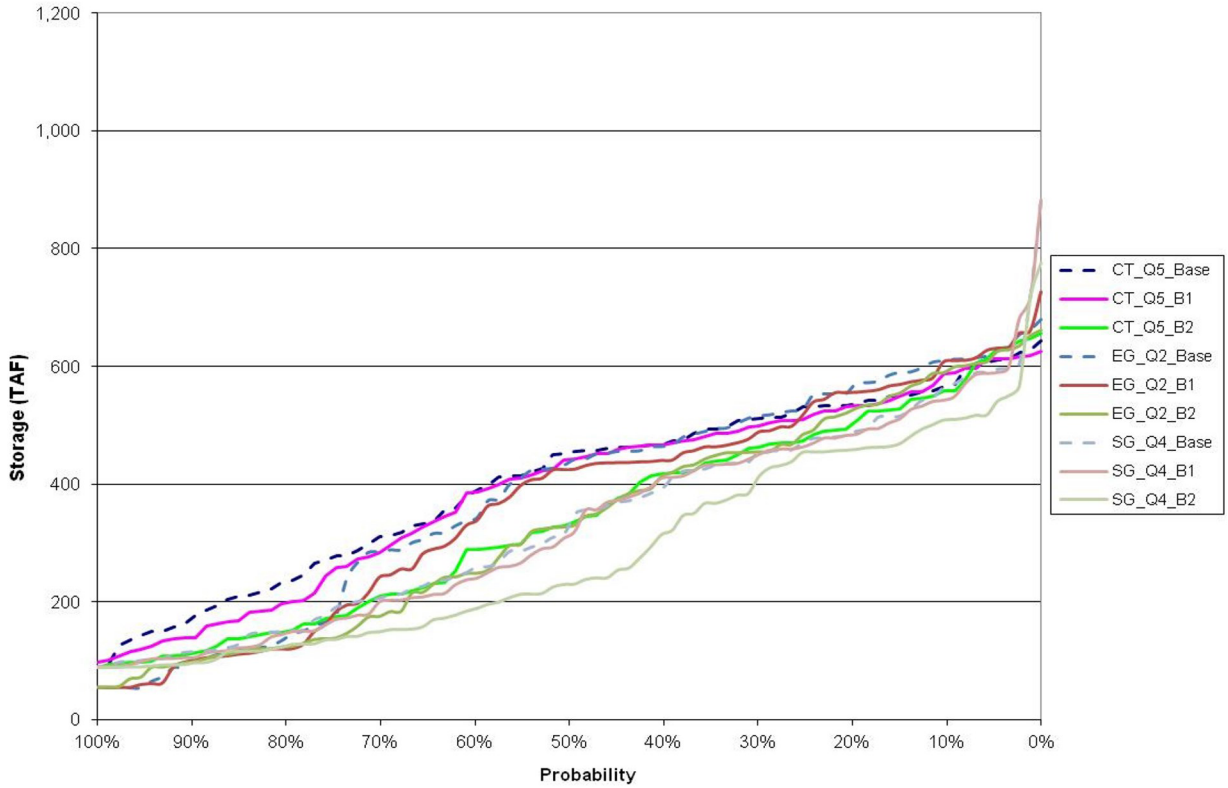

Figure 7-90. Exceedance of SWP San Luis End-of-September Storage in Portfolio B

(representing storage available for water supply) and at the end of September (representing carryover storage conditions) in Shasta, Folsom, Oroville, New Melones, Millerton, CVP San Luis, and SWP San Luis Reservoirs under scenarios CT-Q5, EG-Q2, and SG-Q4. As in the Baseline, the highest storage levels occurred in SG-Q4 (wetter), and the lowest storage levels occurred in the EG-Q2 (drier) scenario.

Figures 7-91 and 7-92 show the same information for the Sites Reservoir in B2. In B1, Lake Shasta storage was significantly higher than in the Baseline, reflecting the additional capacity of the enlarged reservoir. In B2, the CVP-SWP system benefited from the additional storage in NODOS; and for Lake Shasta storage, the benefits remained similar to the corresponding Baseline conditions. In both B1 and B2, Oroville and Folsom Lakes had moderately higher storage levels than in the Baseline conditions, reflecting the additional overall increased storage available to meet water demands; and CVP and SWP San Luis storage levels were moderately lower than in the Baseline. Storage at Millerton and New Melones were almost the same in both B1 and B2 as in the Baseline.

7.2.2.2 Delta Exports and Delta Outflow

Figures 7-93 through 7-100 are the annual exceedance plots of Delta exports from the Banks PP and Jones PP, and of total Delta exports under socioeconomic-climate scenarios CT-Q5 (central tendency), EG-Q2 (drier) and, SG-Q4 (wetter), and the change in annual average flows relative to their associated Baseline conditions at these locations for all 18 socioeconomic-climate scenarios. Figures 7-97 and 7-98 show the same information for Delta outflow. Both B1 and B2 showed increases in exports and reductions in Delta outflow relative to the Baseline conditions. The B2 suite (NODOS) tended to have larger increases in exports and larger reductions in Delta outflow than occur with B1 (Enlarged Shasta). In both suites, most of the change in exports occurred at the Banks PP under the drier Q1 and Q2 climate projections. Total average annual Delta exports increased by 0 to 68 TAF/year in B1 and by 0 to 167 TAF/year in B2 across the range of all socioeconomic-climate scenarios. Delta outflows were reduced by 15 to 100 TAF/year in B1 and by 0 to 222 TAF/year in B2, with the largest changes corresponding with the drier Q1 and Q2 climate projections.

In both B1 and B2, the greatest increases in exports and reductions in Delta outflow occurred with the drier climate scenarios (Q1 and Q2) because the lower export levels in the Baseline in these scenarios allowed for more incremental pumping under the Portfolio B simulations. Conversely, the smallest increases in exports occurred with the wetter climate scenarios (Q3 and Q4) where pumping was already at the maximum in many years in the Baseline, leaving less room for additional exports under Portfolio B.

7.2.2.3 Delta Salinity

Figure 7-101 shows the exceedance plots of average X2 position from February through June during the twenty-first century under socioeconomic scenarios CT Q5, EG-Q2, and SG-Q4. Figure 7-102 shows the average X2 position for all 18 socioeconomic-climate scenarios for the months of February through June for the Portfolio B actions. As can be seen on the figures, the changes in X2 position were relatively small, reflecting the small changes in Delta flows resulting from the Portfolio B actions relative to their Baseline conditions.

7.2.3 Other Performance Assessments

7.2.3.1 Economics

Figures 7-103 through 7-106 show the net improvement in net water supply system costs from the urban economic models LCPSIM and OMWEM, the net improvement in avoided cost from the water quality economic model SBWQM, and the net improvement in net agricultural revenue from the SWAP model for each Portfolio B suite under the CT-Q5, EG-Q2, and SG-Q4 socioeconomic-climate scenarios at the 2025, 2055, and 2085 LODs.

The South Bay urban economic model results from LCPSIM showed almost no change in economic values in the SG-Q4 scenario for either B1 or B2. For B1, there were economic benefits of up to about $4 million per year in the CT-Q5 scenario and somewhat larger economic benefits of up to about $37 million per year in the EG-Q2 scenario. For B2, there were economic benefits of up to about $10 million per year in the CT-Q5 scenario

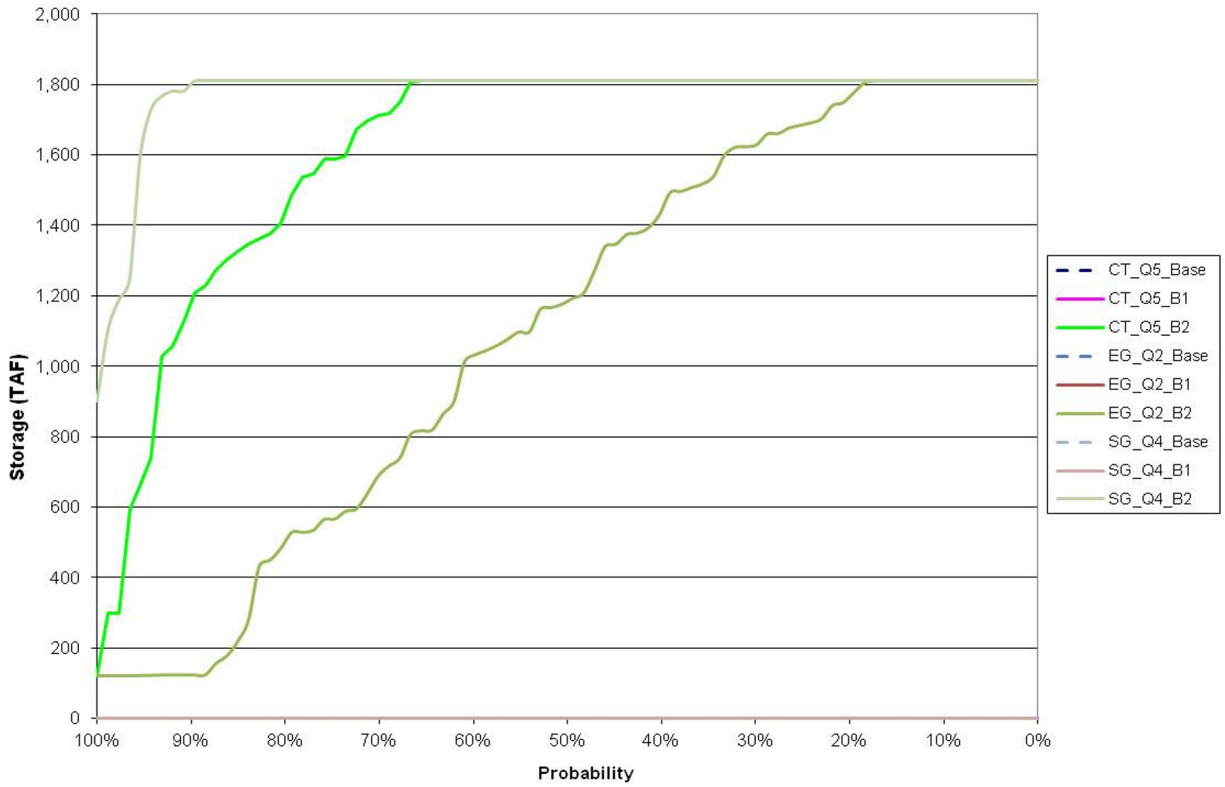

Figure 7-91. Exceedance of NODOS End-of-May Storage in Portfolio B

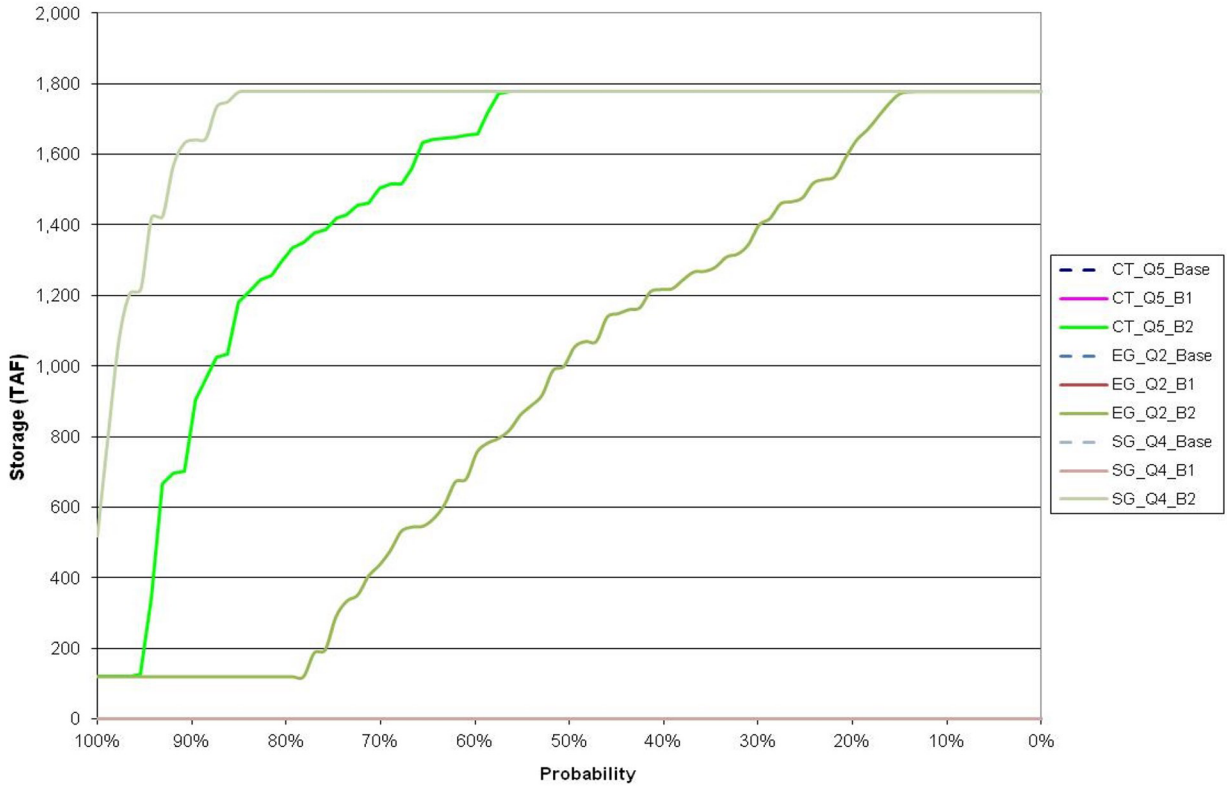

Figure 7-92. Exceedance of NODOS End-of-September Storage in Portfolio B

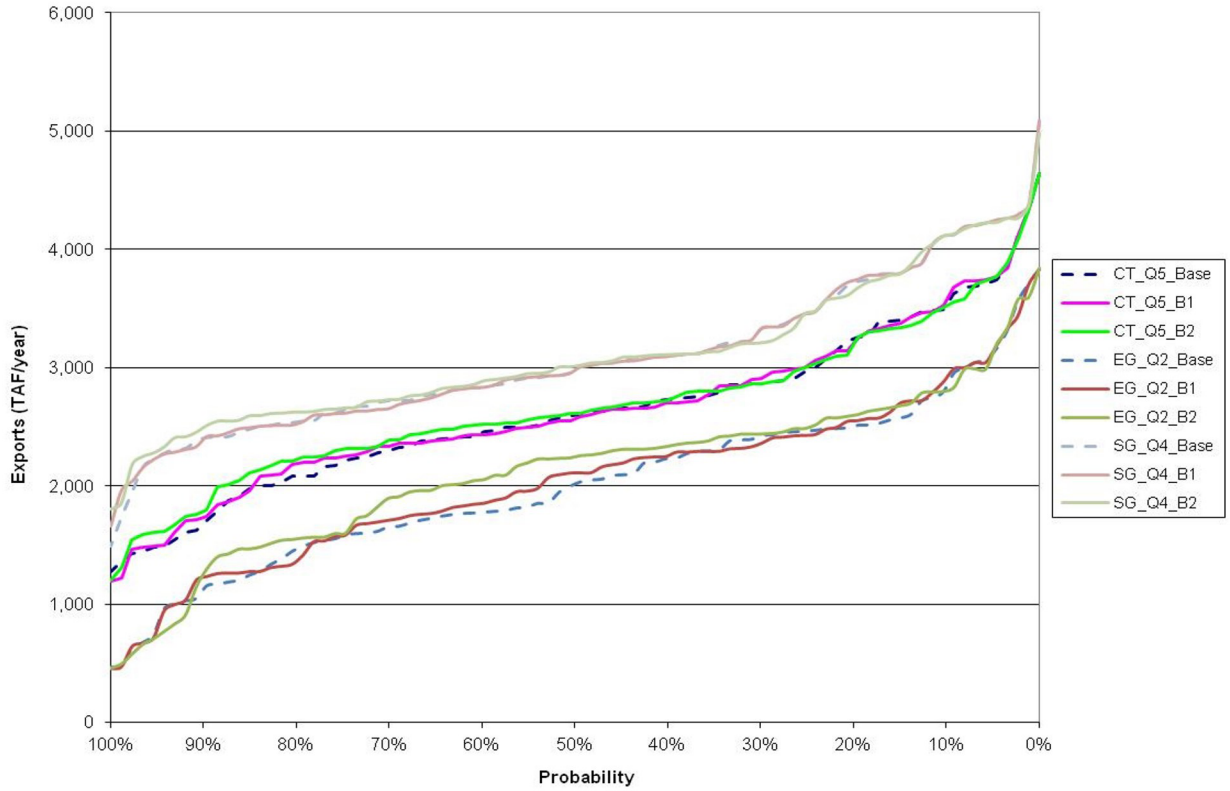

Figure 7-93. Annual Exceedance of Banks Pumping in Portfolio B

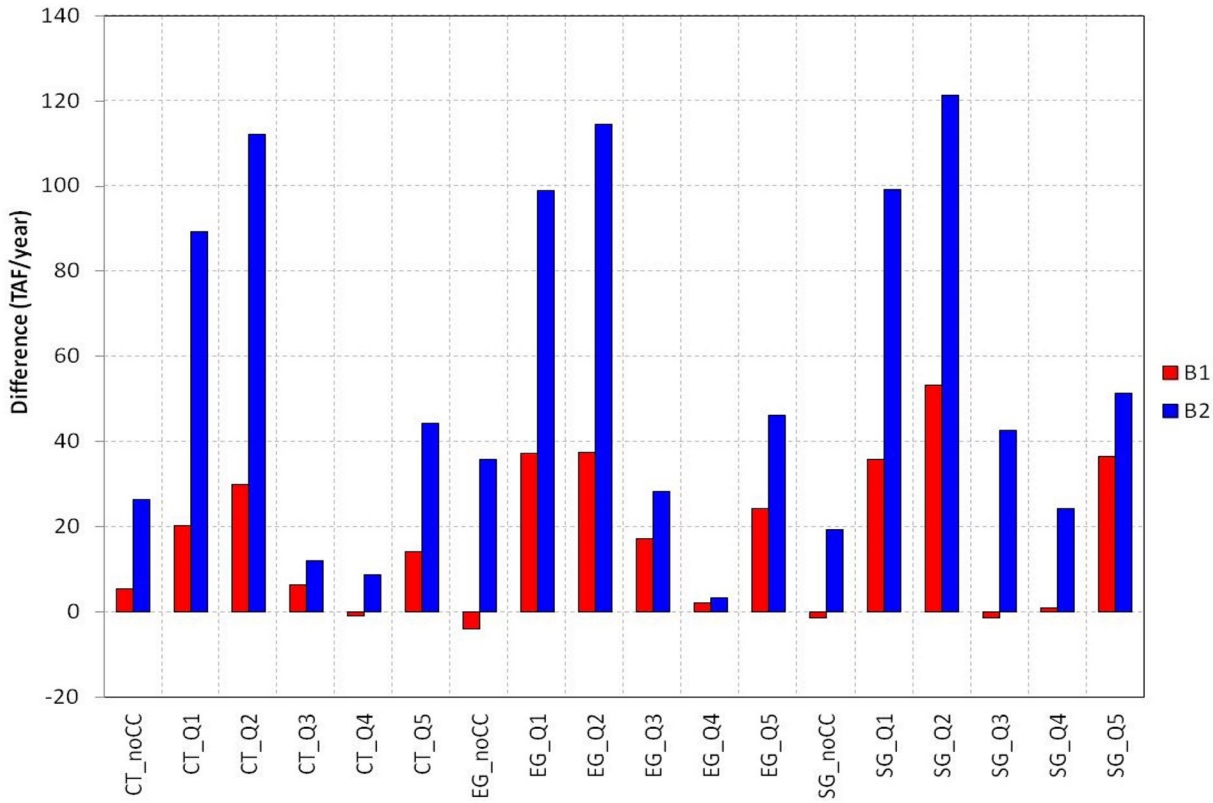

Figure 7-94. Average Annual Change in Banks Pumping for Portfolio B Relative to the Baseline in Each Scenario

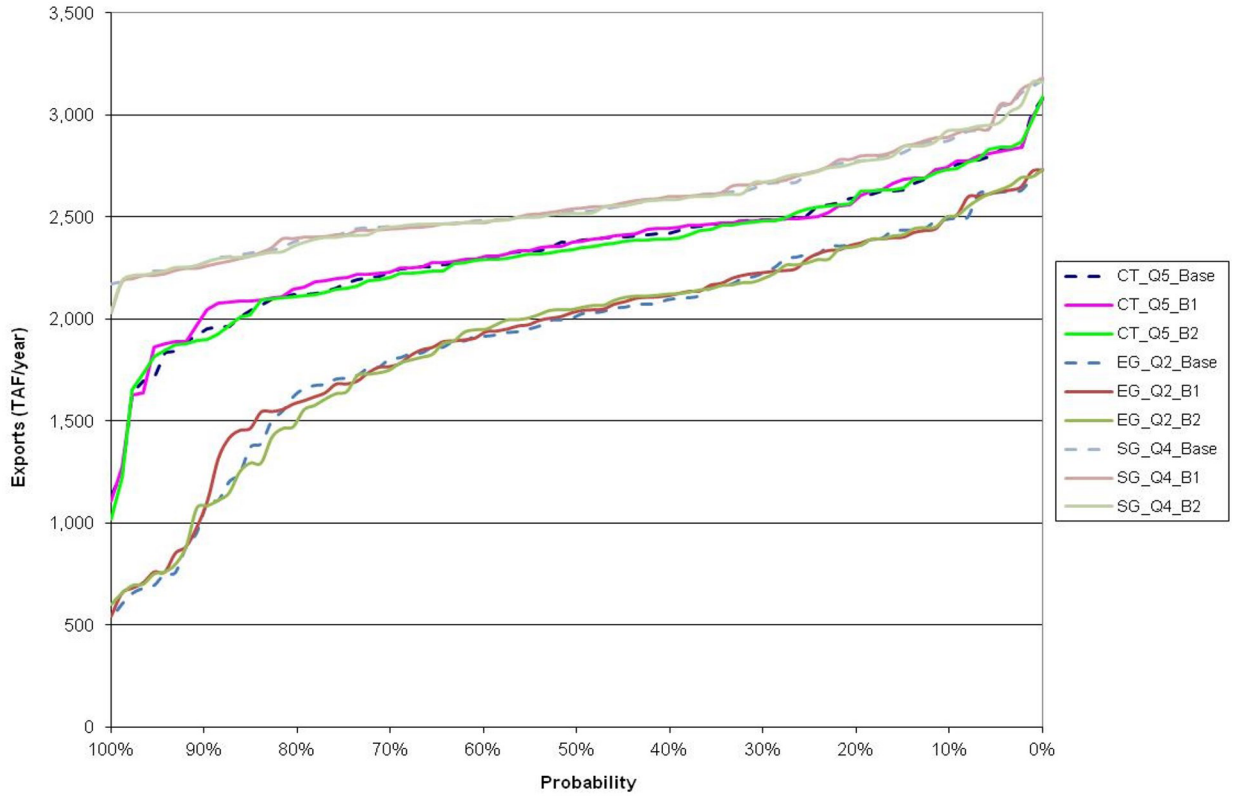

Figure 7-95. Annual Exceedance of Jones Pumping in Portfolio B

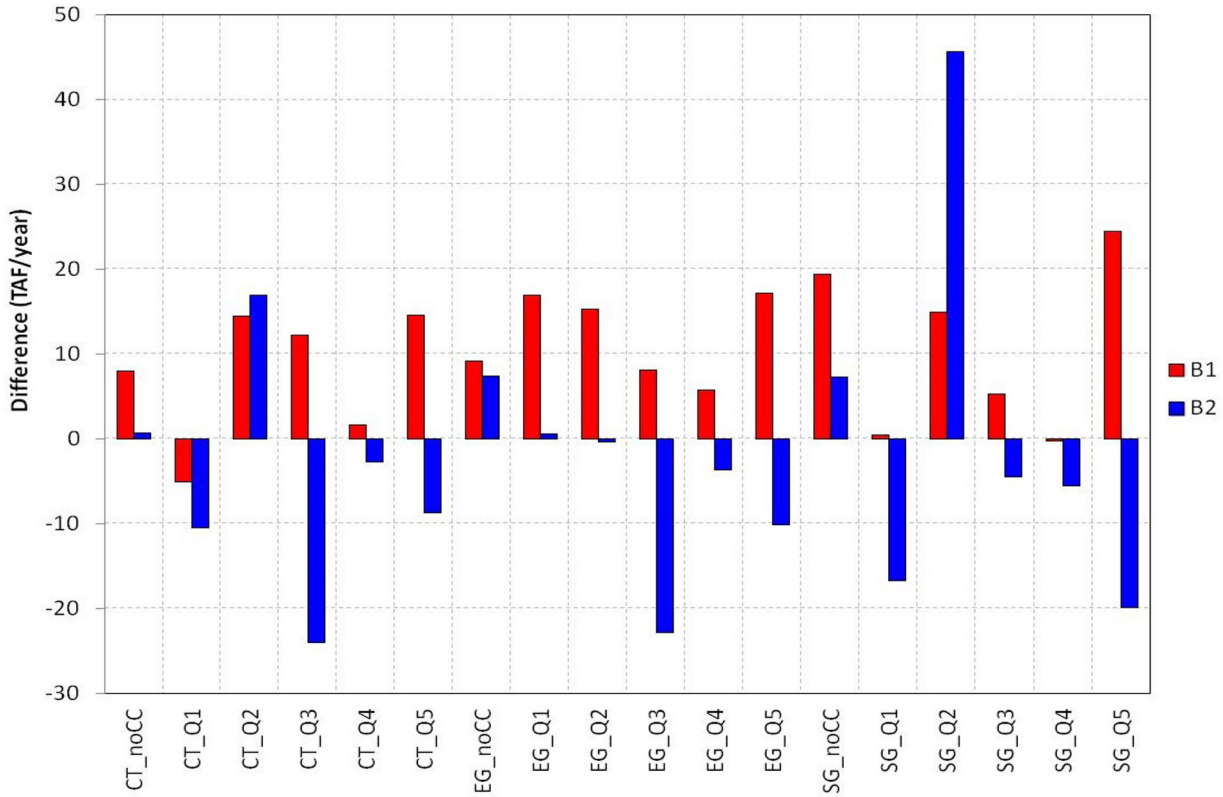

Figure 7-96. Average Annual Change in Jones Pumping for Portfolio B Relative to the Baseline in Each Scenario

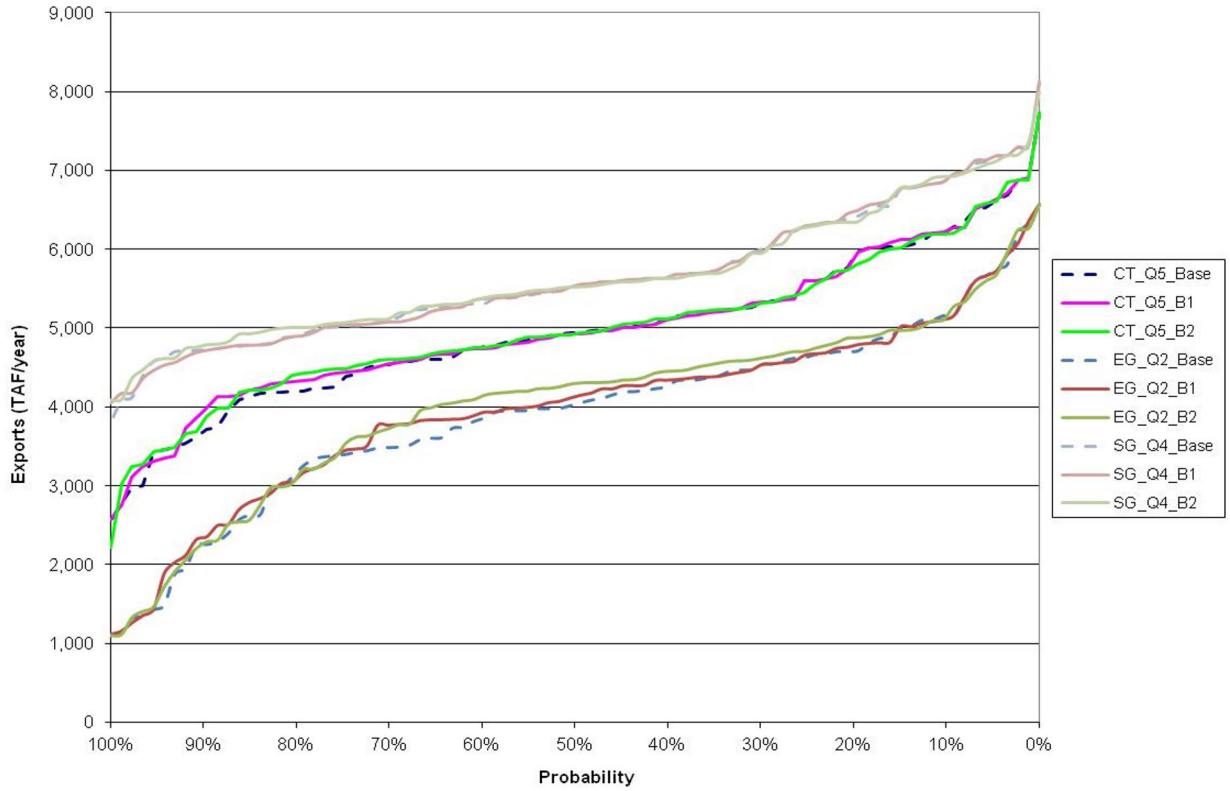

Figure 7-97. Annual Exceedance of Total Delta Exports in Portfolio B

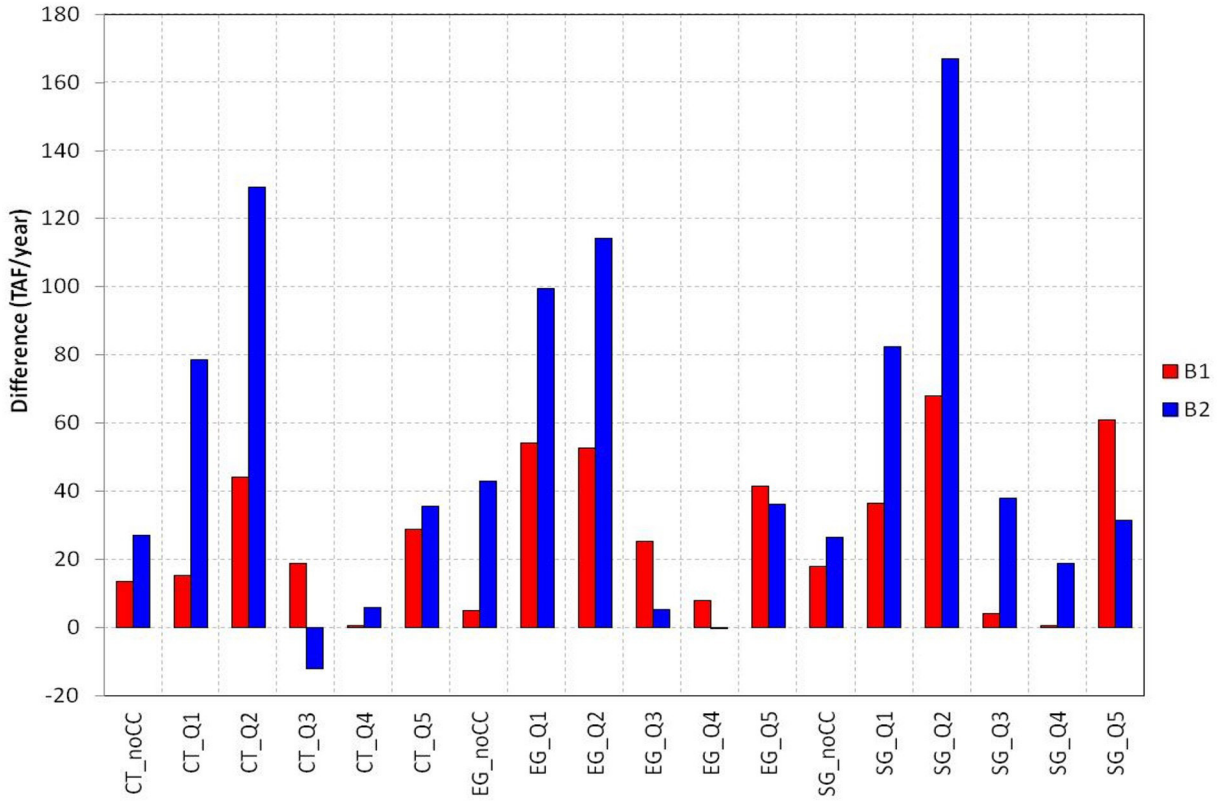

Figure 7-98. Average Annual Change in Total Delta Exports for Portfolio B Relative to the Baseline in Each Scenario

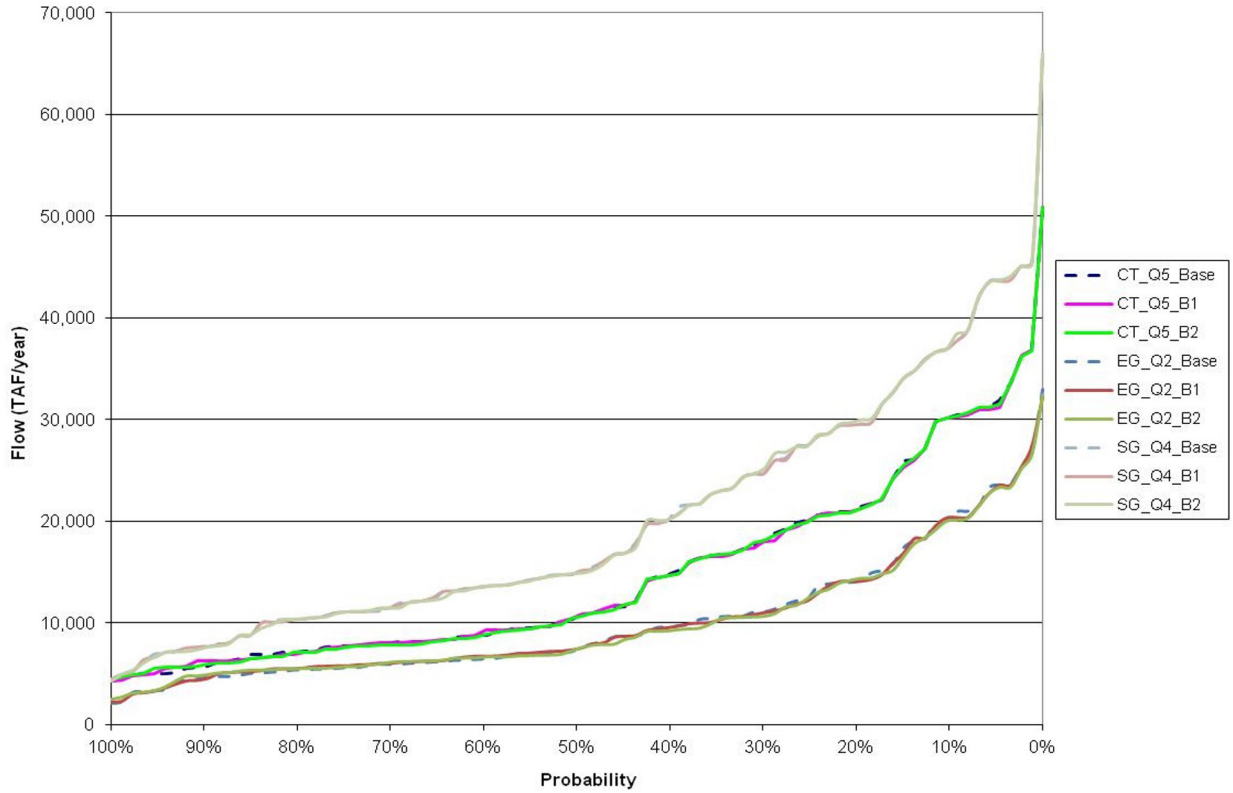

Figure 7-99. Annual Exceedance of Delta Outflow in Portfolio B

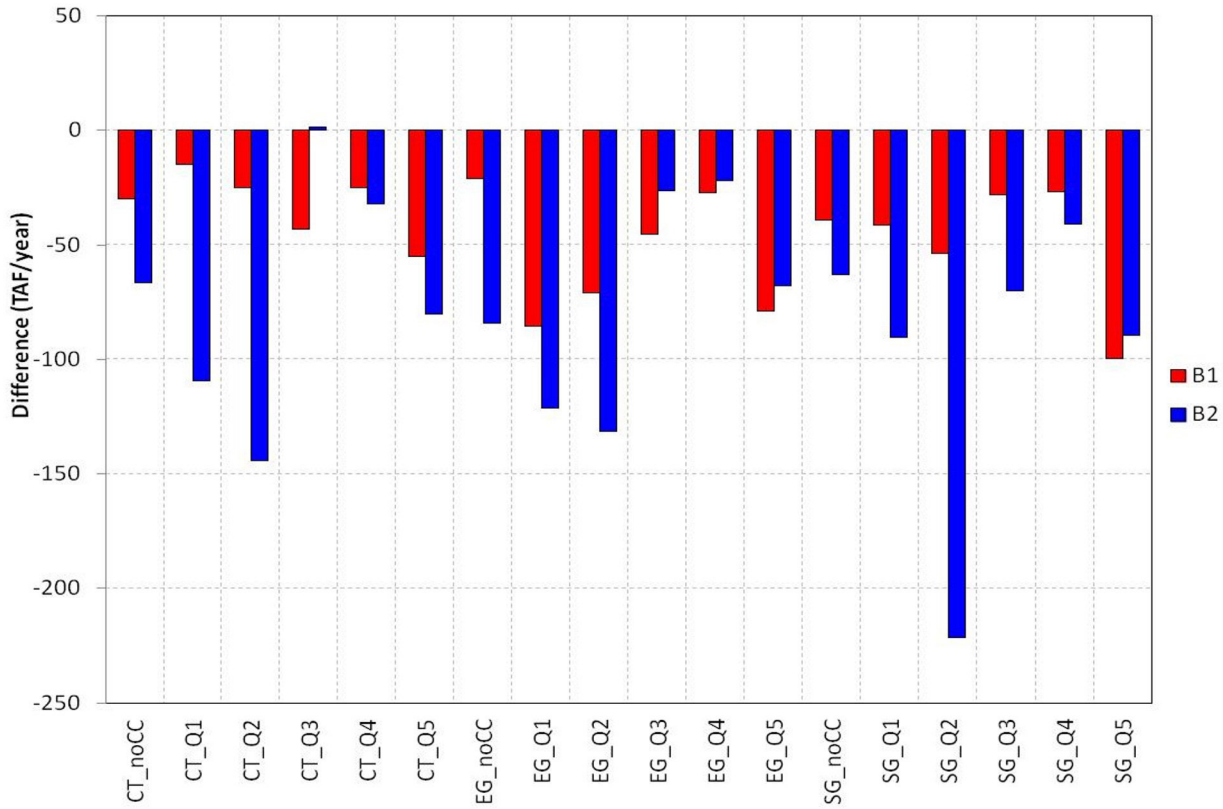

Figure 7-100. Average Annual Change in Delta Outflow for Portfolio B Relative to the Baseline in Each Scenario

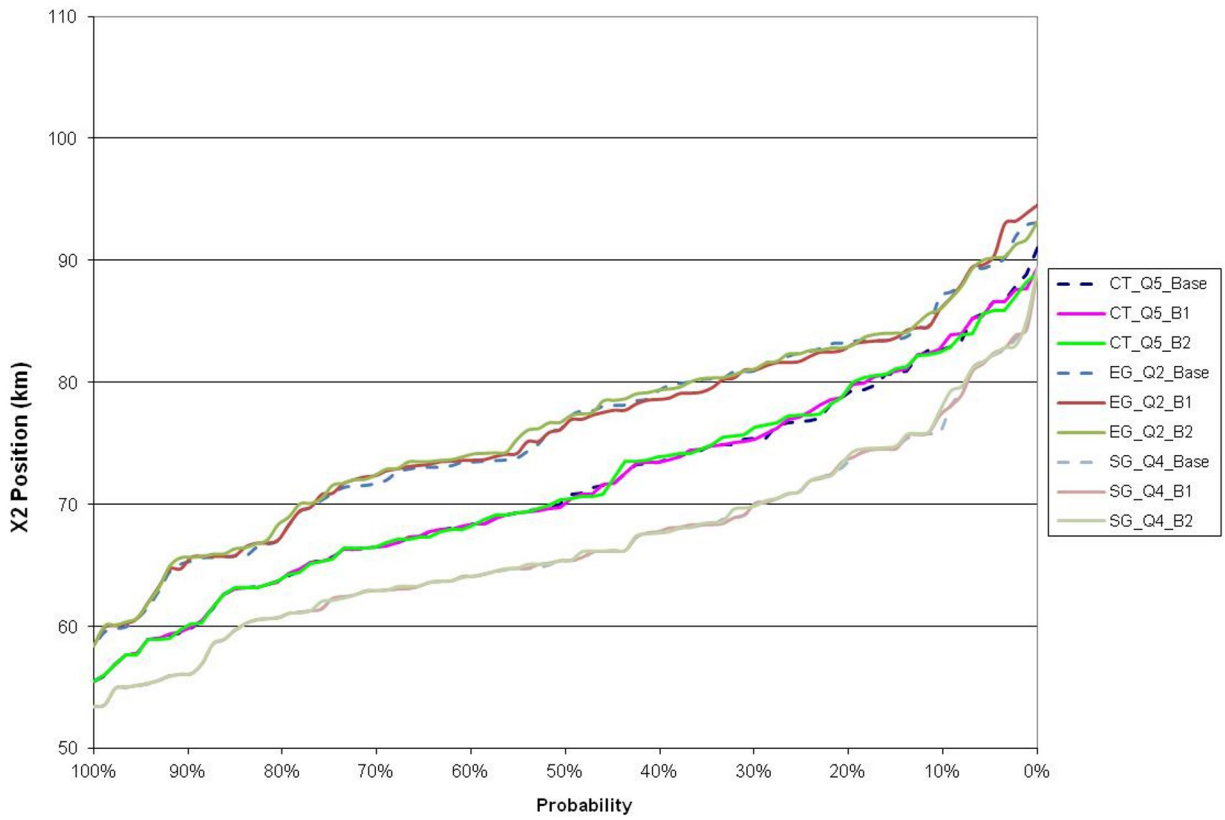

Figure 7-101. Exceedance of Average February-to-June X2 Position in Portfolio B

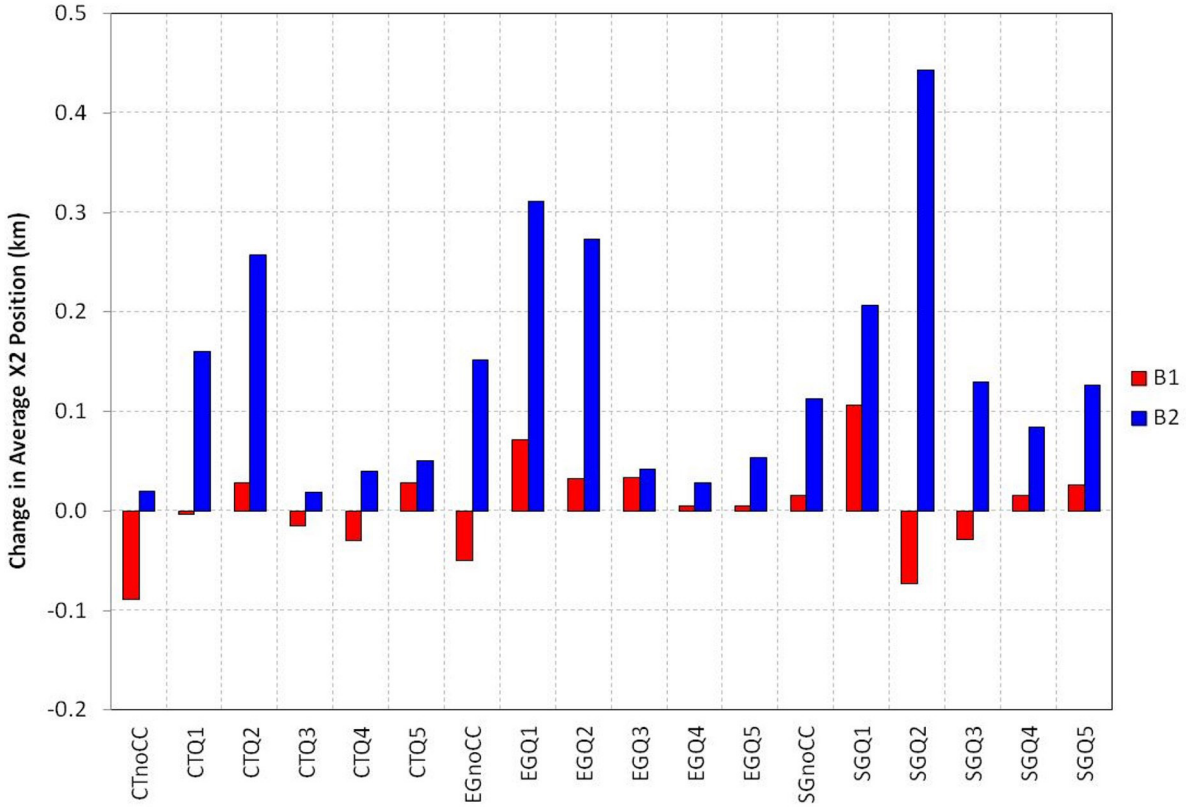

Figure 7-102. Change in Average February-to-June X2 Position for Portfolio B Relative to the Baseline in Each Scenario

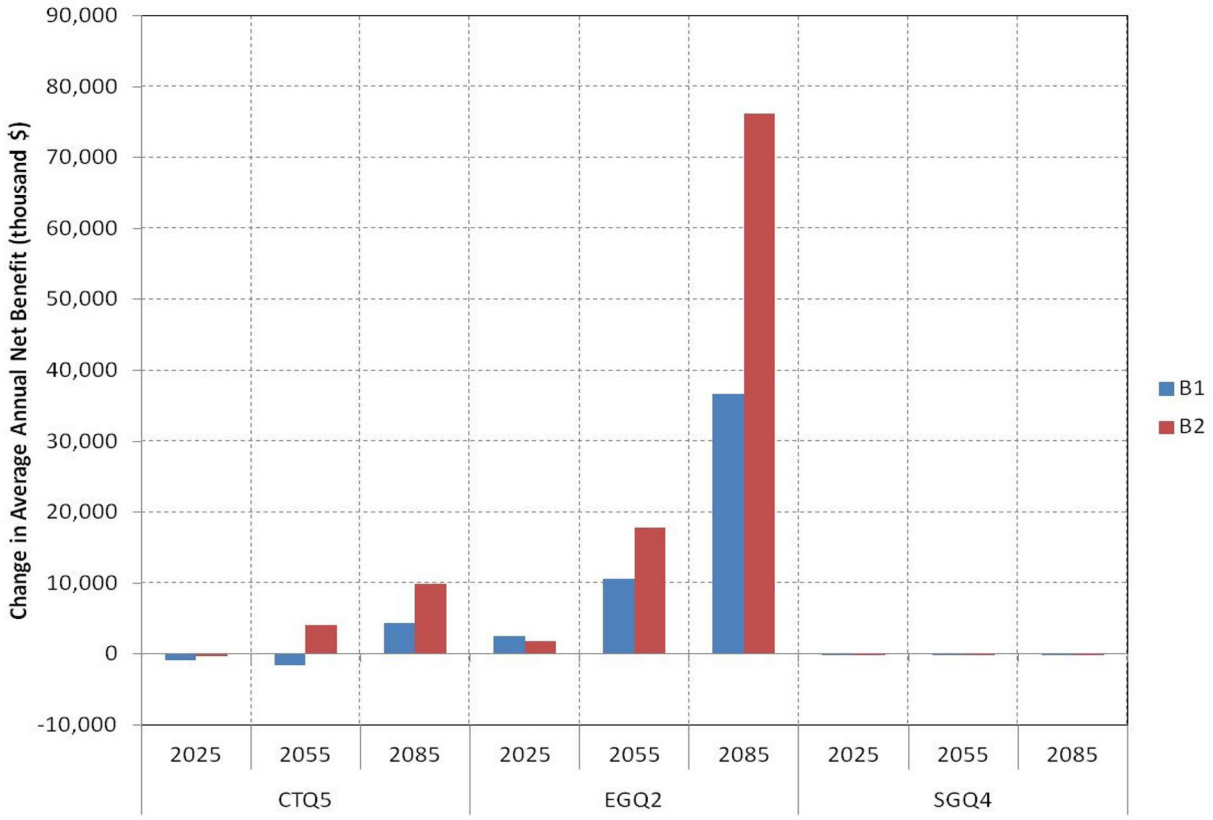

Figure 7-103. Improvement in Average Annual Urban Net Water Supply System Costs in South Bay Region from LCPSIM in Portfolio B

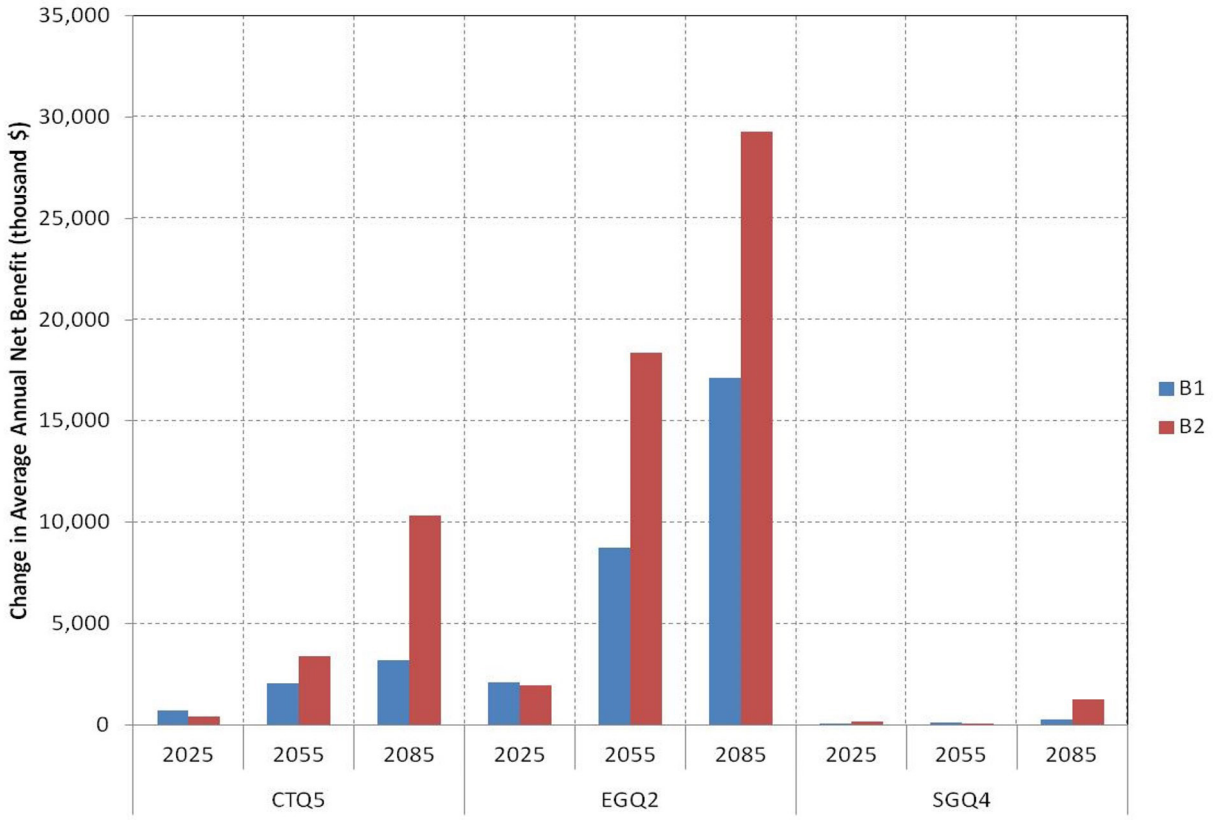

Figure 7-104. Improvement in Average Annual Urban Net Water Supply System Costs in Central Valley from OMWEM in Portfolio B

Figure 7-105. Improvement in Average Annual Avoided Water Quality Costs in South Bay Region from SBWQM in Portfolio B

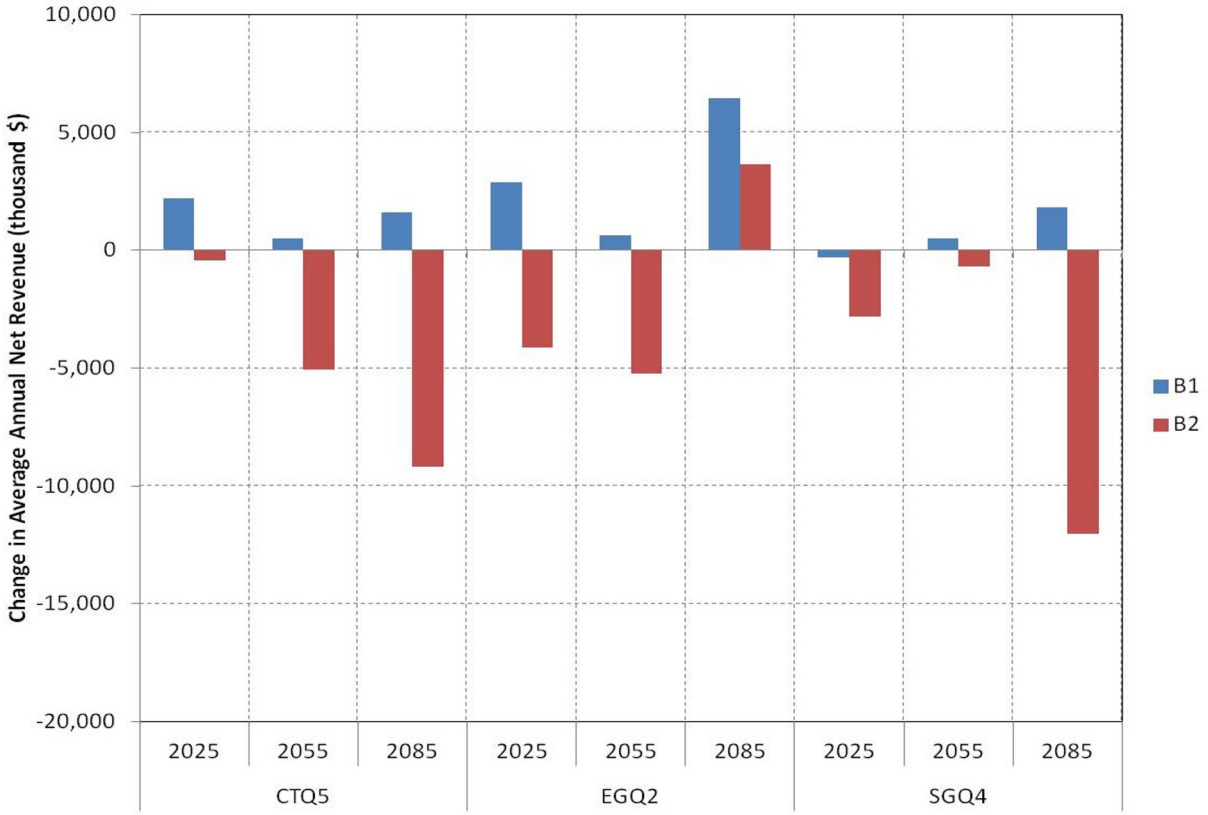

Figure 7-106. Improvement in Average Annual Agricultural Net Revenue in Central Valley from SWAP in Portfolio B

and somewhat larger economic benefits of up to about $76 million per year in the EG-Q2 scenario. These benefits resulted from the reductions in shortage costs due to the increased deliveries to the South Bay region, and were larger in EG-Q2 because the South Bay has higher demands and, therefore, high marginal shortage costs in EG-Q2 due to the increased population in the Expansive Growth socioeconomic scenario.

Figure 7-107 shows the long-term average salinity at CCWD and SBA diversion locations in Portfolio B. South Bay region water quality costs simulated by SBWQM showed a small increase in costs of up to about $2 million per year in B1 and about $5 million per year in B2 in the CT-Q5 scenario. In each case, this resulted from a net increase in total salt load due to increased export levels but not enough salinity reduction at the export locations to reduce the overall salt load. By contrast, in both the EG-Q2 and SG-Q4 scenarios, the effects of changes in exports and in salinity resulted in very little change in water quality costs with either the B1 or B2 actions.

The changes in Central Valley agricultural economic model results from SWAP and urban economic results from OMWEM showed only small differences with B1 and B2 actions as compared to the Baseline (see Figure 7-106), reflecting the small changes in CVP and SWP deliveries in the Central Valley with the implementation of Enlarged Shasta(B1) and NODOS(B2). In B1, the average annual economic changes across the different scenarios and LODs ranged from no benefit to a benefit of about $6 million per year for SWAP and from no benefit to a benefit of about $17 million per year for OMWEM. In B2, the average annual economic changes across the different scenarios and LODs ranged from a cost of about $12 million per year to a benefit of about $4 million per year in agricultural net revenue from SWAP. The reductions in net revenue were caused by small reductions in deliveries relative to the Baseline. The economic benefits in urban regions from OMWEM ranged from no benefit to a benefit of about $29 million per year.

7.2.3.2 Water Temperature

Figures 7-108 through 7-111 show exceedance plots and average changes of daily water temperatures from July through September relative to the Baseline for CT Q5, EG-Q2, and SG-Q4 scenarios in the Sacramento River at Keswick and at Jelly's Ferry. For Suite B1, the mean daily temperatures in the Sacramento River at Keswick were about 0.2°F lower than in the Baseline, and the temperatures at Jelly's Ferry were about 0.2–0.3°F lower than the Baseline. These modest reductions in temperature occurred because of the increased storage and available coldwater pool in the Enlarged Shasta action (B1). As observed in the Baseline cases, the SG-Q4 (wetter) scenario had the lowest temperatures, and the EG-Q2 (drier) scenario had the highest temperatures, with CT-Q5 falling between them.

For Suite B2, the CT-Q5 and EG-Q2 scenarios also had lower temperatures than in the Baseline at the two Sacramento River locations. In CT-Q5, mean daily temperatures were about 0.1°F lower than in the Baseline; and in EG-Q2, the mean daily temperatures were about 0.2°F lower than in the Baseline. These results were due to increases in Shasta Lake storage that occurred in B2. In the SG-Q4 scenario, there was a small temperature increase under the B2 scenario, with mean daily temperatures increasing by about 0.1°F. This was primarily because of increased flow coming into the Sacramento River from the Trinity and Whiskeytown systems as compared to Lake Shasta. Figures 7-112 through 7-117 show exceedance plots and average changes of daily water temperatures relative to the Baseline for the same three socioeconomic scenarios in the San Joaquin River at Lost Lake, at Gravelly Ford, and at Vernalis from August through November. Under all scenarios for both B1 and B2, there were only minimal changes in temperatures at all three San Joaquin River locations relative to the Baseline, indicating that increased storage in the Sacramento River system had negligible impacts on temperatures in the San Joaquin River.

7.2.3.3 Hydropower and Greenhouse Gas Emissions

Figures 7-118 and 7-119 show the changes in net hydropower generation and in GHG emissions (that is, increase in GHG emissions in the SWP system or reduction in potential GHG offsets in the CVP system) in the CVP and SWP systems in Portfolio B relative to the Baseline. In the CVP system there was very little change in net generation or GHG emissions or offsets in B2. However, in B1, there was an increase in

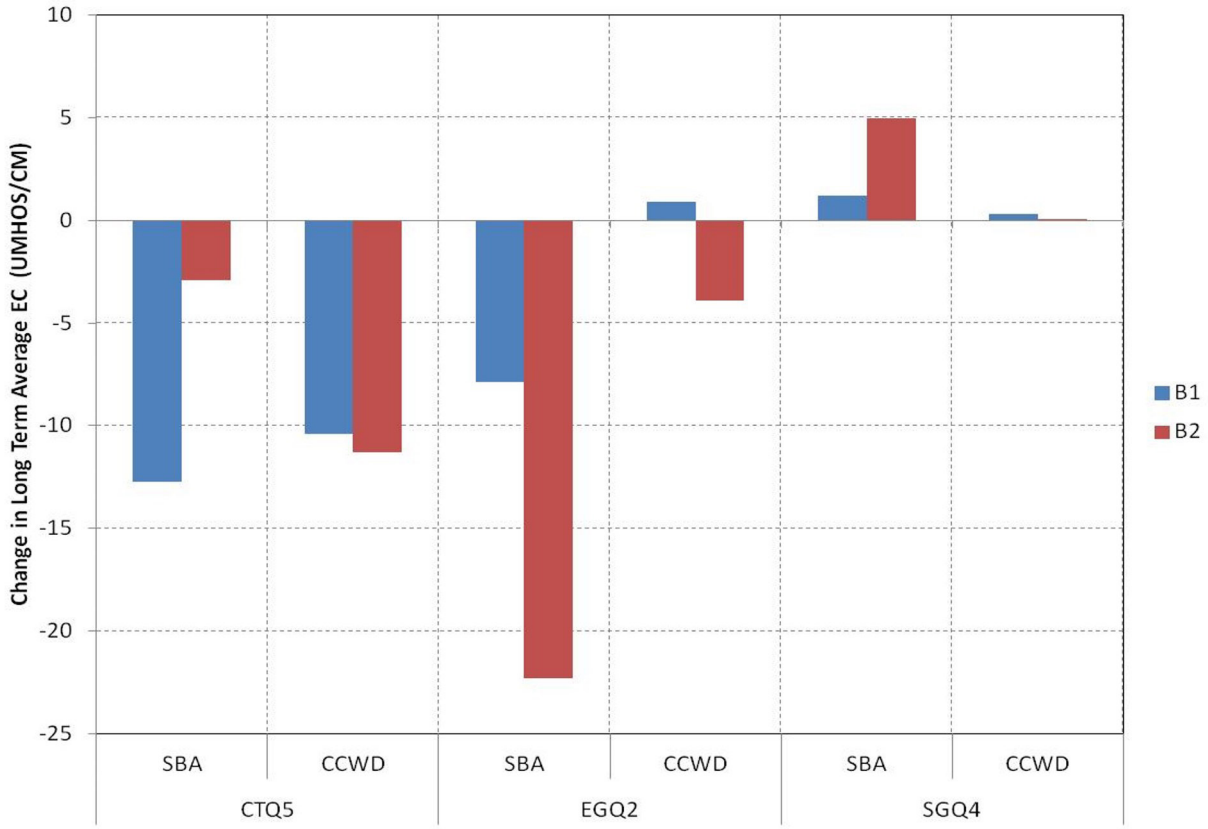

Figure 7-107. Long-Term Average Salinity at CCWD and SBA Diversion Locations in Portfolio B

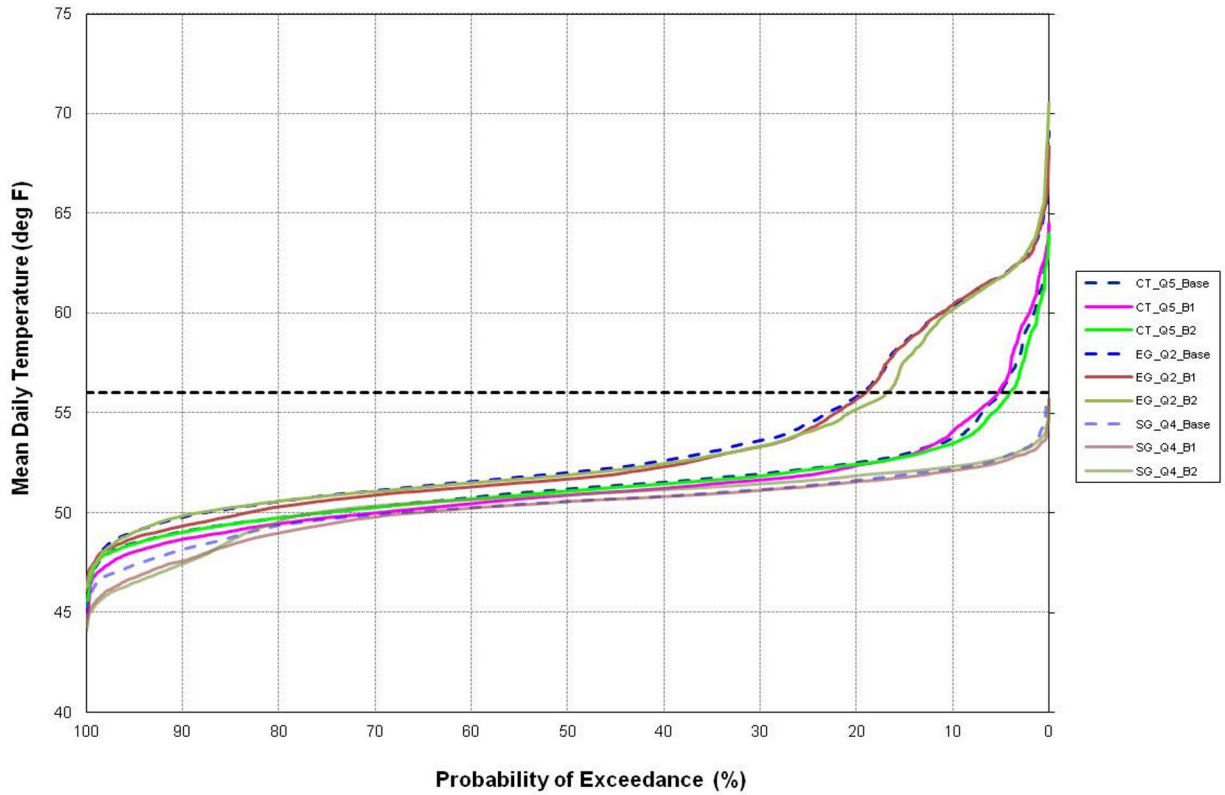

Figure 7-108. Exceedance of Mean Daily Temperature on Sacramento River at Keswick from July to September in Portfolio B

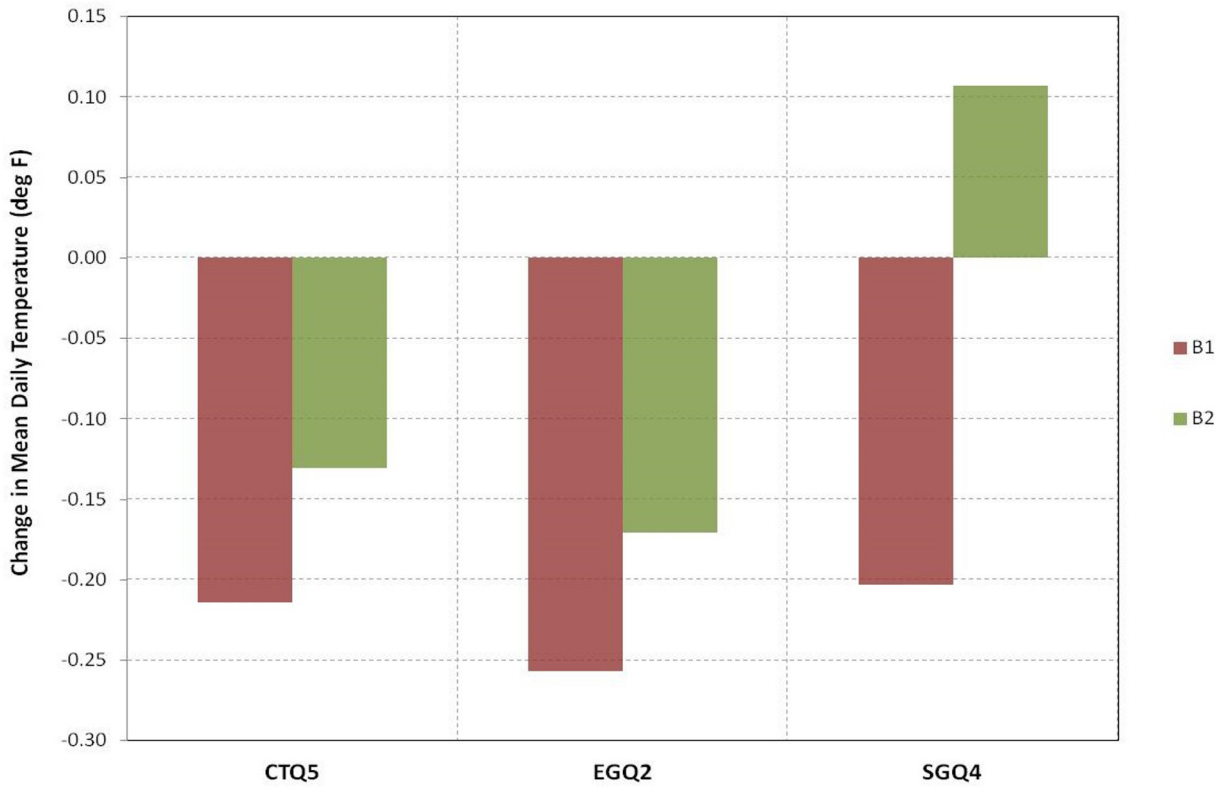

Figure 7-109. Change in Mean Daily Temperature on Sacramento River at Keswick from July to September in Portfolio B

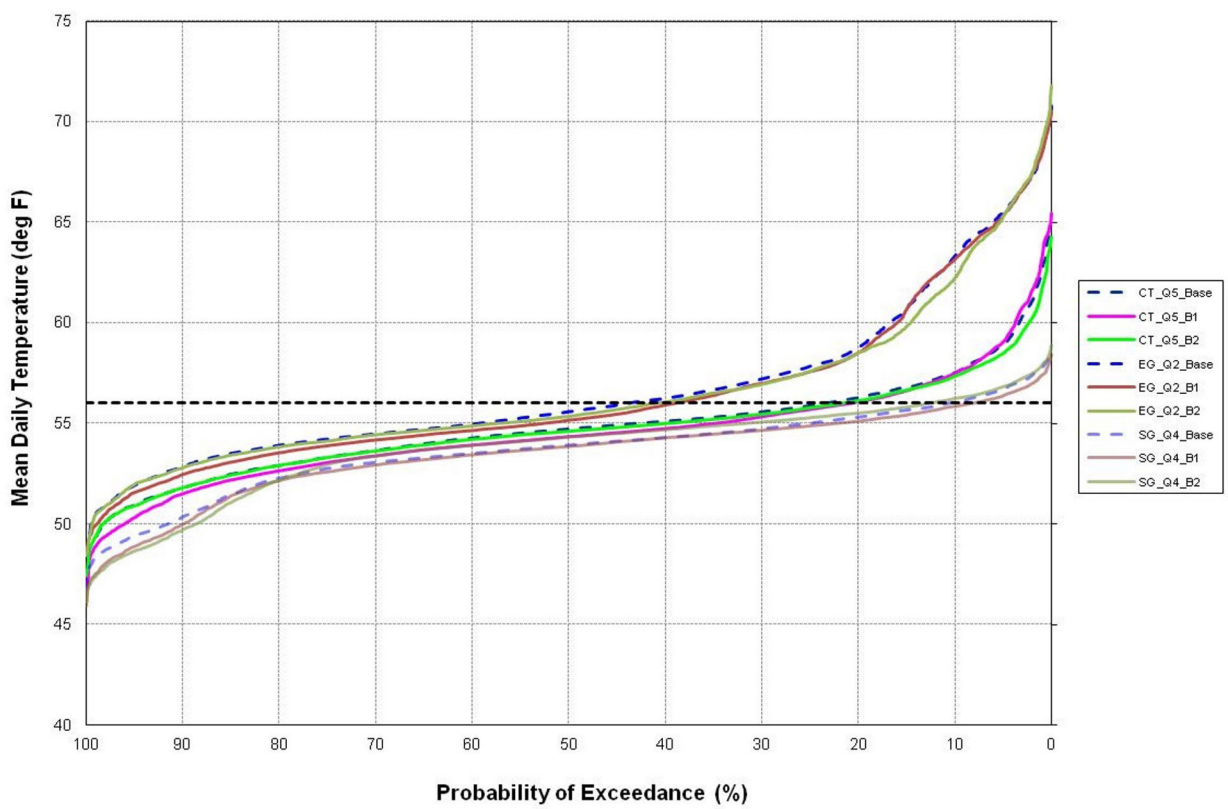

Figure 7-110. Exceedance of Mean Daily Temperature on Sacramento River at Jelly's Ferry from July to September in Portfolio B

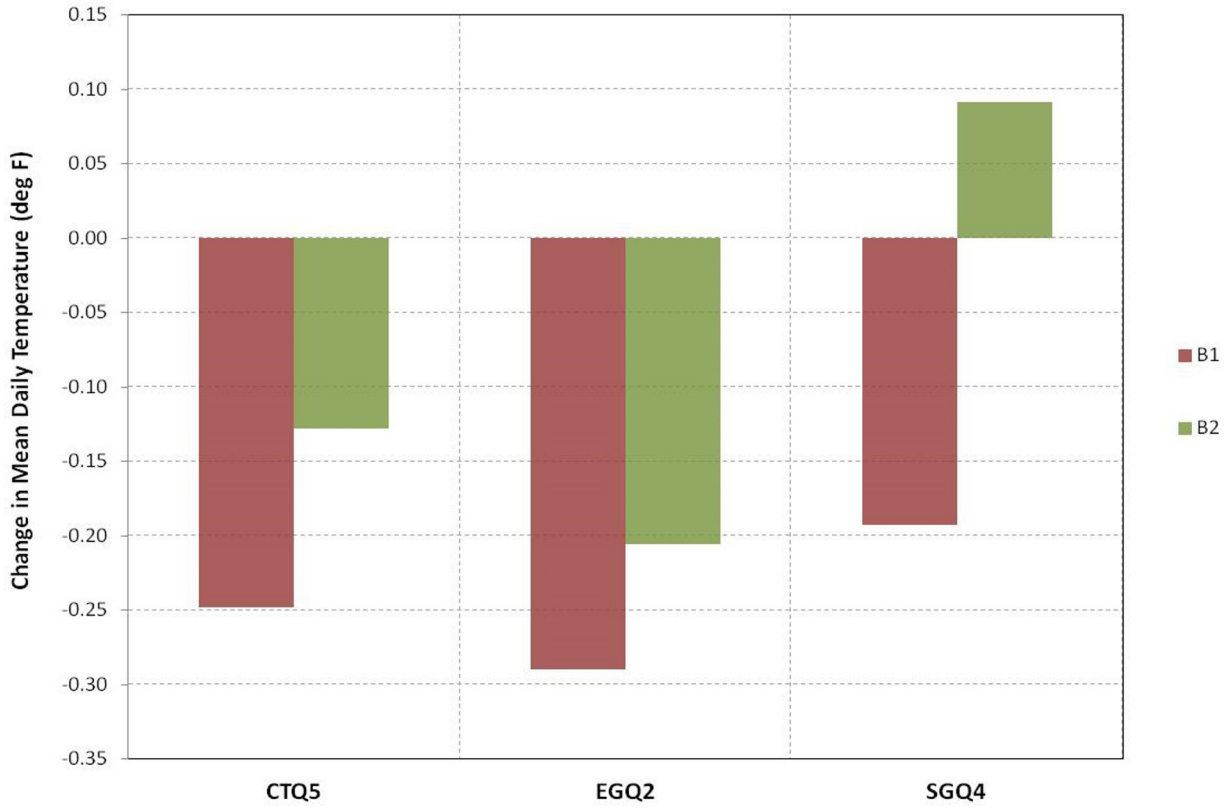

Figure 7-111. Change in Mean Daily Temperature on Sacramento River at Jelly's Ferry from July to September in Portfolio B

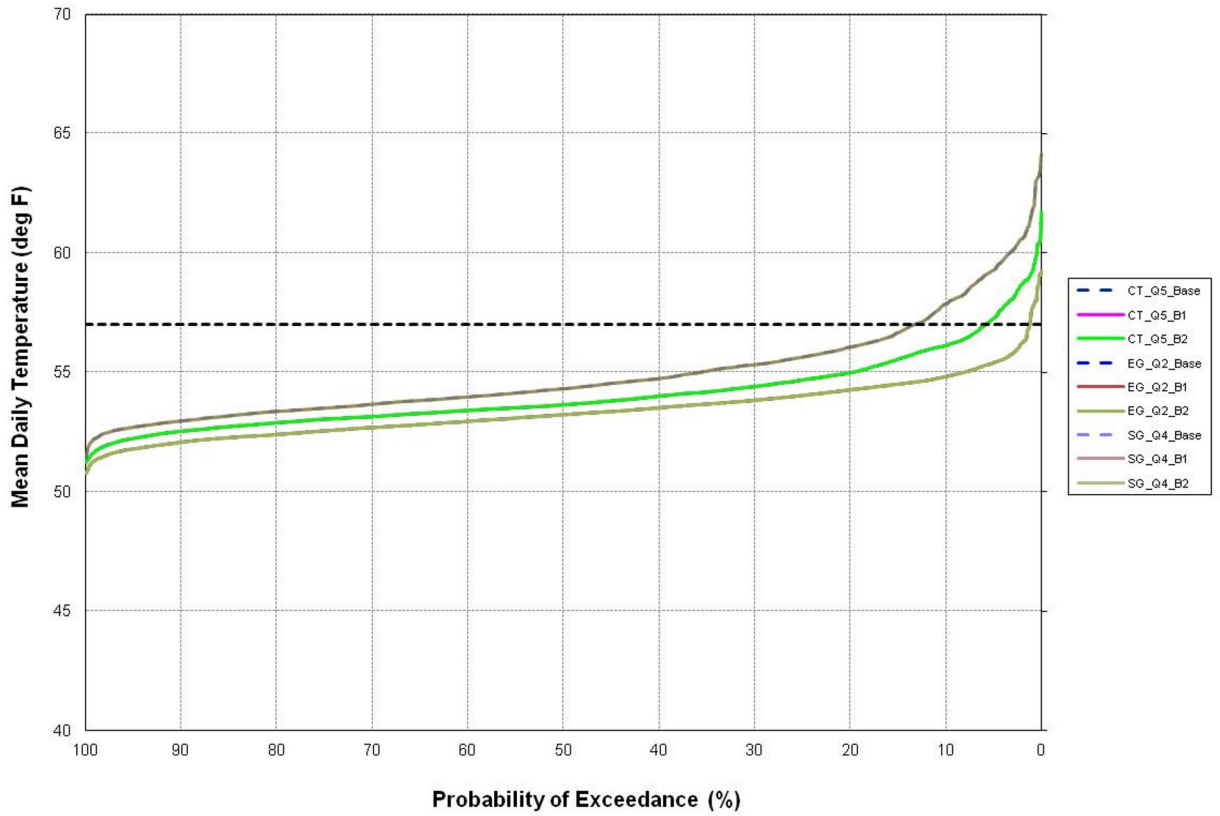

Figure 7-112. Exceedance of Mean Daily Temperature on San Joaquin River at Lost Lake from August to November in Portfolio B

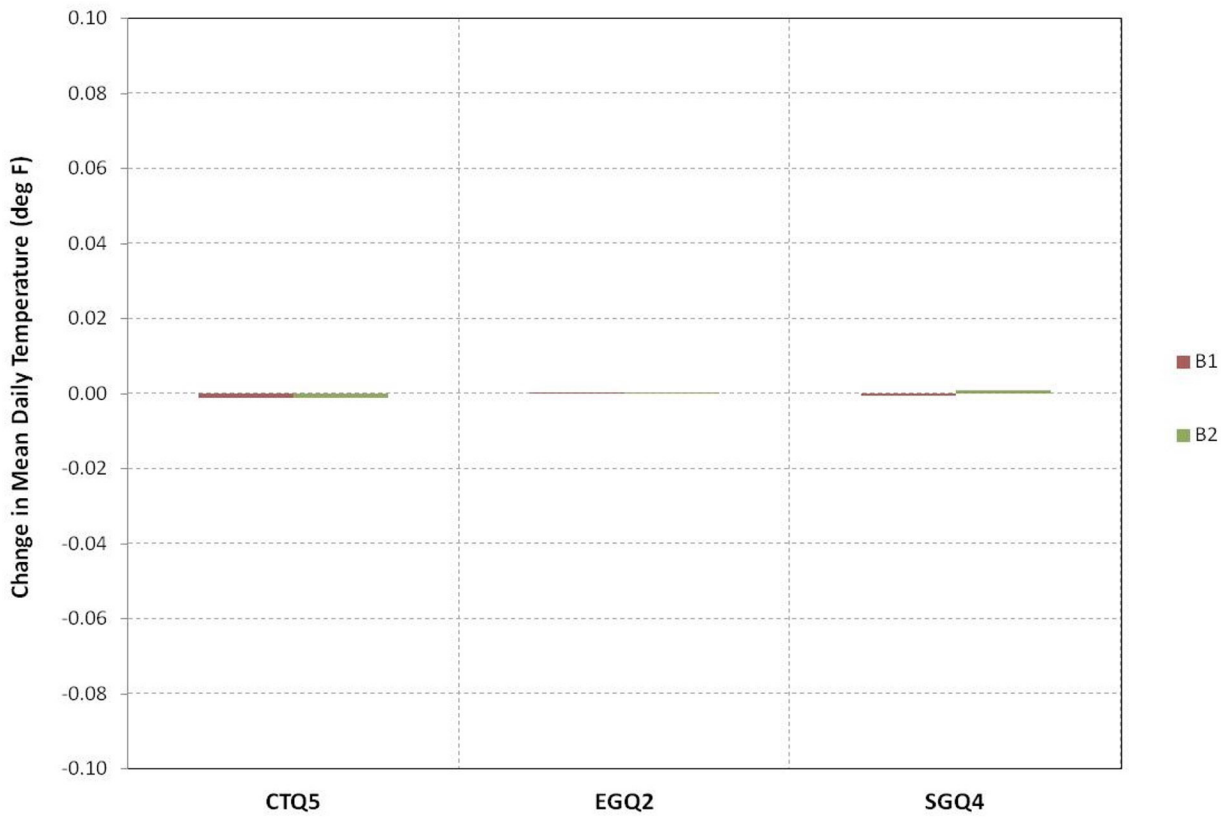

Figure 7-113. Change in Mean Daily Temperature on San Joaquin River at Lost Lake from August to November in Portfolio B

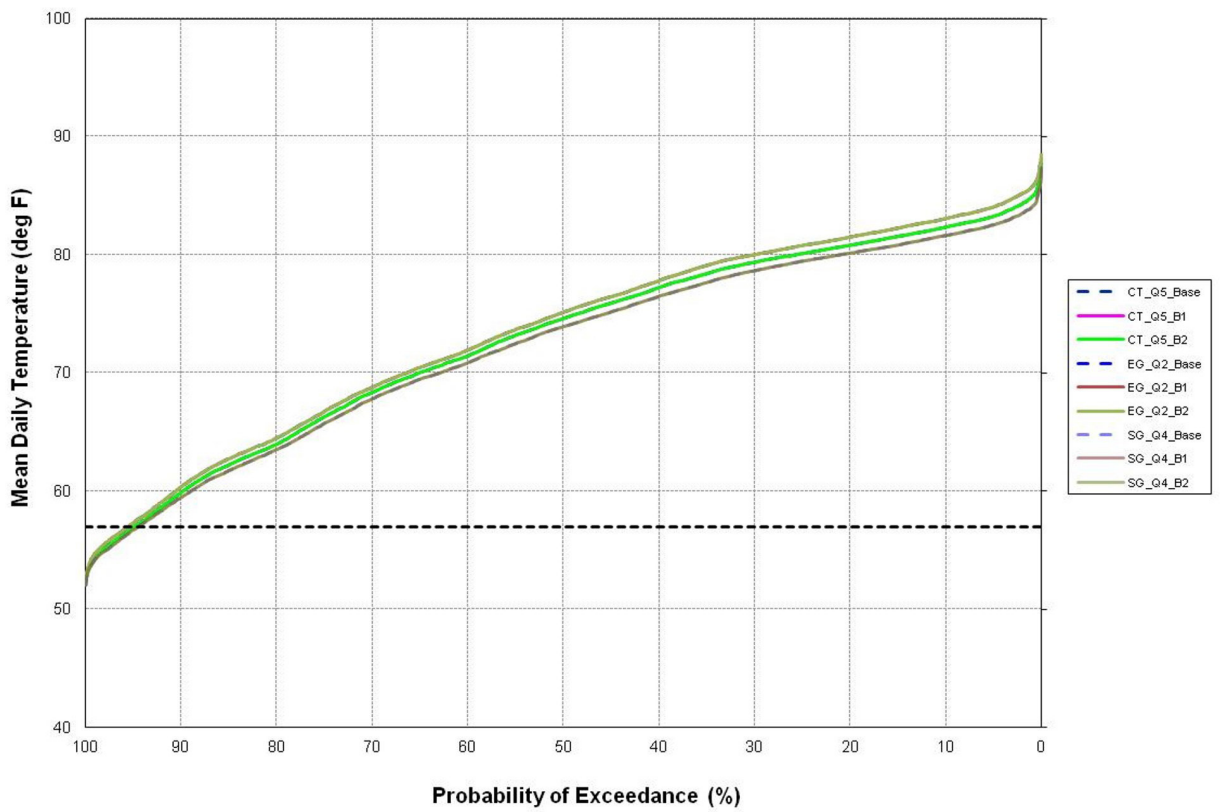

Figure 7-114. Exceedance of Mean Daily Temperature on San Joaquin River at Gravelly Ford from August to November in Portfolio B

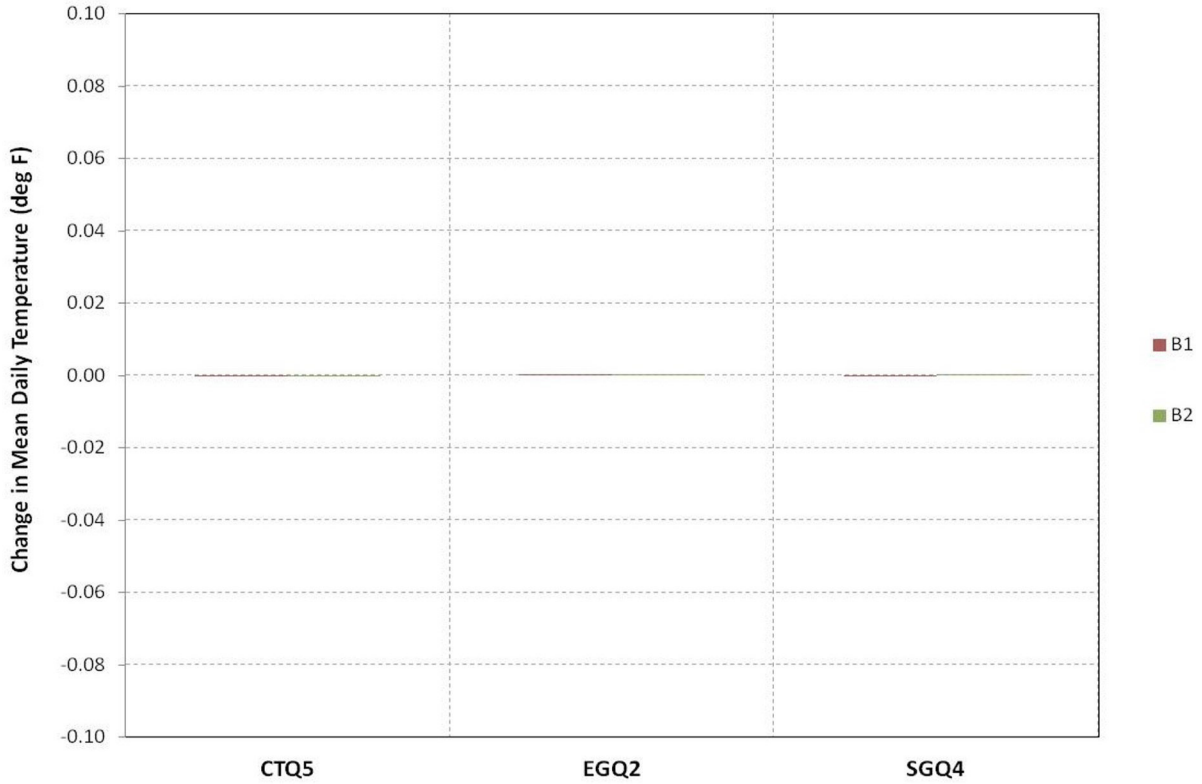

Figure 7-115. Change in Mean Daily Temperature on San Joaquin River at Gravelly Ford from August to November in Portfolio B

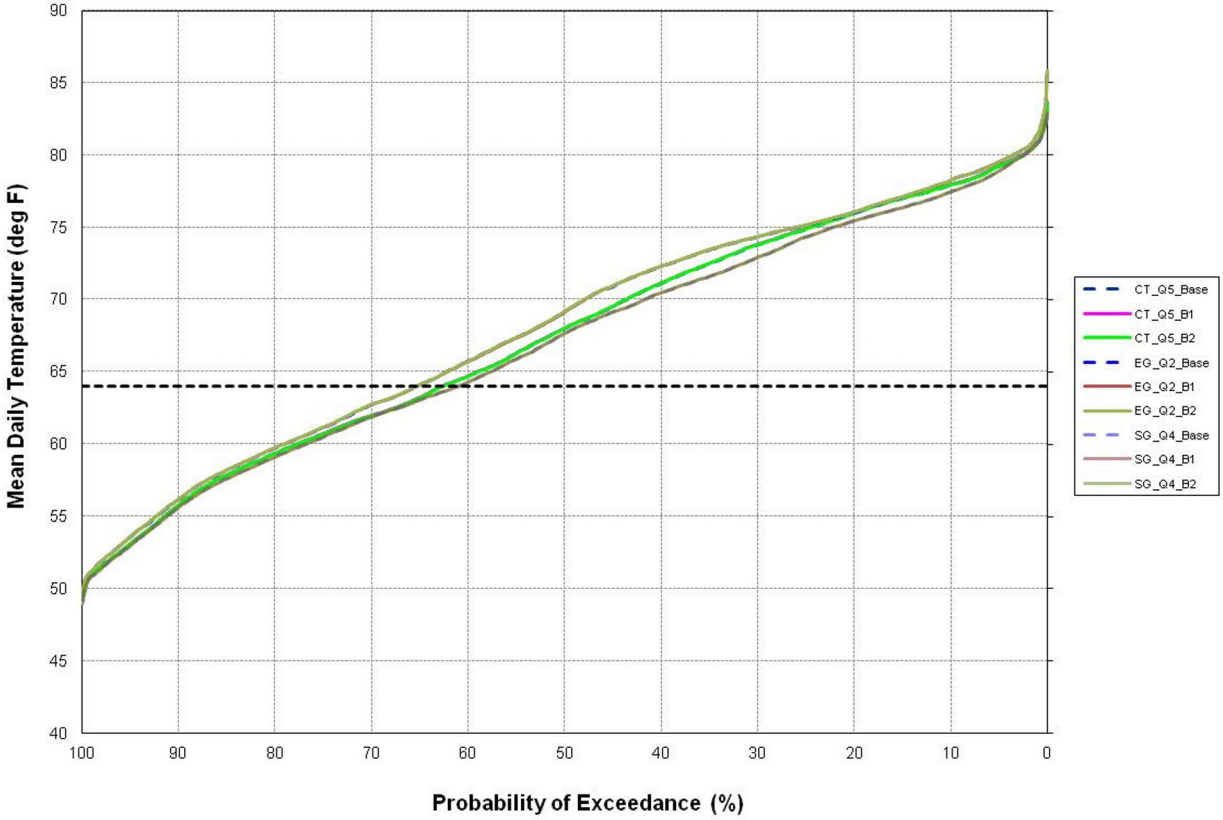

Figure 7-116. Exceedance of Mean Daily Temperature on San Joaquin River at Vernalis from August to November in Portfolio B

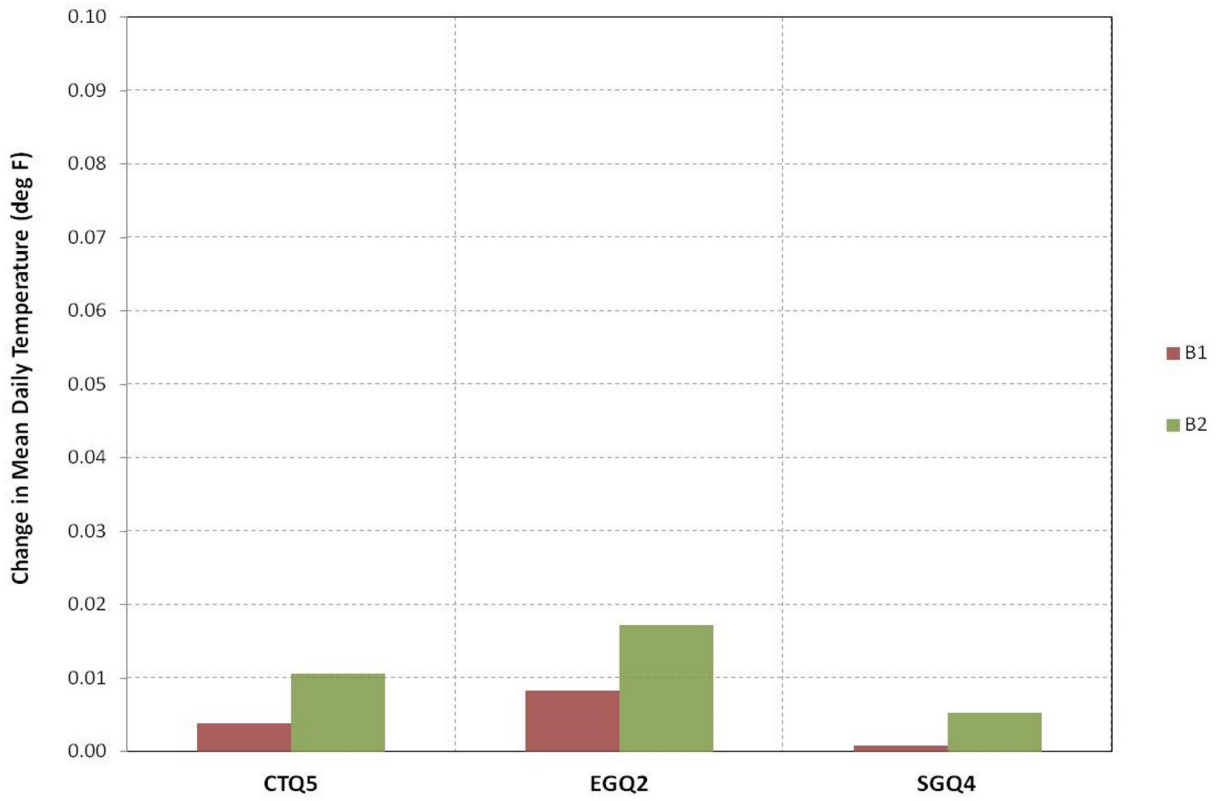

Figure 7-117. Change in Mean Daily Temperature on San Joaquin River at Vernalis from August to November in Portfolio B

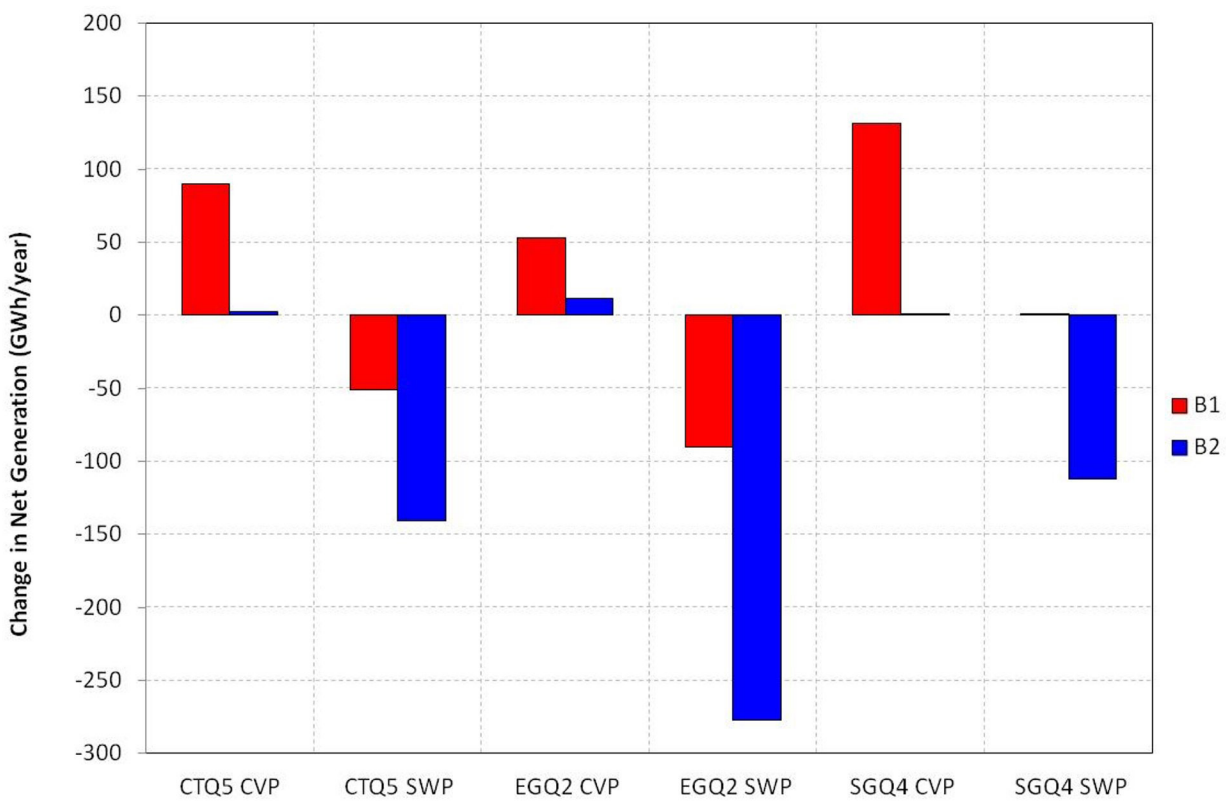

Figure 7-118. Change in Average Annual Net Energy Generation for the CVP and SWP Systems in Portfolio B

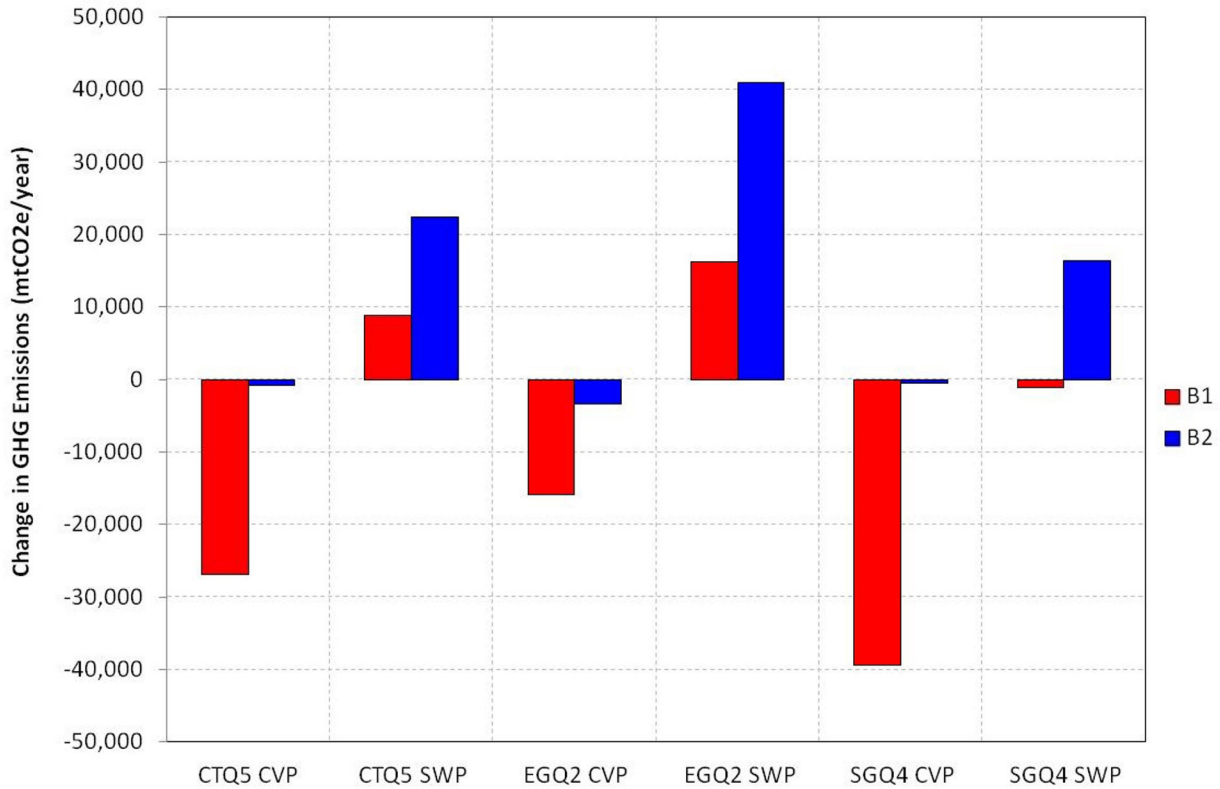

Figure 7-119. Change in Average Annual Greenhouse Gas Emissions for the CVP and SWP Systems in Portfolio B

net generation of about 50–130 GWh/year and a decrease in potential GHG offsets of about 16,000–40,000 mTCO2e as a result of increased storage levels in Lake Shasta.

In the SWP system, there was a reduction in net hydropower generation and an increase in GHG emissions in both B1 and B2, which was caused by the increase in Delta export levels relative to the Baseline. In B1, the SWP's reduction in net generation was about 0–90 GWh/year, and the GHG emissions increased by about 0–16,000 mTCO2e across the three scenarios. In B2, the SWP's reduction in net generation was about 110–280 GWh/year, and the GHG emissions increased by about 16,000–41,000 mTCO2e across the three scenarios.

7.3 Portfolio C: Delta Conveyance and North-of-Delta Storage

The Delta Conveyance and North-of-Delta Storage portfolio was designed to investigate potential improvements in water supply reliability by integrating modest levels of conservation described in Portfolio A with increased North-of-Delta storage described in Portfolio B and Delta conveyance improvements. The details of each of these simulated water management actions are described in Section 6.3. Simulation Suite A1 was included as the first suite simulated in Portfolio C with three additional simulation suites added sequentially, resulting in four steps in which the following actions added one-by-one:

1. Modest agricultural and urban conservation (same as A1)
2. Delta Conveyance + conservation without additional Sacramento Valley storage (C2)
3. Delta Conveyance + conservation with Enlarged Shasta (C3)
4. Delta Conveyance with conservation + both NODOS and Enlarged Shasta (C4)

Table 7-3 shows the assumptions and water management actions that are included in each simulation suite.

Table 7-3. Simulation Suites and Assumptions Included in Portfolio C

Assumption	Simulation Suite A1	Simulation Suite C2	Simulation Suite C3	Simulation Suite C4
Baseline Assumptions	x	x	x	x
Local Actions				
Modest Ag and M&I Conservation	x	x	x	x
Municipal Recycling and Desalination				
Aggressive Ag and M&I Conservation				
Systemwide Actions				
Delta Conveyance		x	x	x
Shasta Lake Enlargement			x	x
North-of-Delta Offstream Storage				x
South-of-Delta SW or GW Storage				
Enhanced Environmental Flows				

Notes:
GW = groundwater

SW = surface water

7.3.1 Supplies and Demands in CVP Divisions

Figure 7-120 shows the average reduction in unmet demand in the CVP Service Area for each Portfolio C simulation suite in each socioeconomic-climate scenario. Figures 7-121 through 7-129 show the same information for each CVP Division. As discussed in Portfolio A above, the reduction in unmet demand in the CVP Service Area ranged from 297 to 814 TAF/year (8–16 percent of Baseline unmet demands) with the A1 modest demand-reduction actions across the range of all scenarios. The unmet demands decreased further with the C2 Delta conveyance action by 364 to 947 TAF/year (9–19 percent of Baseline unmet demands) relative to the Baseline. There were additional reductions in unmet demands with the addition of the Enlarged Shasta action in C3 and the addition of NODOS in C4, corresponding with the increasing exports occurring as the additional actions are added to the simulations. The reduction in unmet demands ranged from 371 to 1,005 TAF/year (10–19 percent of Baseline unmet demands) in C3 and from 376 to 1,233 TAF/year (11–23 percent of Baseline unmet demands) when all actions were combined in C4.

Figures 7-130 through 7-132 show the annual time series of groundwater, surface water, and local project supplies, and the unmet demands for the CVP Service Area under CT-Q5, EG-Q2, SG-Q4 scenarios under Portfolio C Suite C2. Figures 7-133 through 7-135 show the same information for Suite C3, and Figures 7-136 through 7-138 show the same information for Suite C4. This information was previously shown for Suite A1 in the discussion on Portfolio A above. Unmet demands in A1 ranged from 800 to 10,900 TAF/year in CT-Q5, from 800 to 14,600 TAF/year in EG-Q2, and from 700 to 7,000 TAF/year in SG Q4. Suites C2, C3, and C4 all showed significant reductions in unmet demand relative to A1 due to the increased surface water deliveries that resulted from new Delta conveyance and the addition of new surface storage. Unmet demands in C2 ranged from 800 to 10,800 TAF/year in CT-Q5, from 800 to 14,500 TAF/year in EG-Q2, and from 700 to 6,700 TAF/year in SG-Q4. Unmet demands in C3 ranged from 800 to 10,800 TAF/year in CT-Q5, from 800 to 14,500 TAF/year in EG-Q2, and from 700 to 6,700 TAF/year in SG-Q4. Unmet demands in C4 ranged from 800 to 10,800 TAF/year in CT-Q5, from 800 to 14,200 TAF/year in EG-Q2, and from 700 to 6,700 TAF/year in SG-Q4.

7.3.2 CVP and SWP System Operations

The following sections describe the results for each of the Portfolio C simulation suites.

7.3.2.1 CVP and SWP Project Storage

Figures 7-139 through 7-154 show the exceedance plots of storage in the Baseline and for in each of

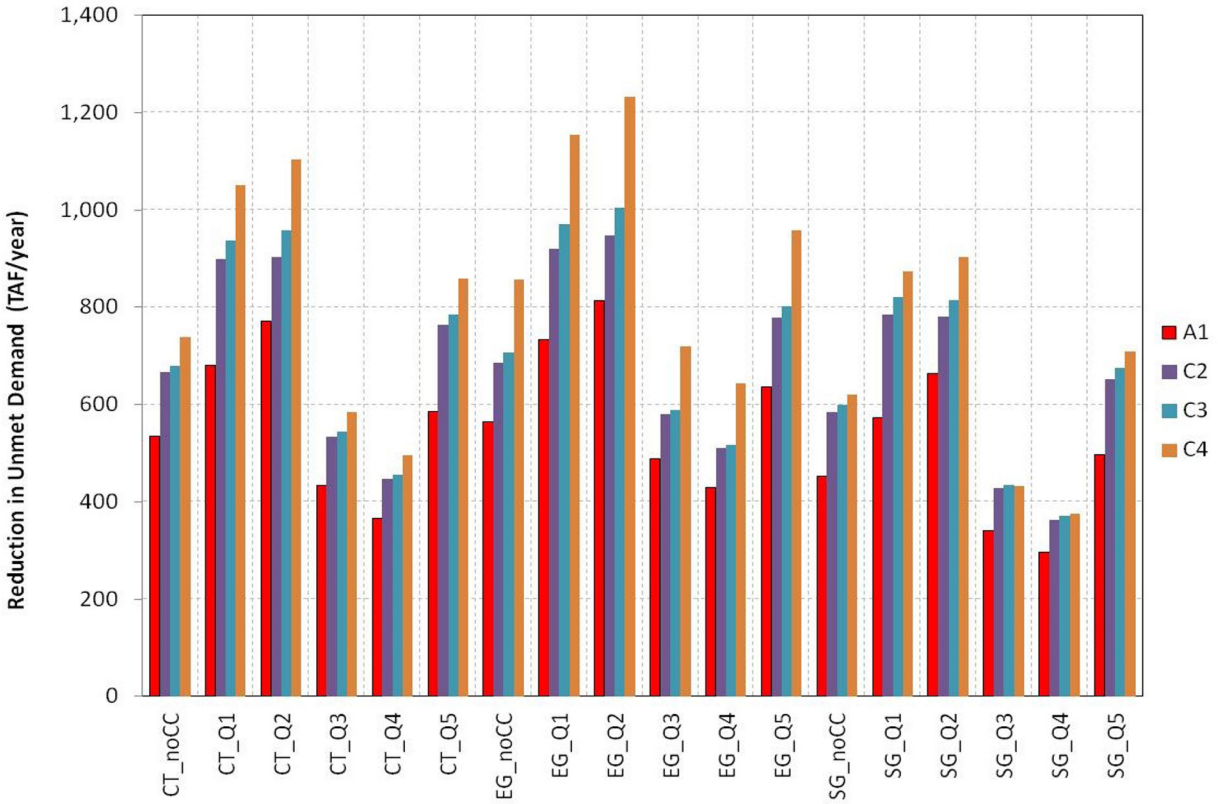

Figure 7-120. Average Annual Reduction in Unmet Demand in the CVP Service Area for Portfolio C in Each Scenario

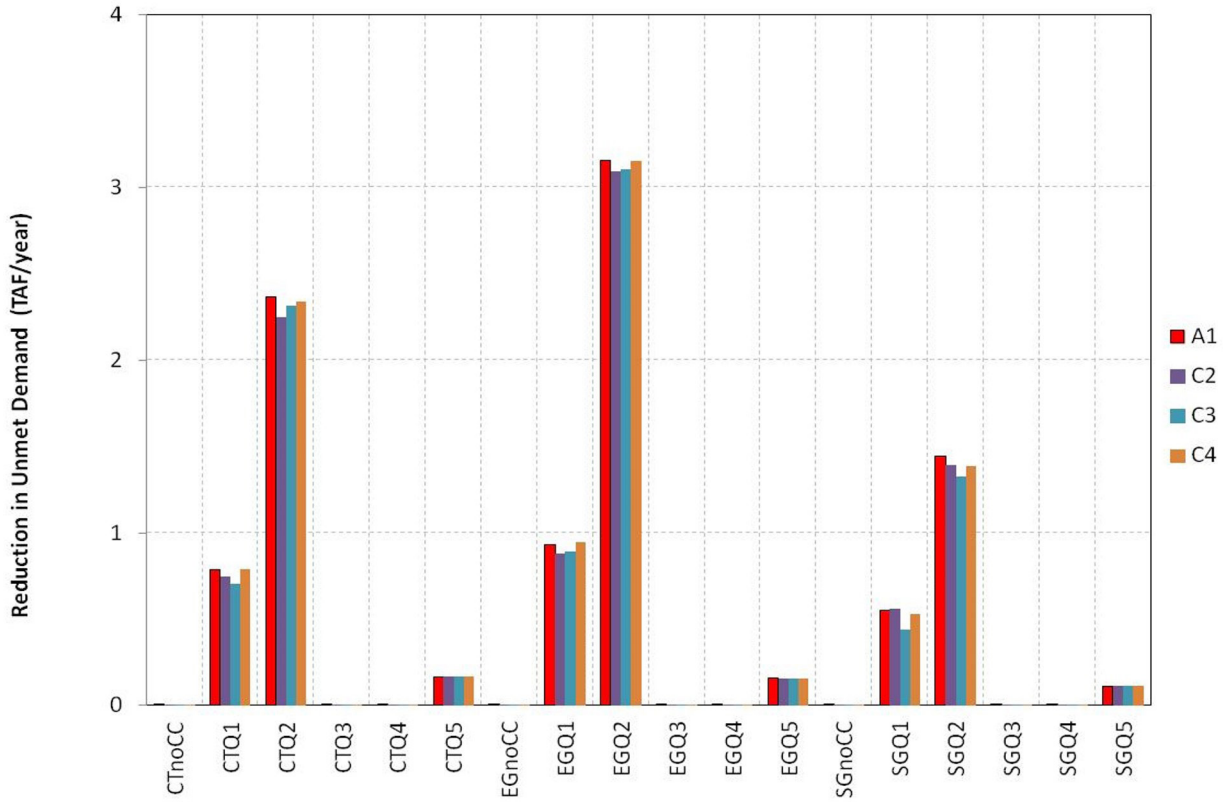

Figure 7-121. Average Annual Reduction in Unmet Demand in the American River Division for Portfolio C in Each Scenario

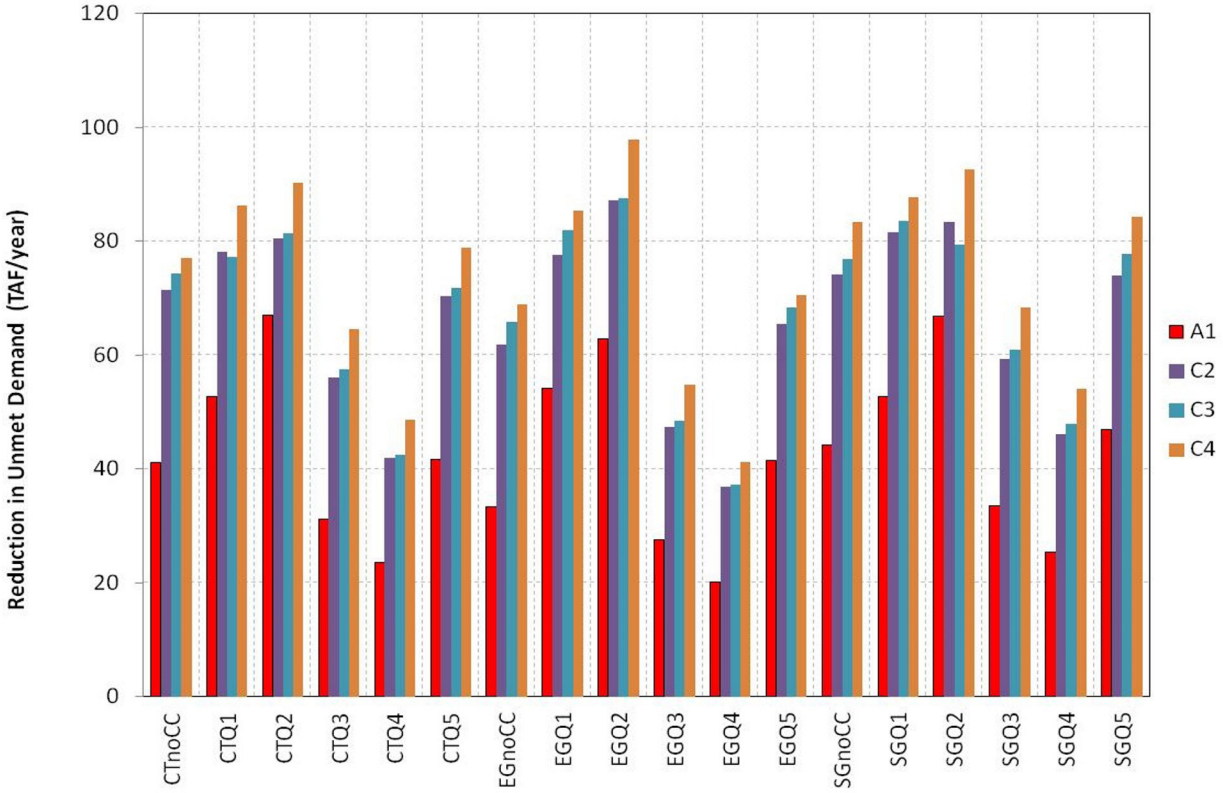

Figure 7-122. Average Annual Reduction in Unmet Demand in the Delta Division for Portfolio C in Each Scenario

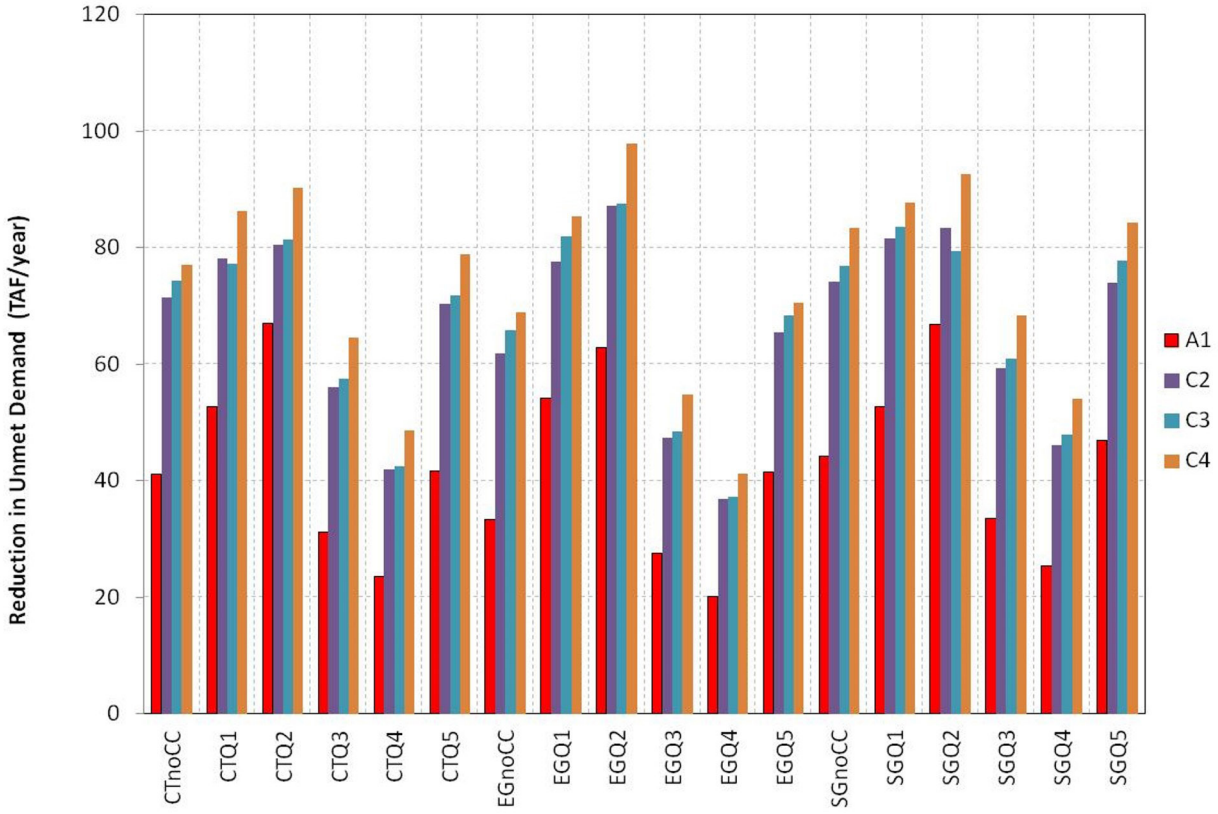

Figure 7-123. Average Annual Reduction in Unmet Demand in the East Side Division for Portfolio C in Each Scenario

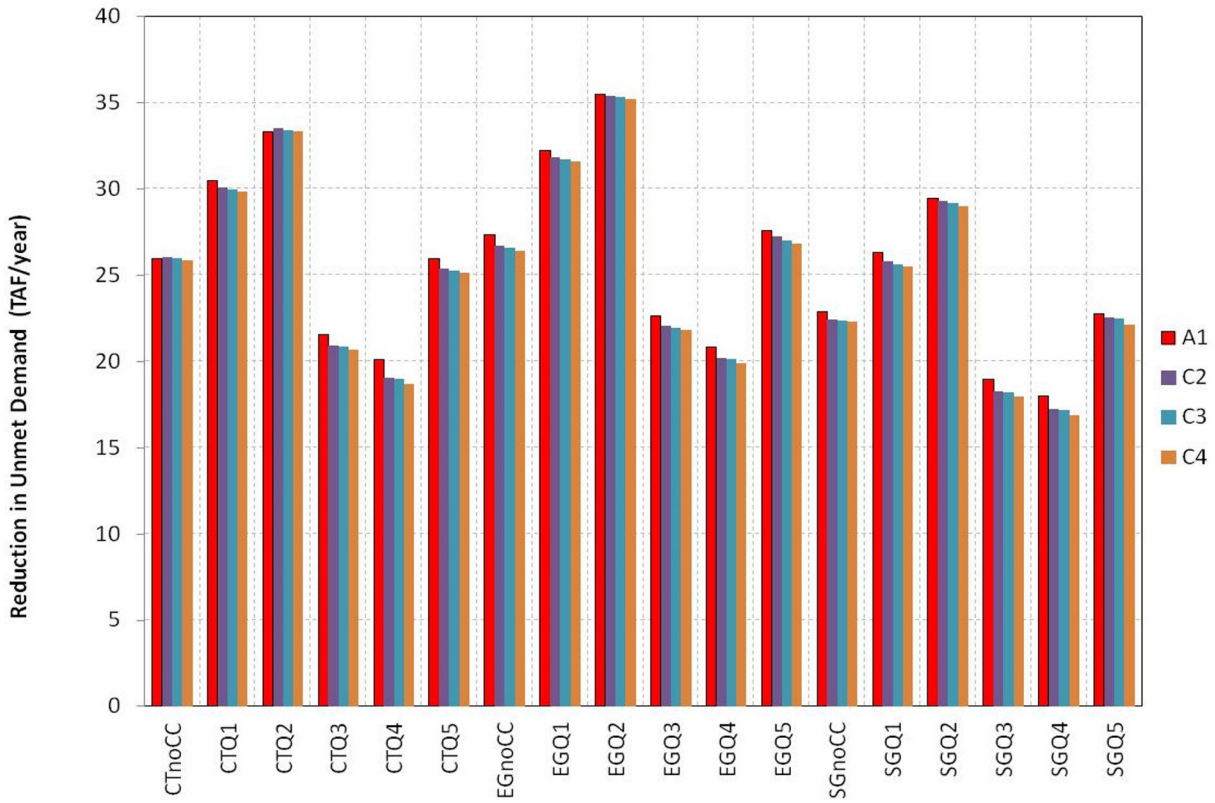

Figure 7-124. Average Annual Reduction in Unmet Demand in the Friant Division for Portfolio C in Each Scenario

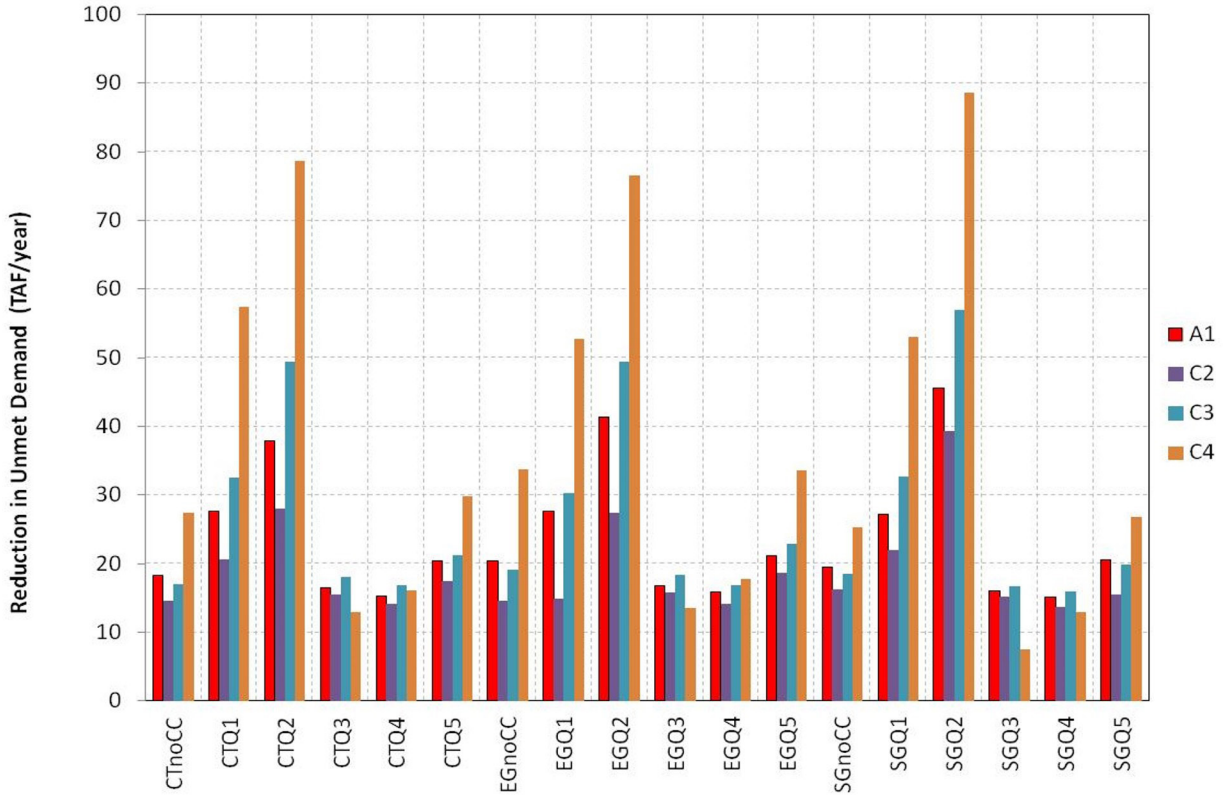

Figure 7-125. Average Annual Reduction in Unmet Demand in the Sacramento River Division for Portfolio C in Each Scenario

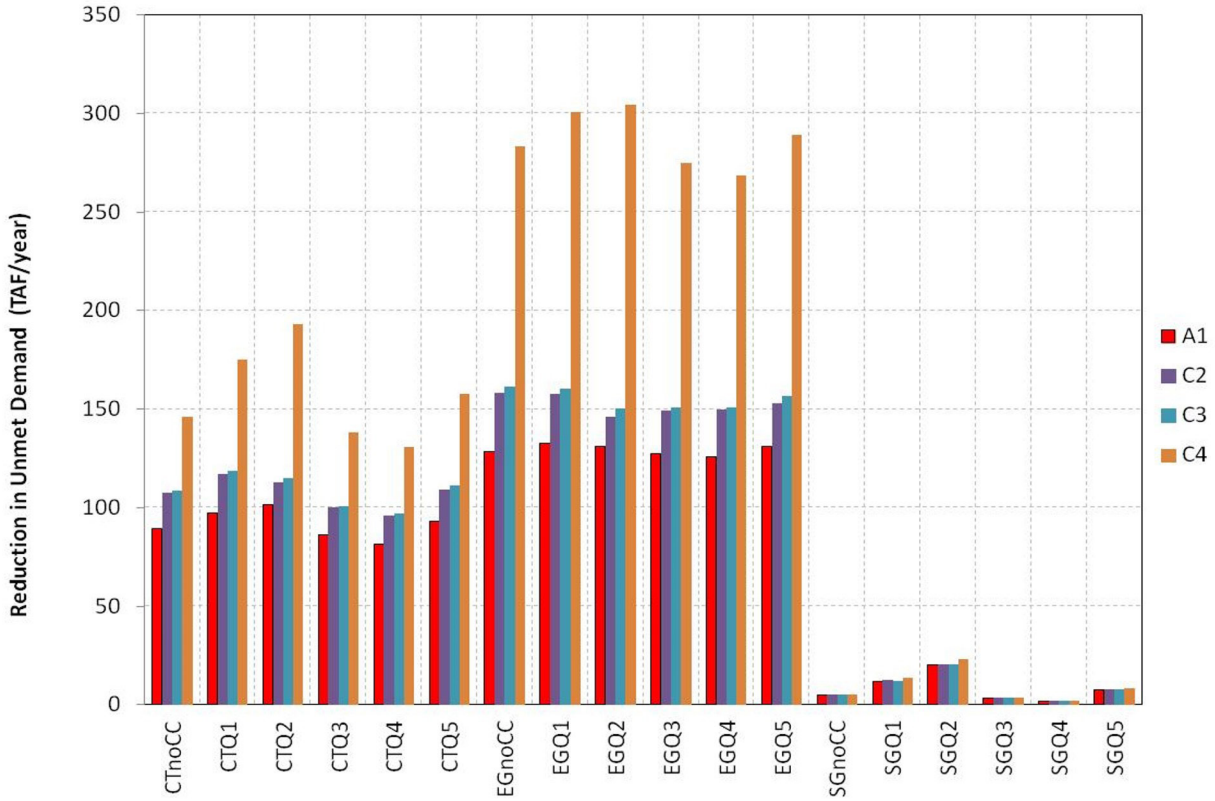

Figure 7-126. Average Annual Reduction in Unmet Demand in the San Felipe Division for Portfolio C in Each Scenario

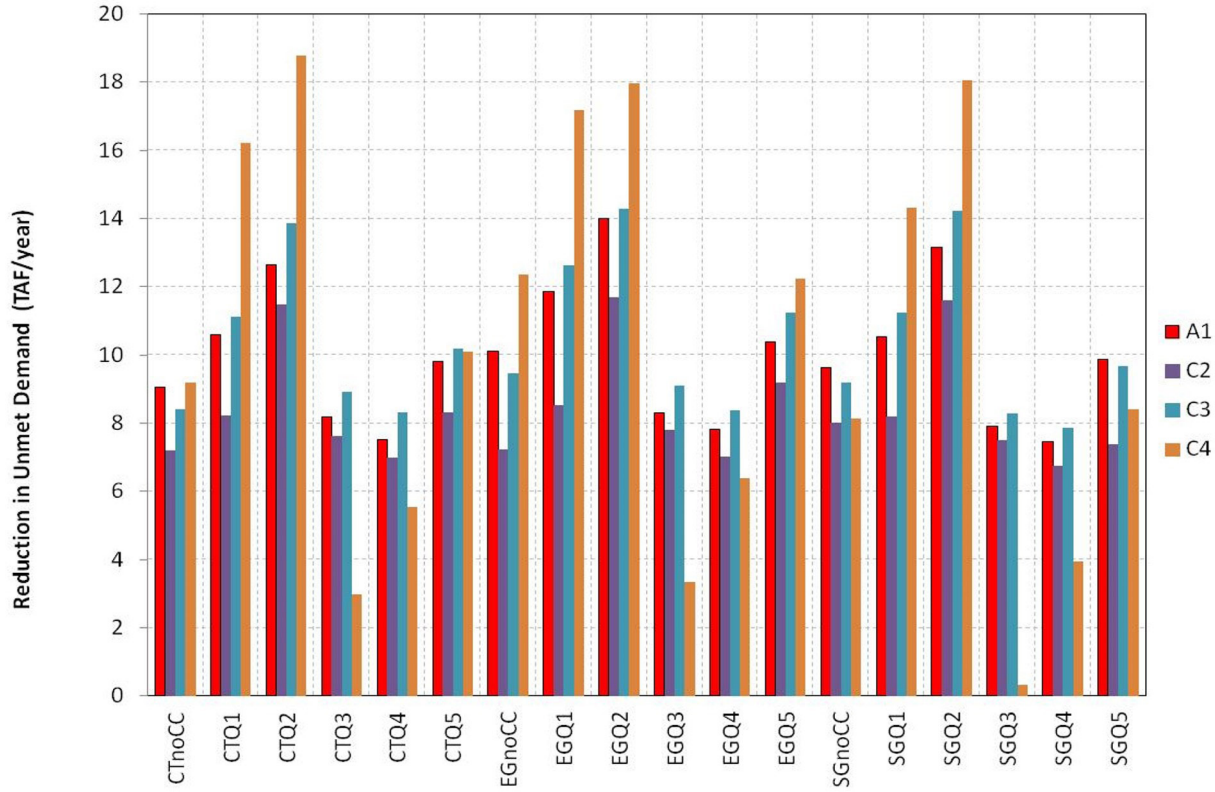

Figure 7-127. Average Annual Reduction in Unmet Demand in the Shasta Division for Portfolio C in Each Scenario

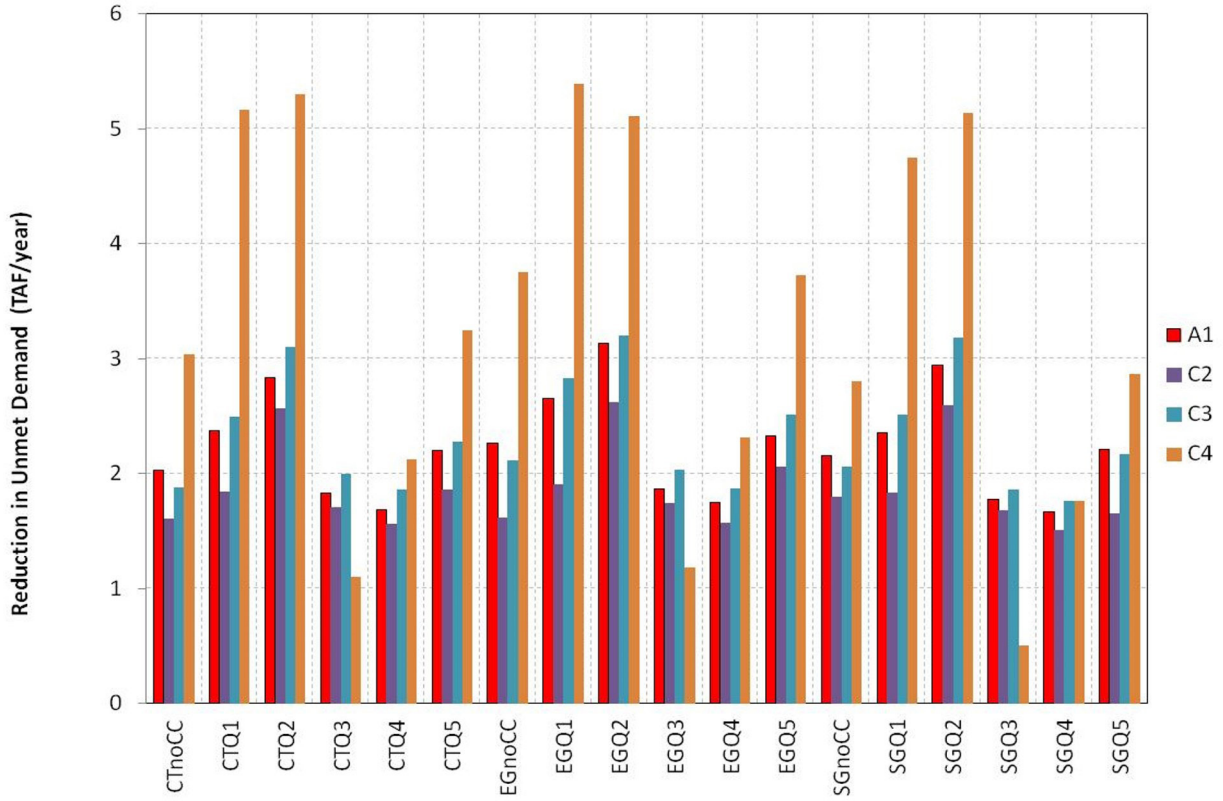

Figure 7-128. Average Annual Reduction in Unmet Demand in the Trinity Division for Portfolio C in Each Scenario

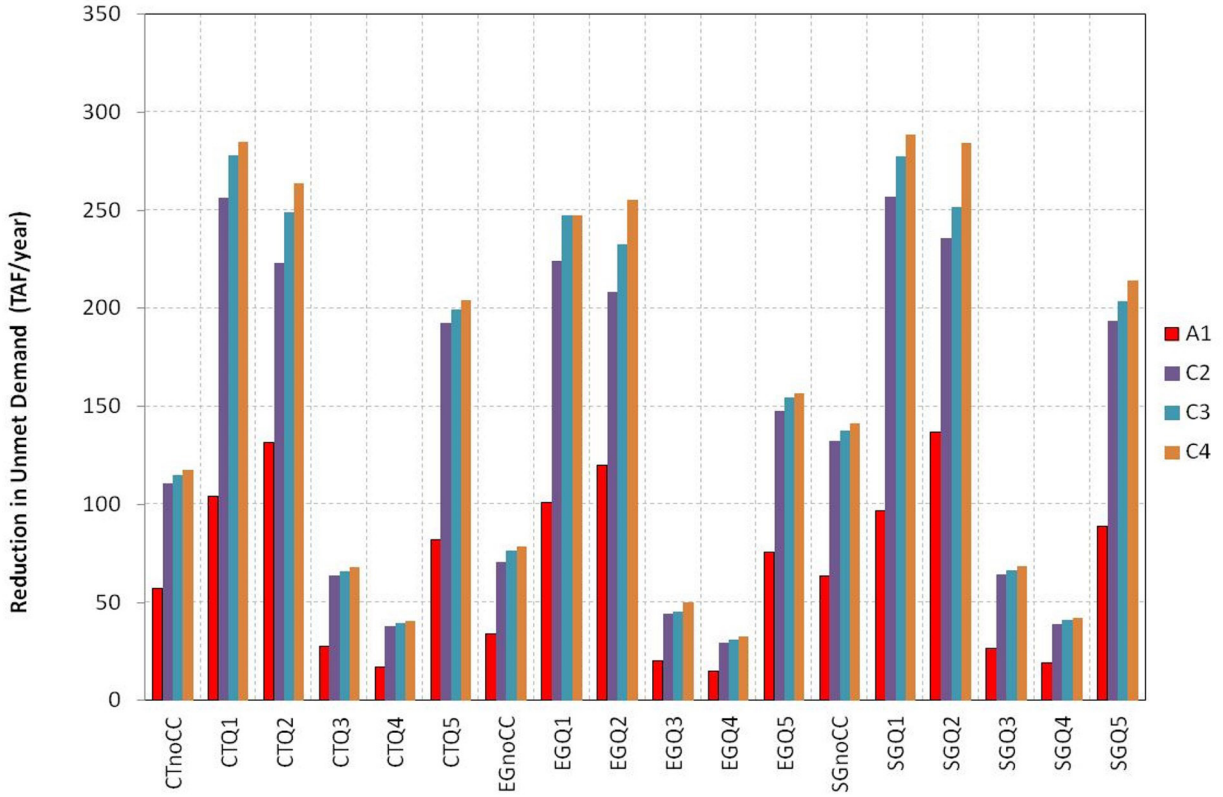

Figure 7-129. Average Annual Reduction in Unmet Demand in the West San Joaquin Division for Portfolio C in Each Scenario

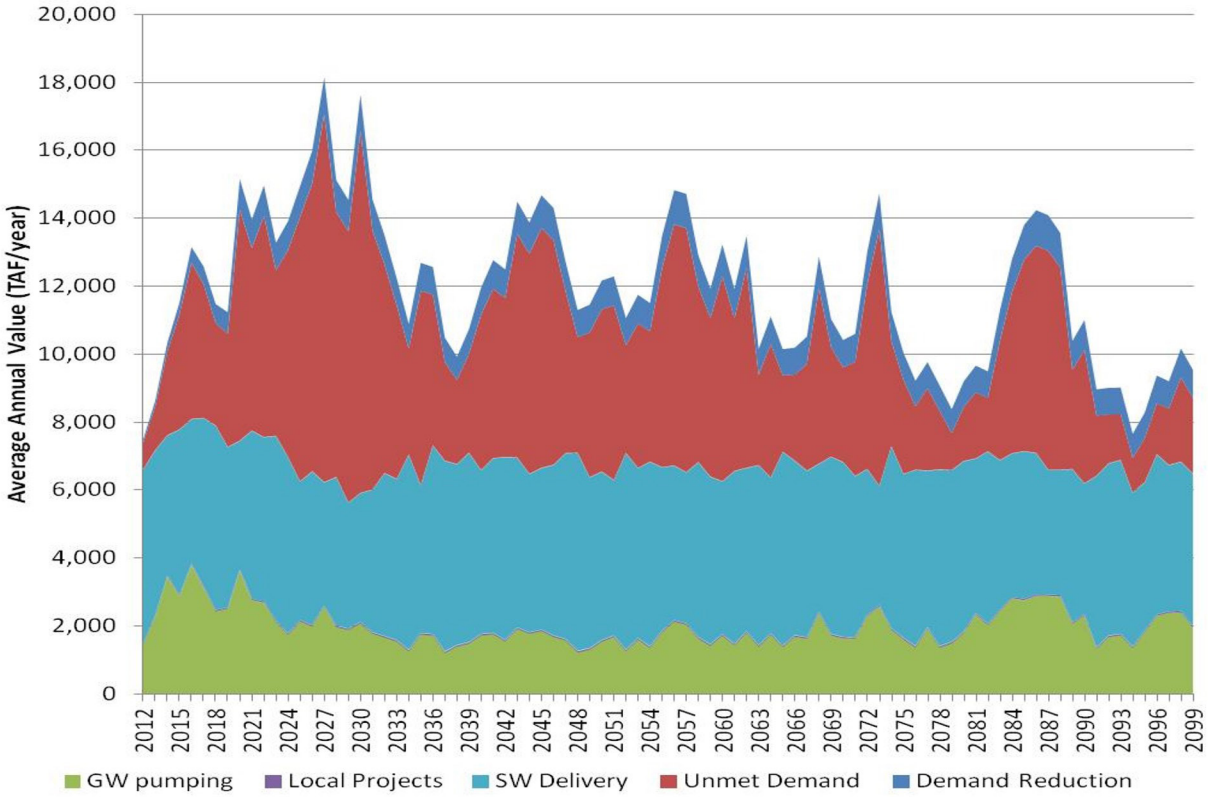

Figure 7-130. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite C2 in the CT-Q5 Scenario

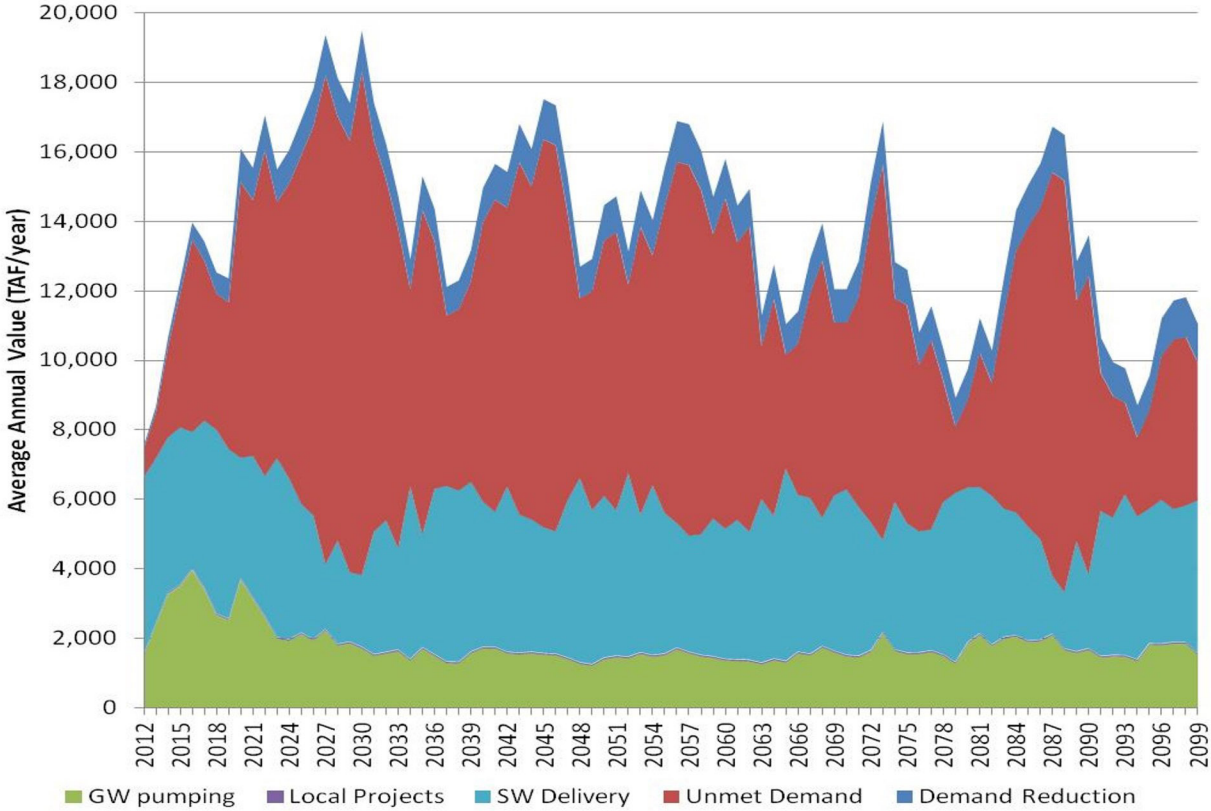

Figure 7-131. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite C2 in the EG-Q2 Scenario

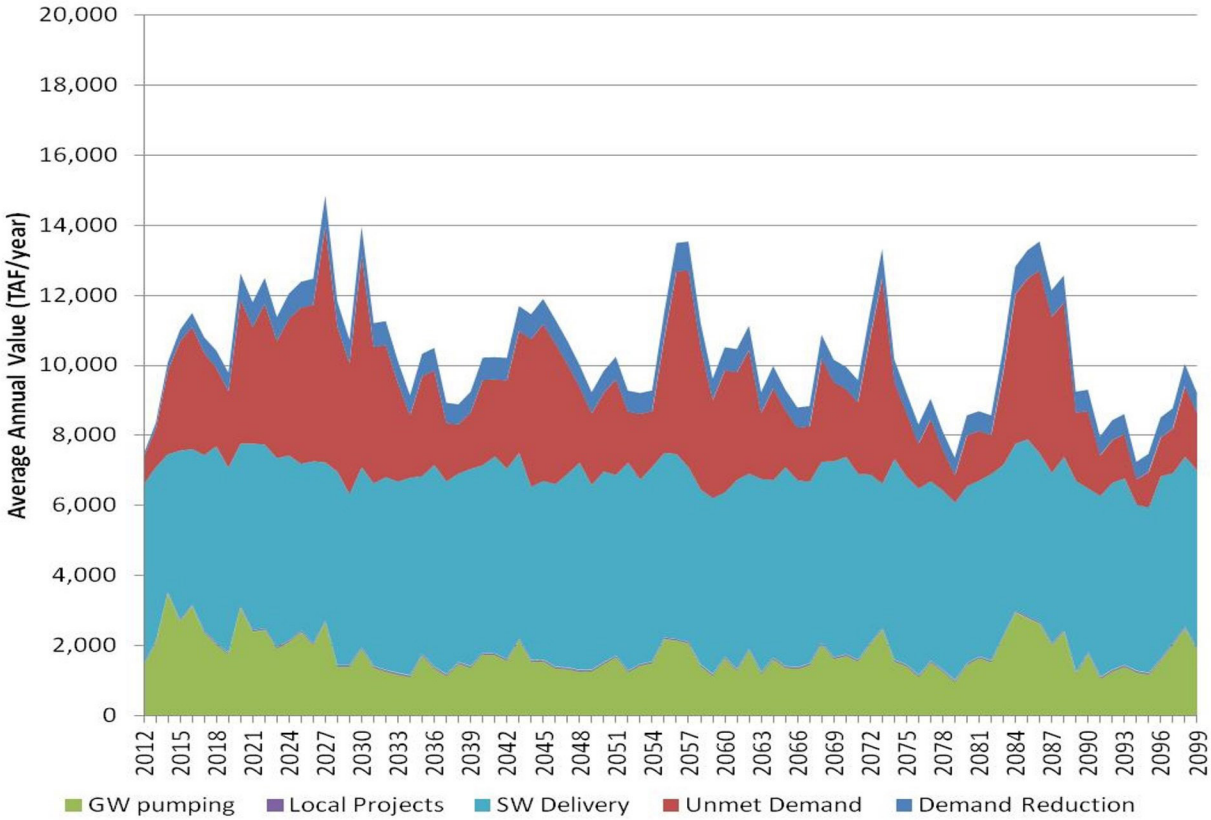

Figure 7-132. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite C2 in the SG-Q4 Scenario

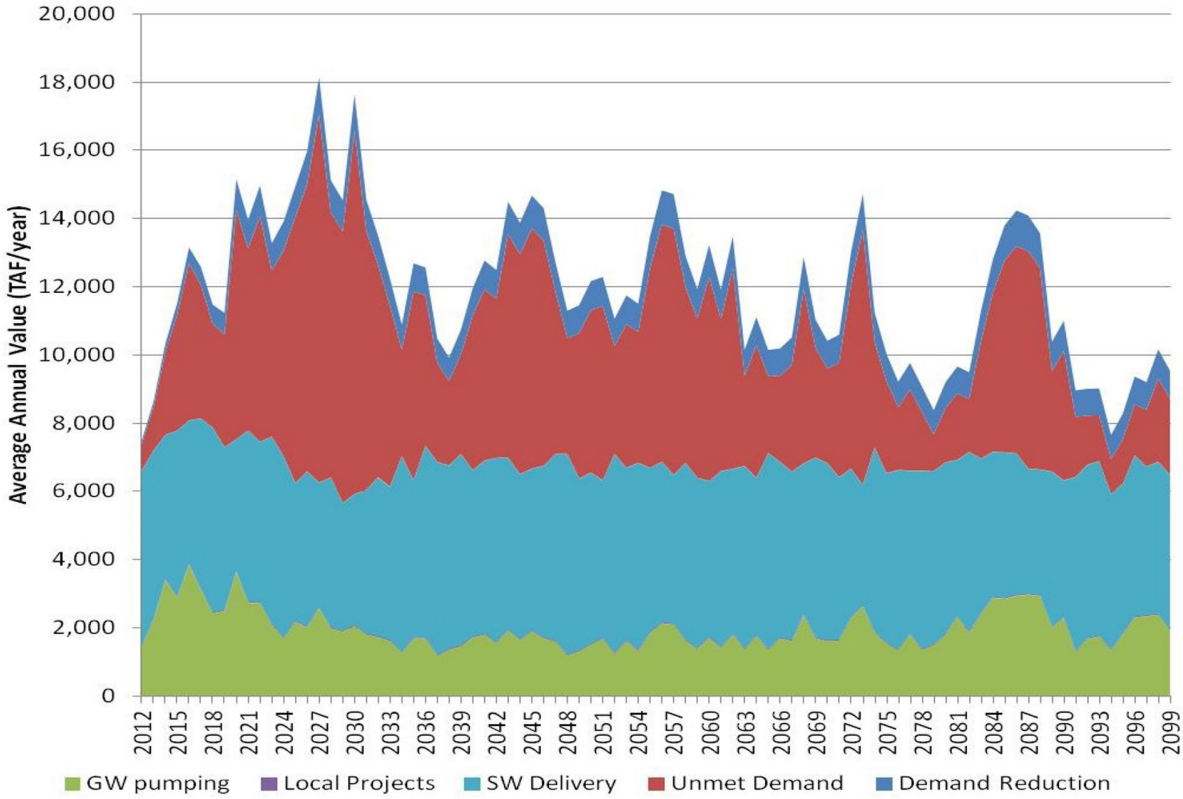

Figure 7-133. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite C3 in the CT-Q5 Scenario

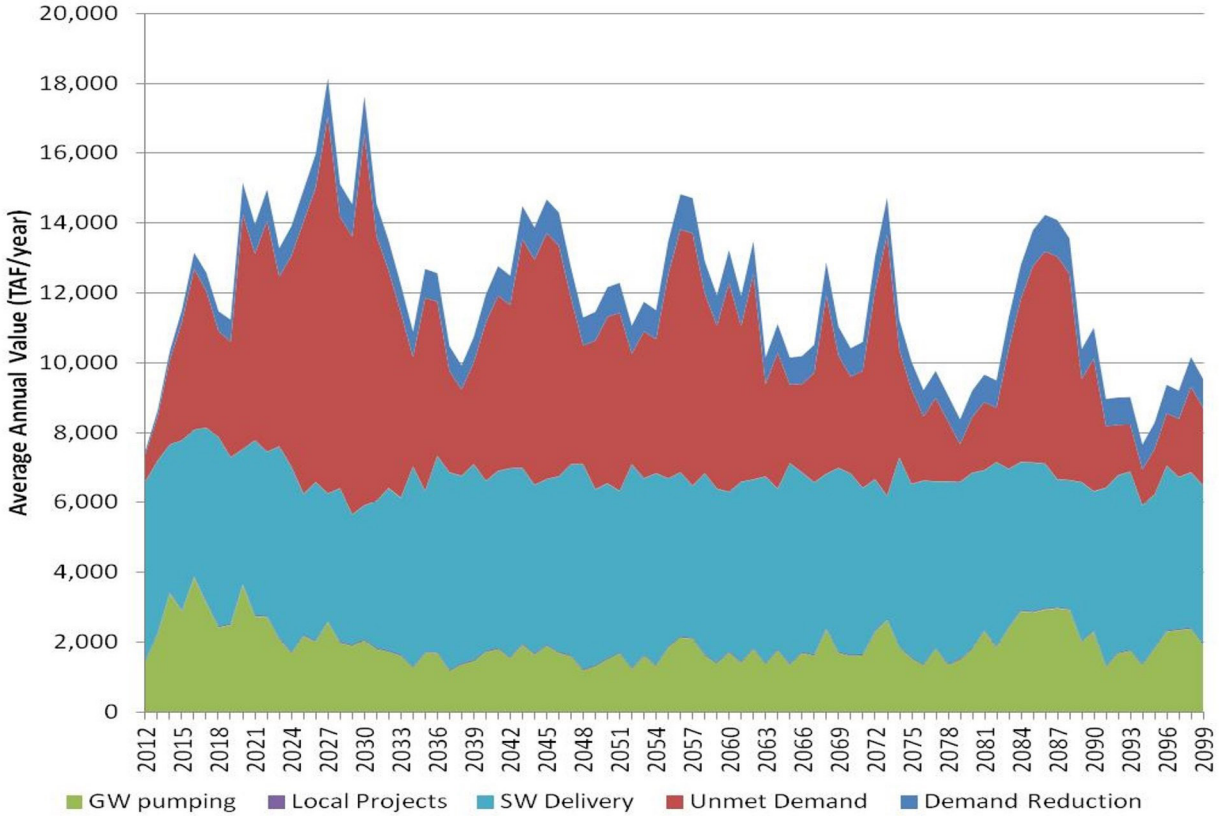

Figure 7-134. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite C3 in the EG-Q2 Scenario

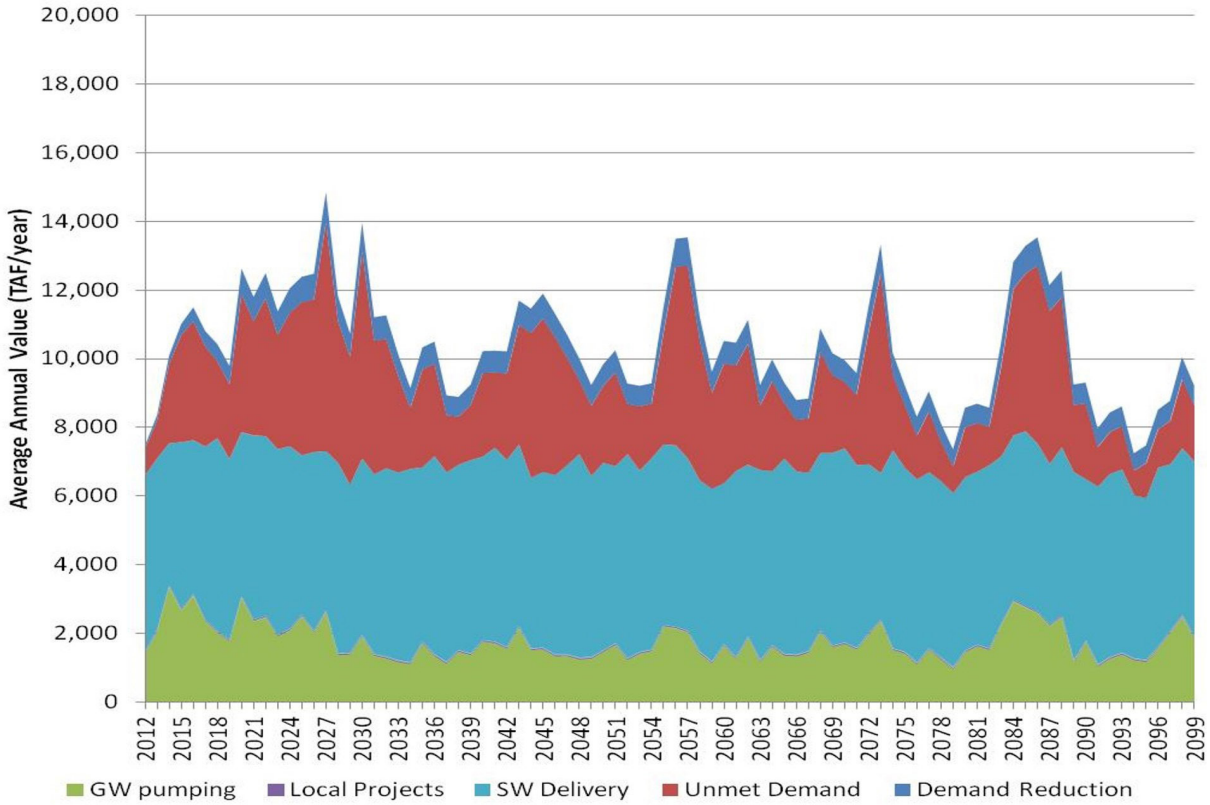

Figure 7-135. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite C3 in the SG-Q4 Scenario

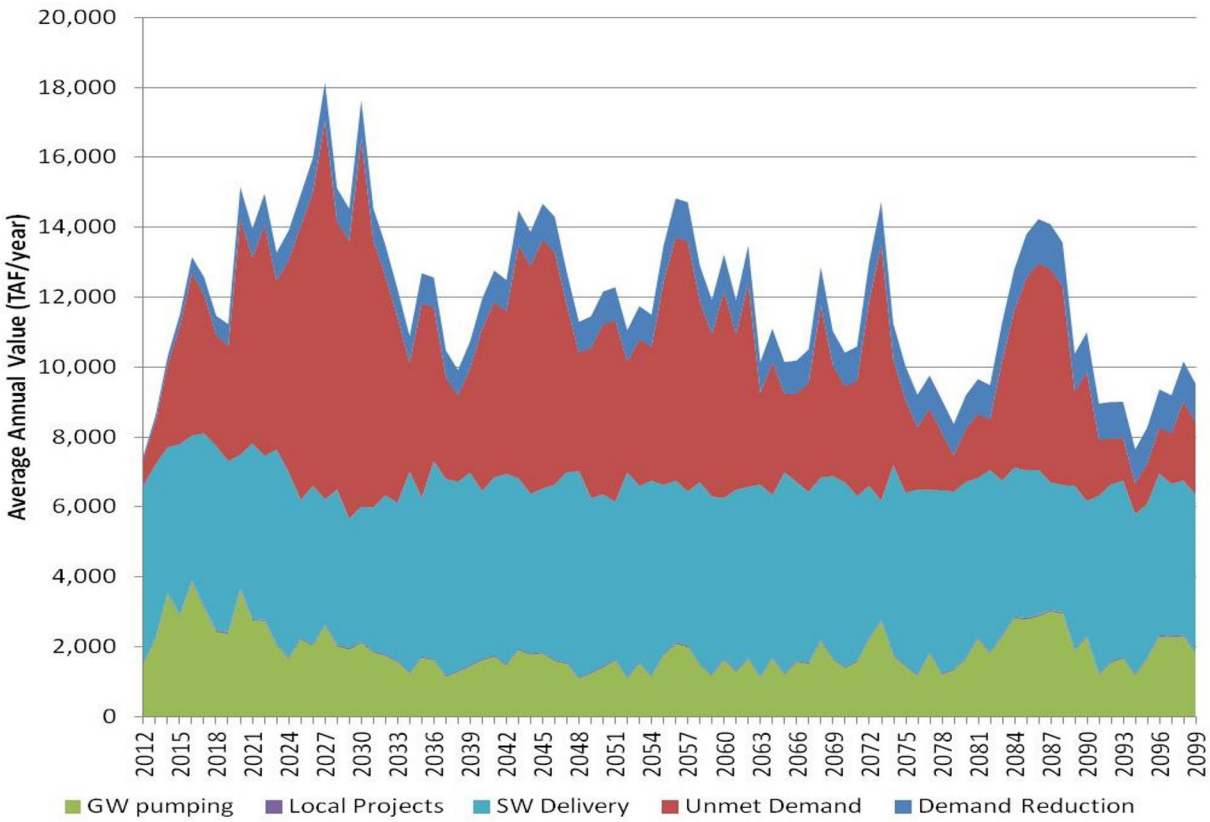

Figure 7-136. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite C4 in the CT-Q5 Scenario

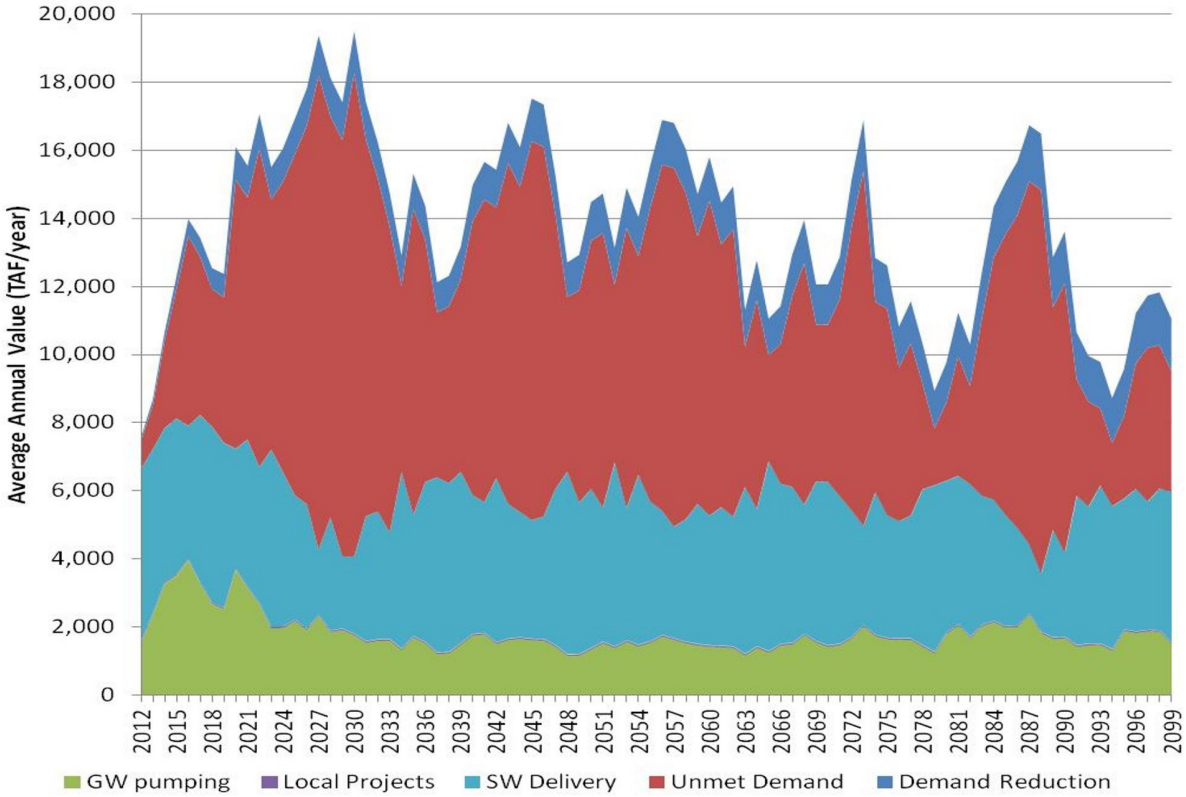

Figure 7-137. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite C4 in the EG-Q2 Scenario

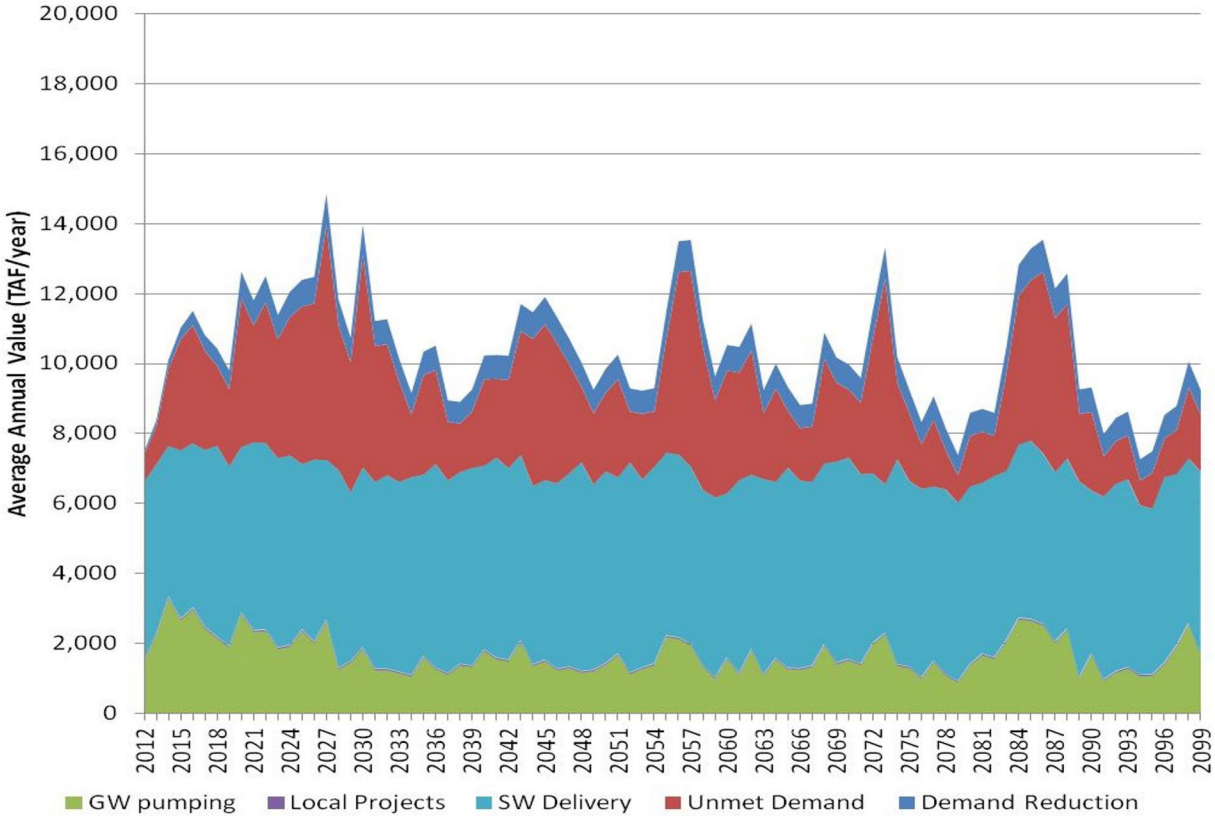

Figure 7-138. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite C4 in the SG-Q4 Scenario

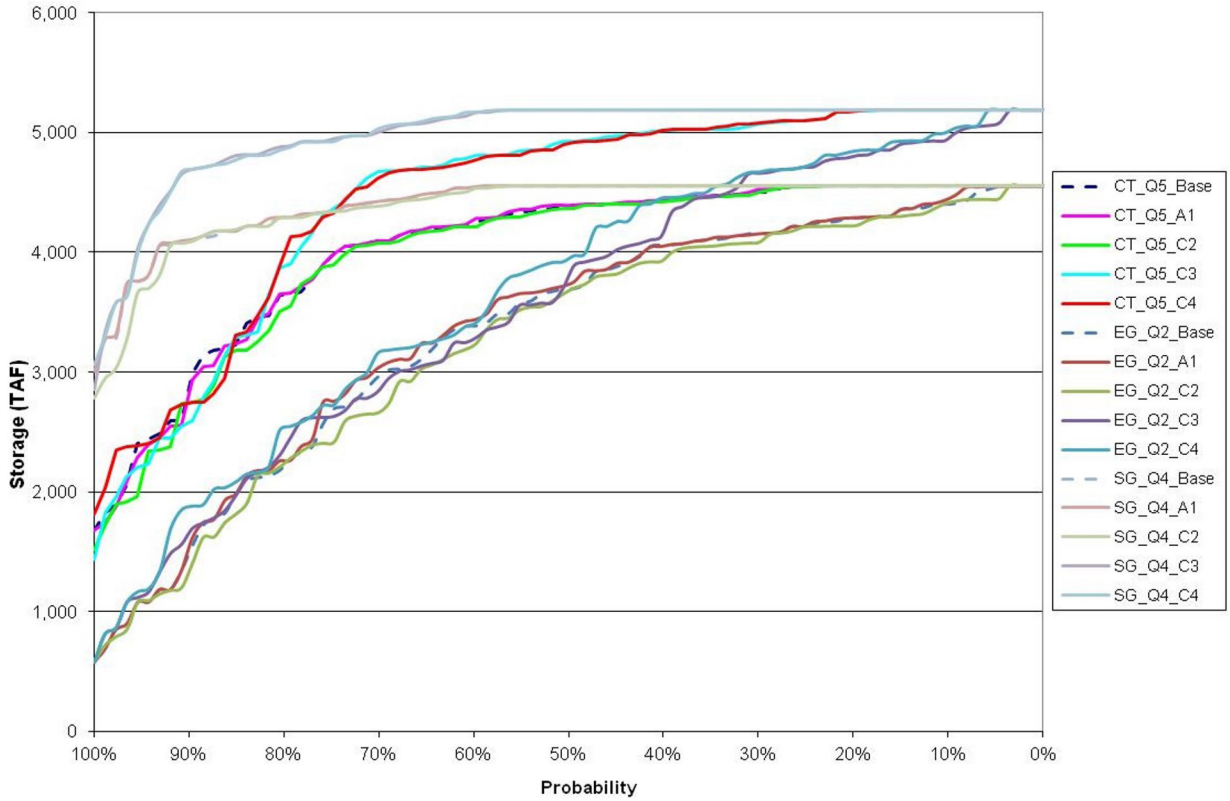

Figure 7-139. Exceedance of Lake Shasta End-of-May Storage in Portfolio C

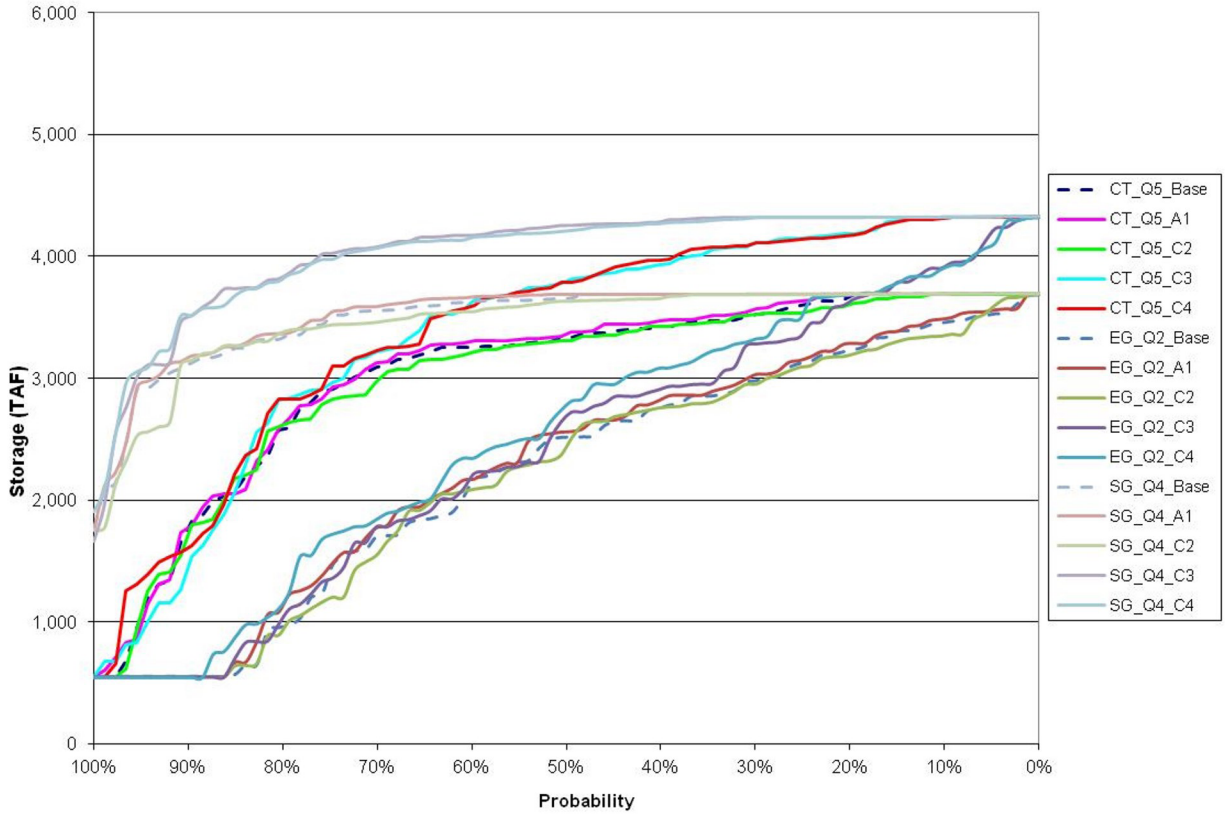

Figure 7-140. Exceedance of Lake Shasta End-of-September Storage in Portfolio C

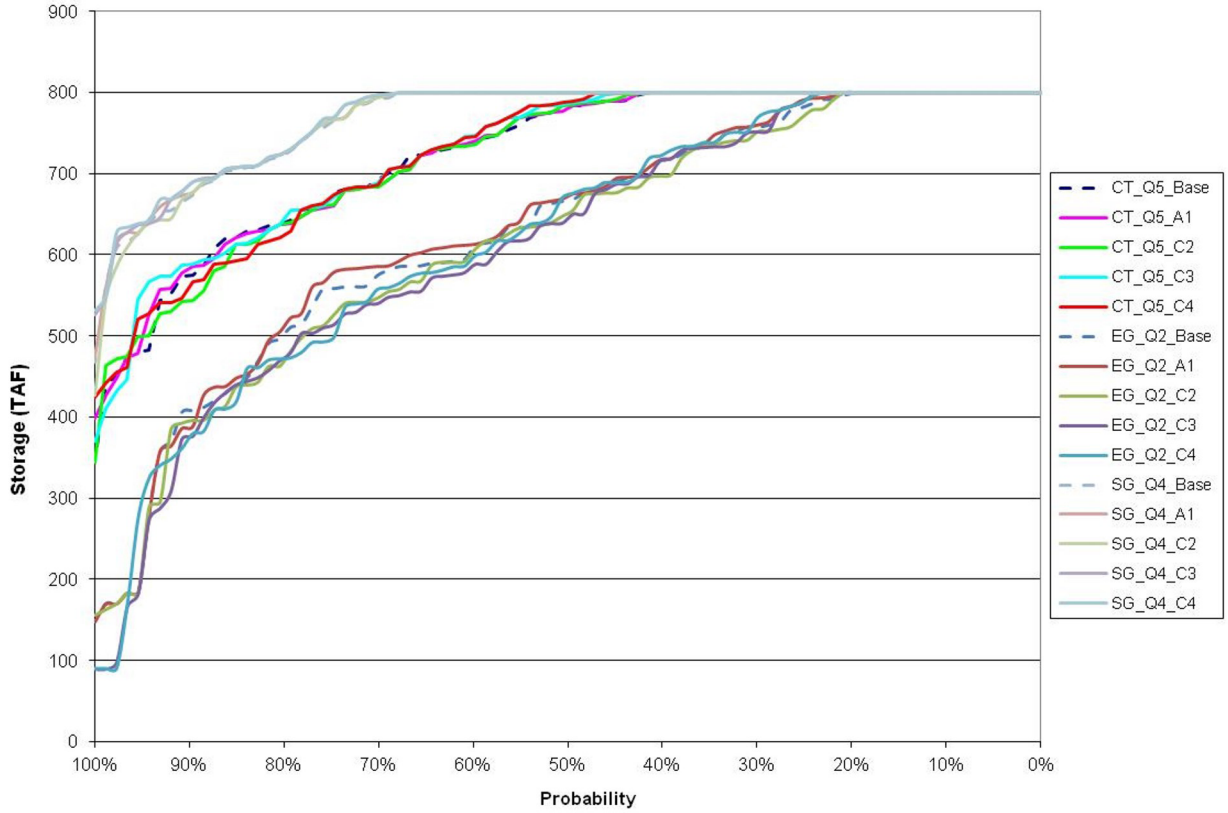

Figure 7-141. Exceedance of Folsom Lake End-of-May Storage in Portfolio C

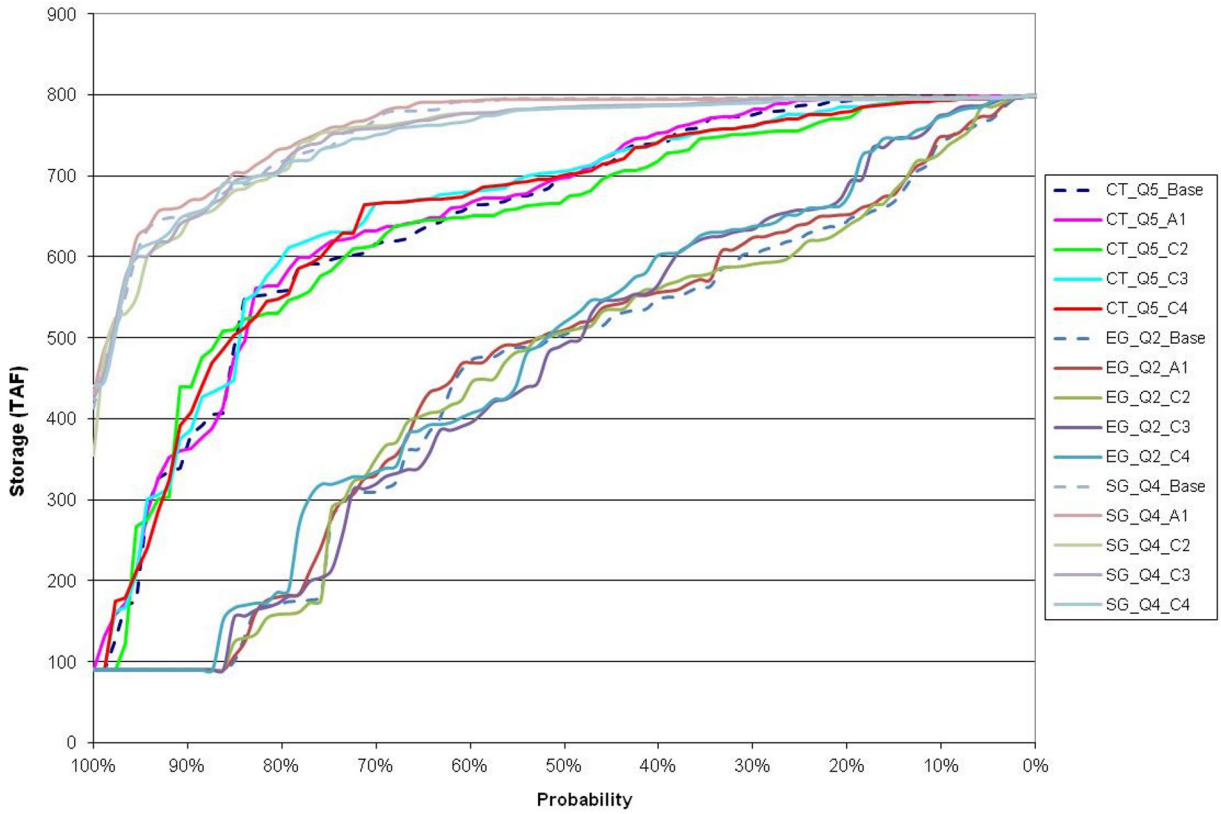

Figure 7-142. Exceedance of Folsom Lake End-of-September Storage in Portfolio C

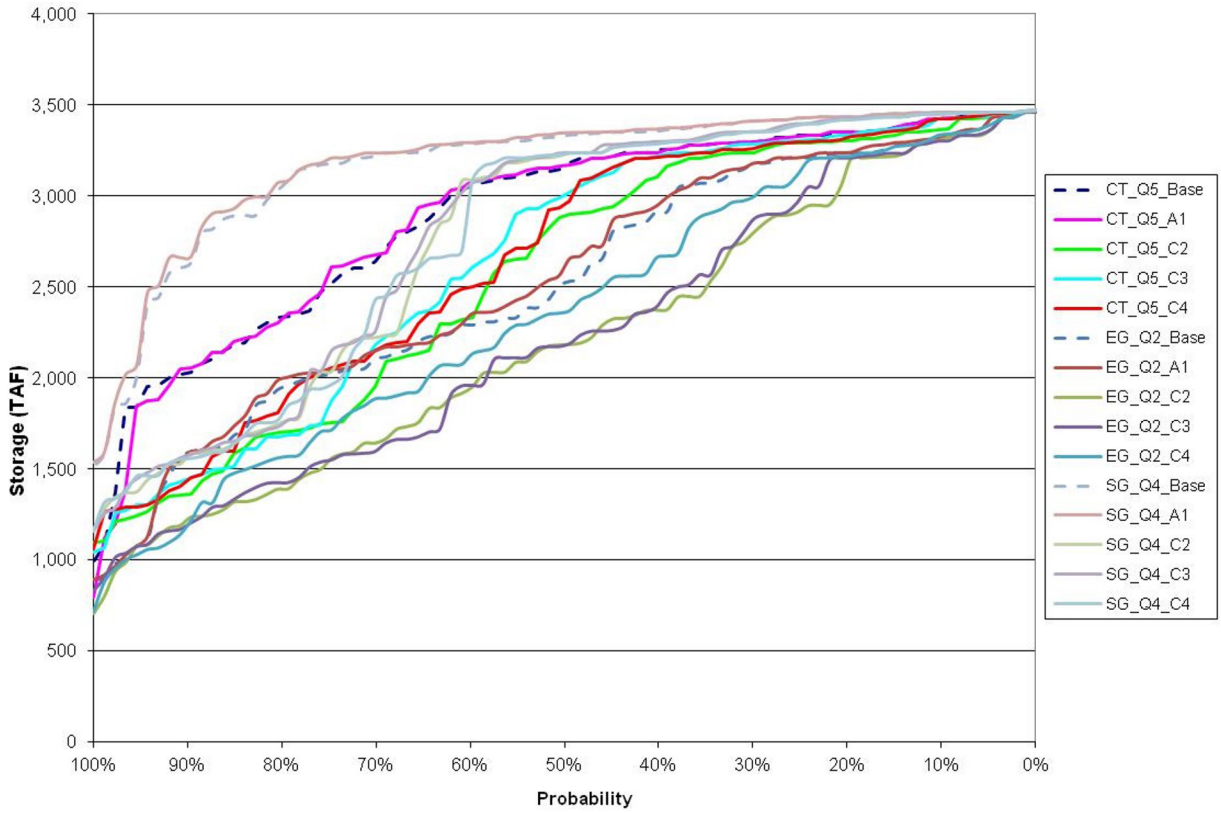

Figure 7-143. Exceedance of Lake Oroville End-of-May Storage in Portfolio C

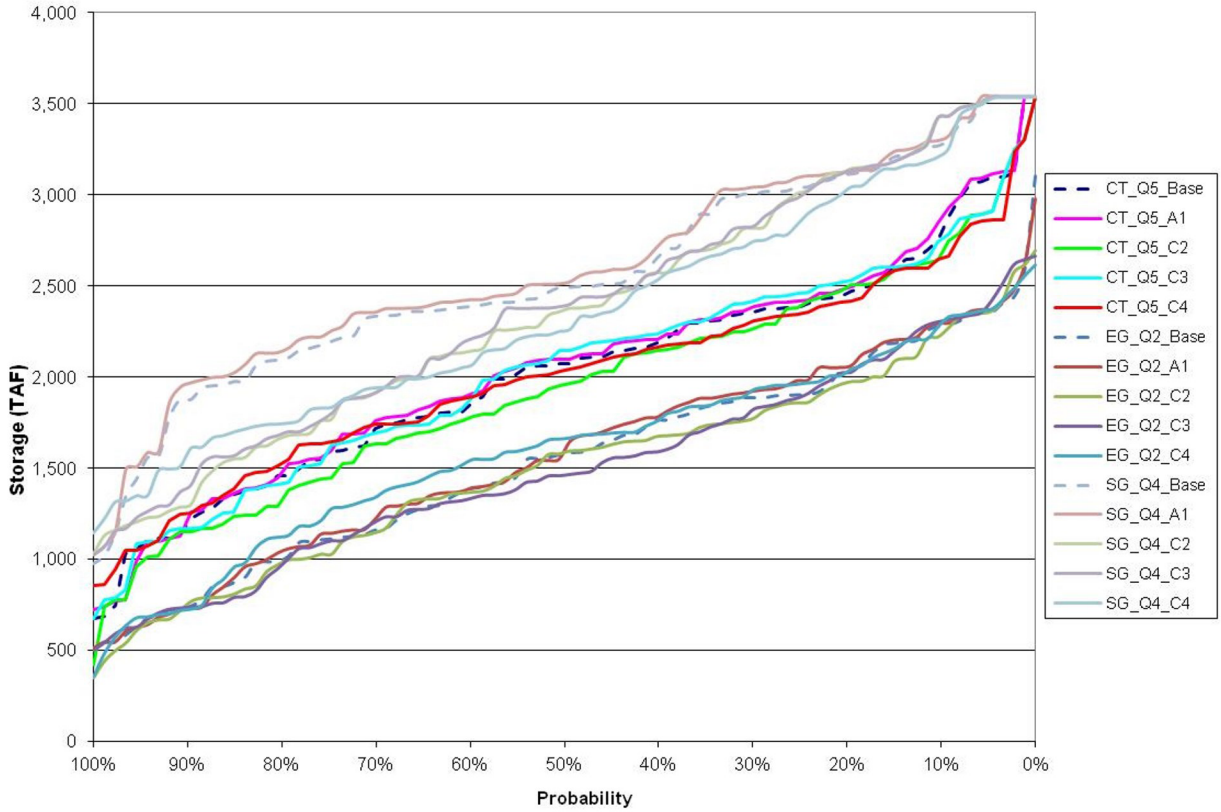

Figure 7-144. Exceedance of Lake Oroville End-of-September Storage in Portfolio C

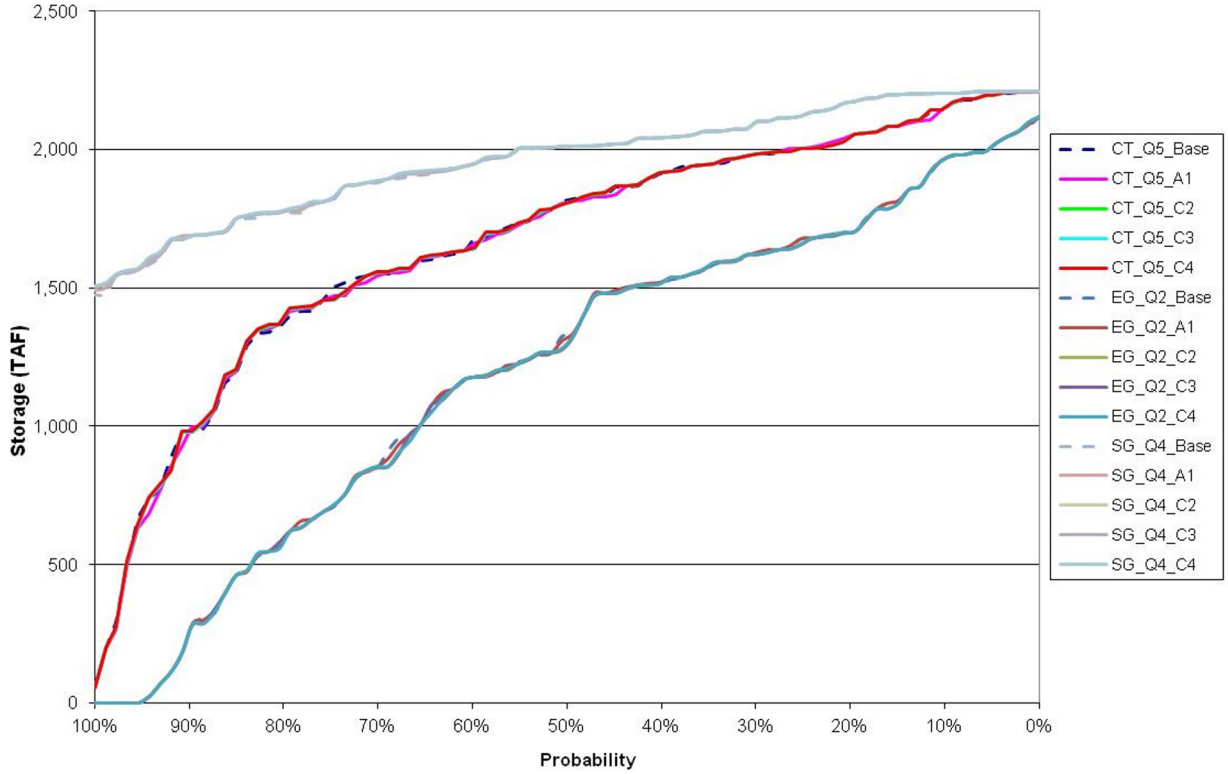

Figure 7-145. Exceedance of New Melones Reservoir End-of-May Storage in Portfolio C

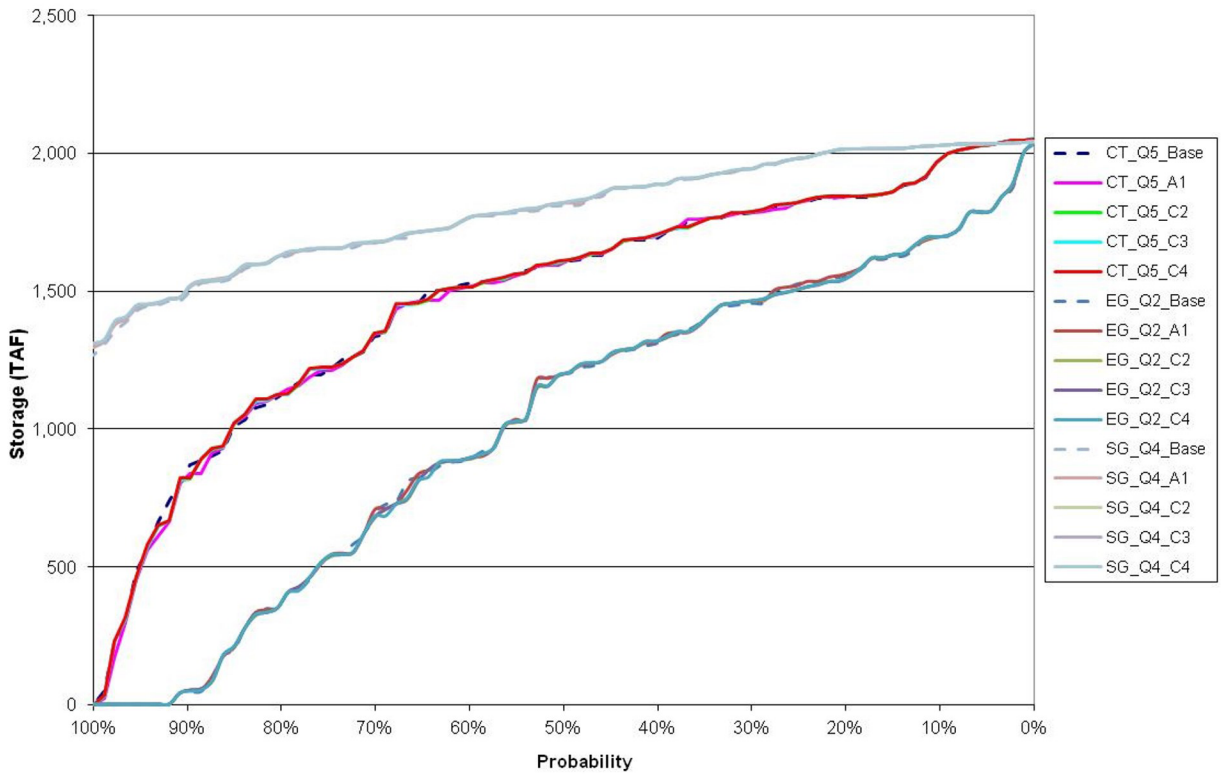

Figure 7-146. Exceedance of New Melones Reservoir End-of-September Storage in Portfolio C

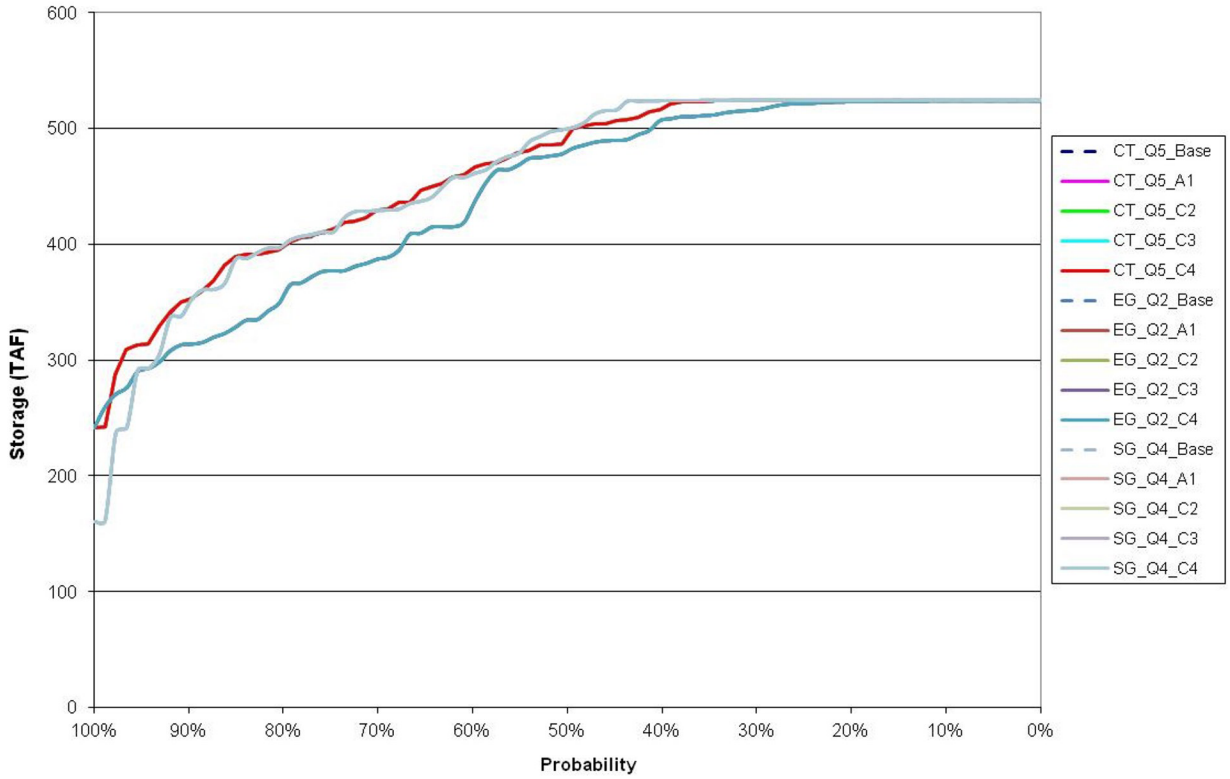

Figure 7-147. Exceedance of Millerton Lake End-of-May Storage in Portfolio C

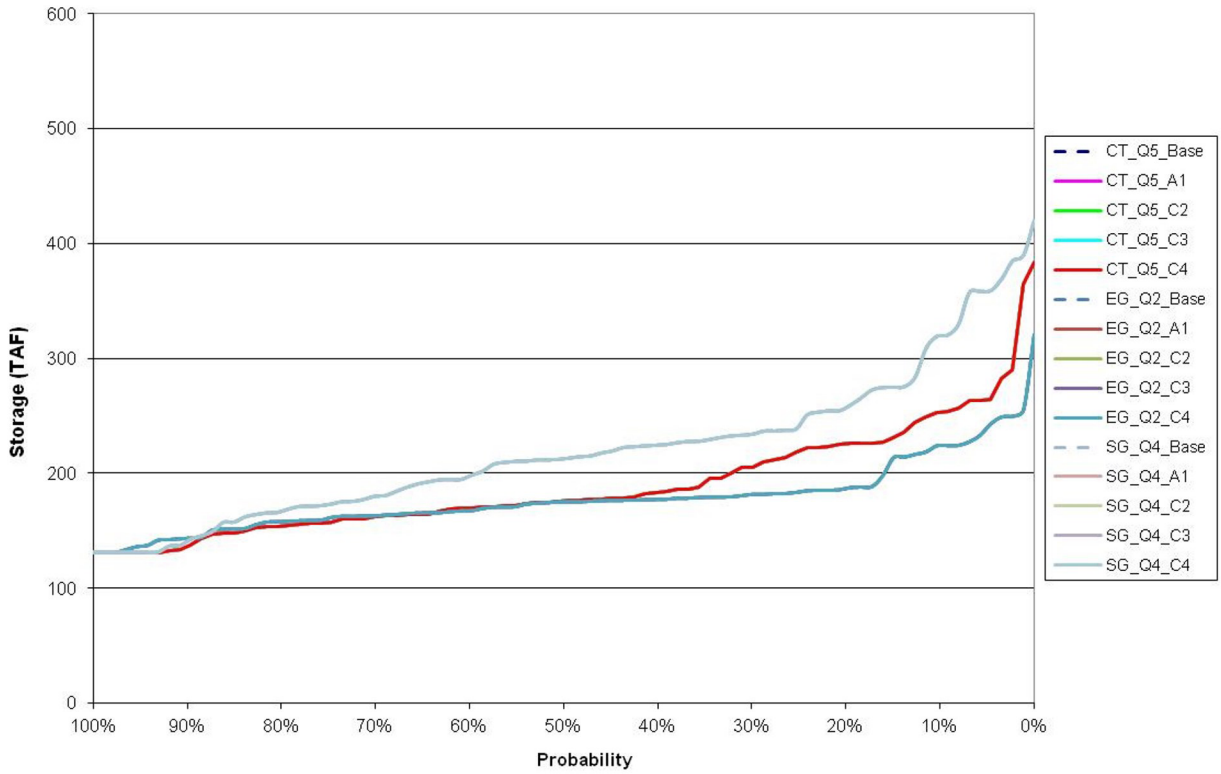

Figure 7-148. Exceedance of Millerton End-of-September Storage in Portfolio C

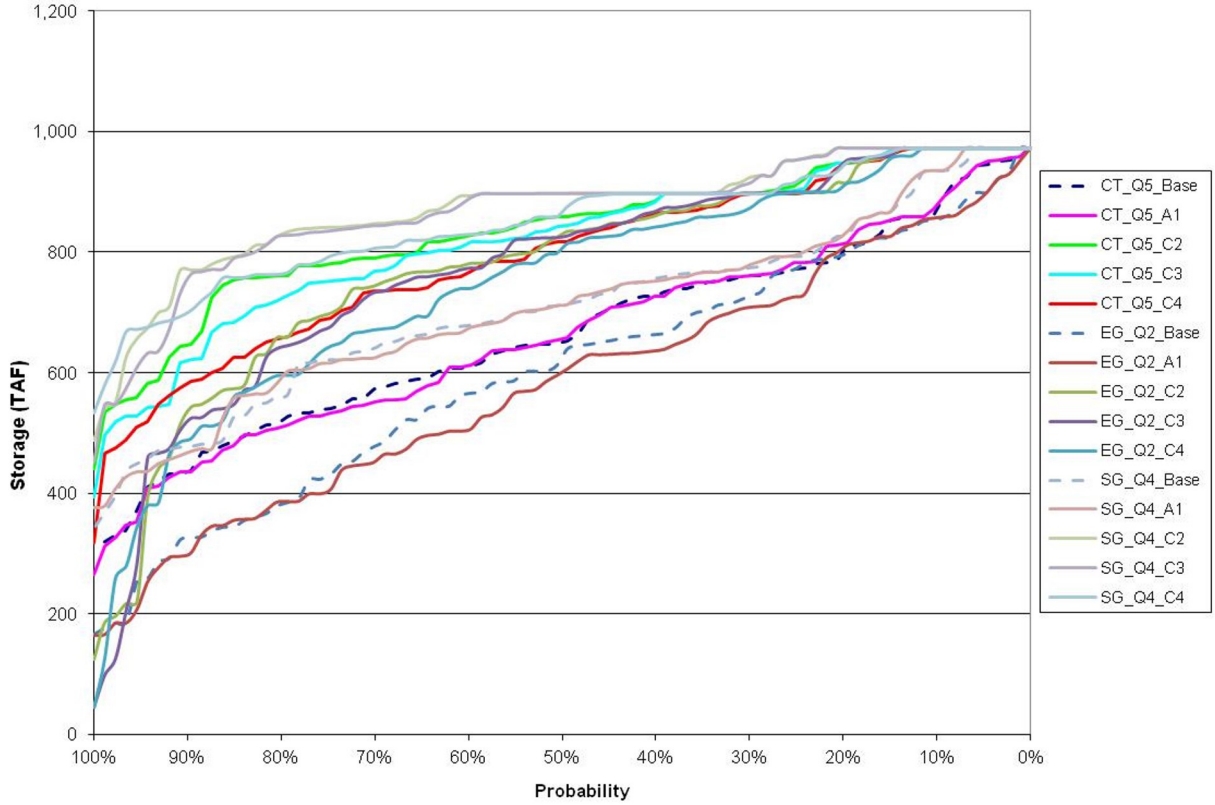

Figure 7-149. Exceedance of CVP San Luis End-of-May Storage in Portfolio C

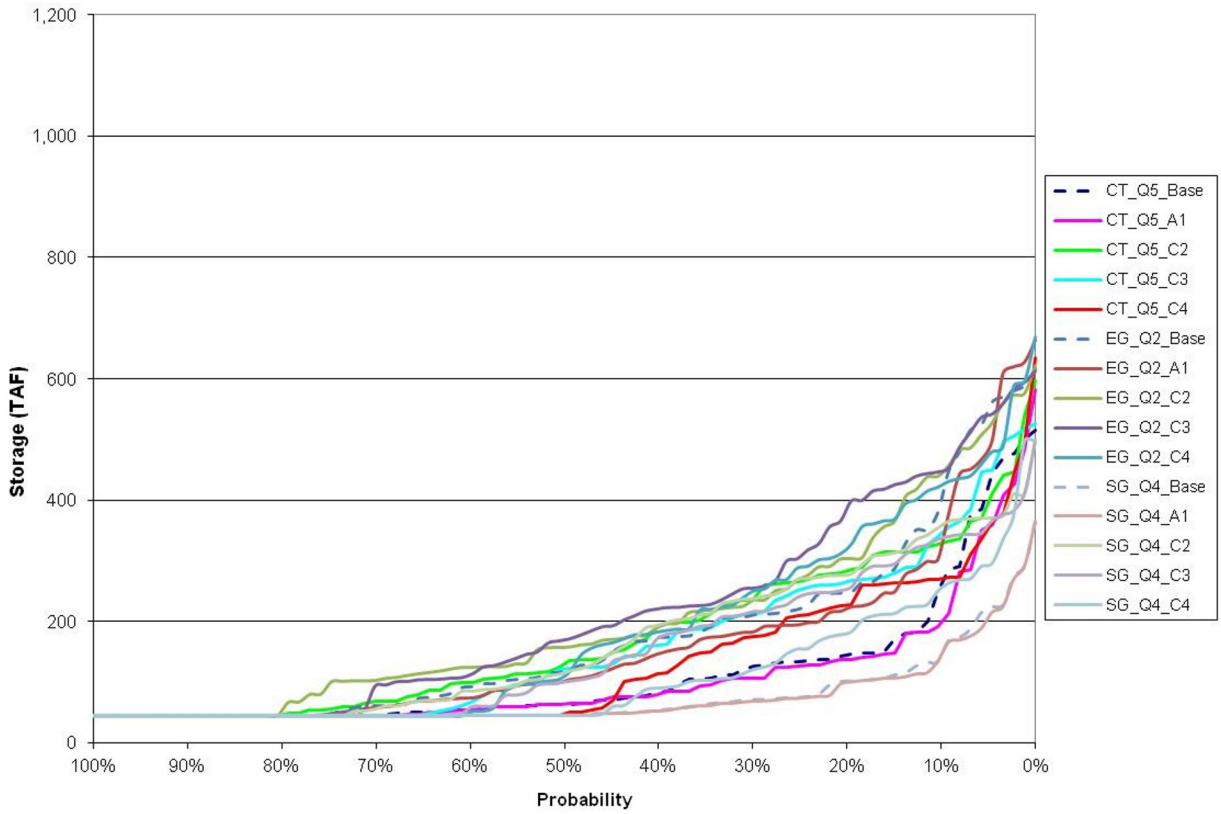

Figure 7-150. Exceedance of CVP San Luis End-of-September Storage in Portfolio C

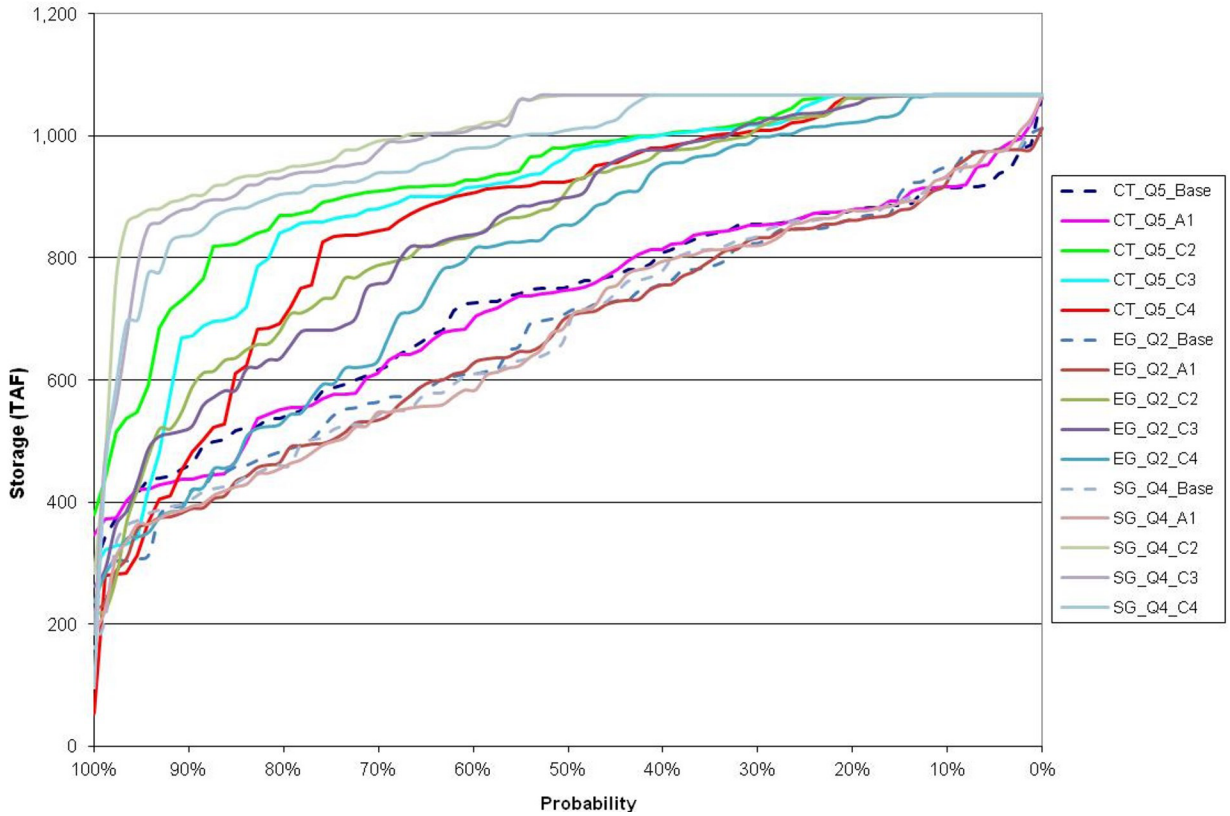

Figure 7-151. Exceedance of SWP San Luis End-of-May Storage in Portfolio C

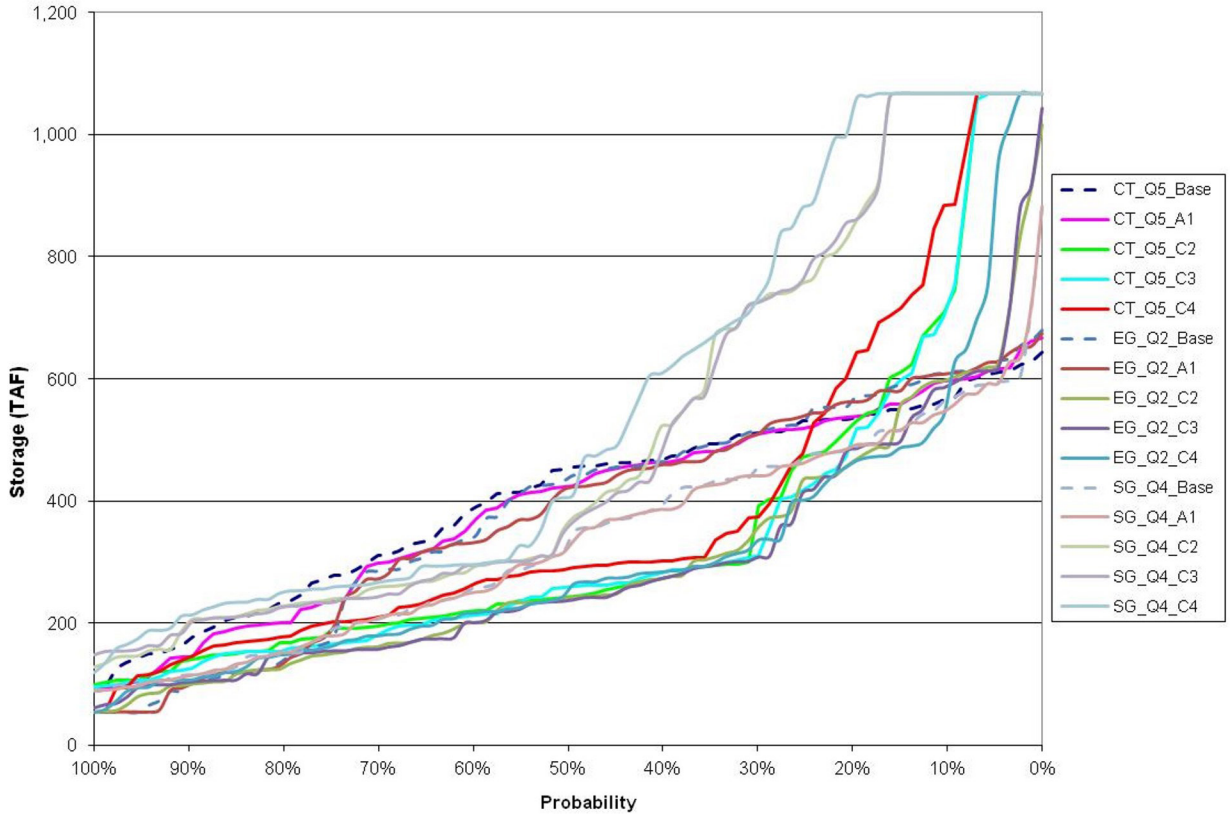

Figure 7-152. Exceedance of SWP San Luis End-of-September Storage in Portfolio C

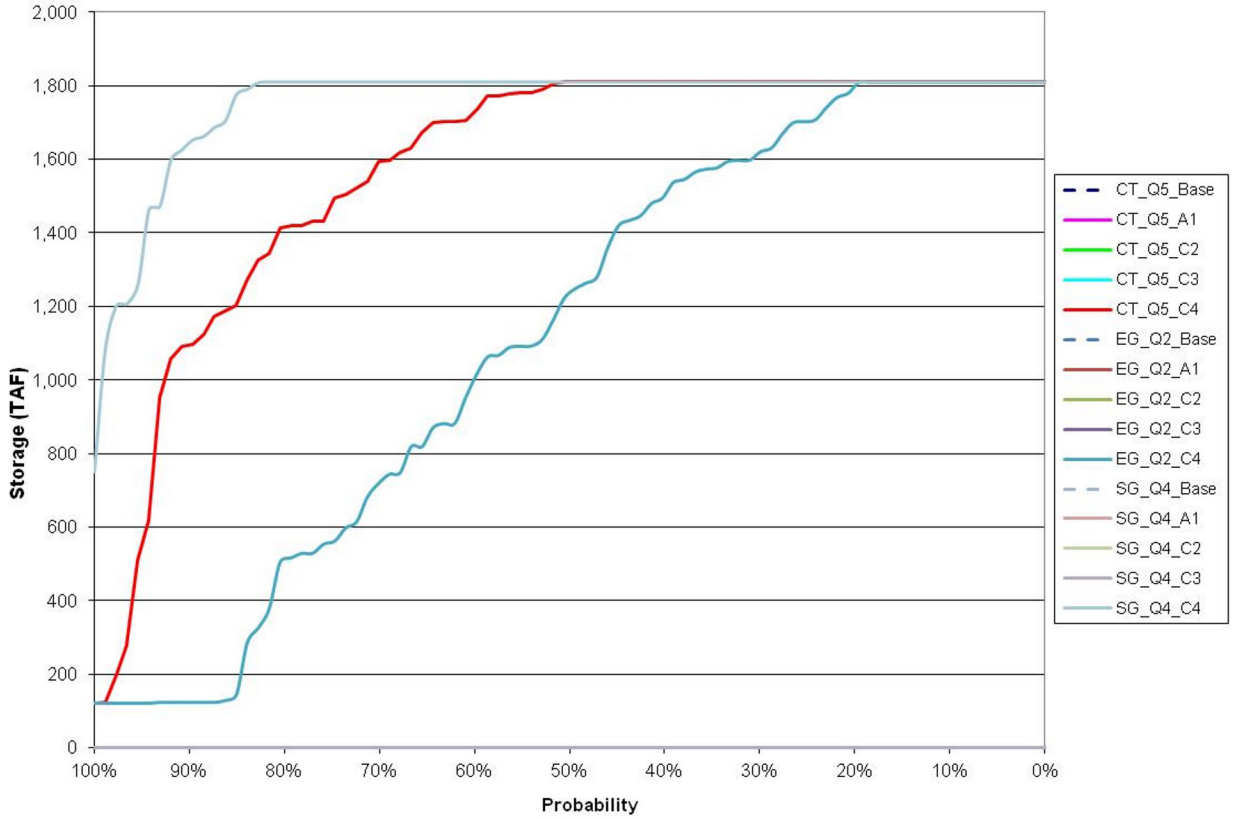

Figure 7-153. Exceedance of NODOS End-of-May Storage in Portfolio C

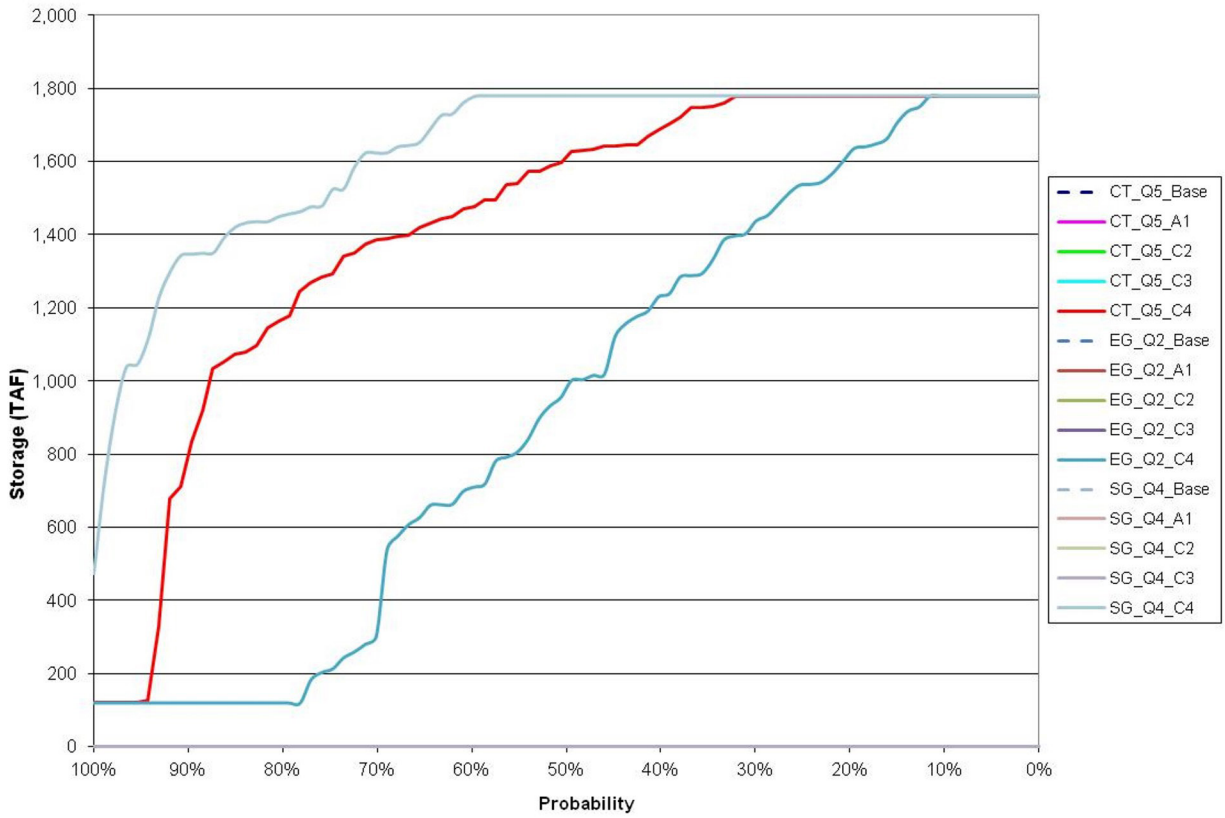

Figure 7-154. Exceedance of NODOS End-of-September Storage in Portfolio C

the Portfolio C simulation suites at the end of May and at the end of September in Shasta, Folsom, Oroville, New Melones, Millerton, CVP San Luis, SWP San Luis Reservoirs, and in NODOS under scenarios CT-Q5, EG-Q2, and SG-Q4. The addition of the Delta conveyance action in C2, C3, and C4 resulted in reductions in storage at Oroville in May as compared to the Baseline and A1, reflecting the increases in SWP pumping that occurred earlier in the year. Lake Oroville storage in C2, C3, and C4 was much closer to the Baseline levels in September, reflecting little impact on SWP carryover storage relative to the Baseline. Lake Shasta storage levels in C2 were similar to the storage in the Baseline and A1, and the enlargement of Shasta Lake resulted in increased Shasta Lake storage in C3 and C4. Folsom, New Melones, and Millerton Lake storage levels were also very similar in all Portfolio C simulations, indicating that there was little impact on CVP storage levels downstream of the Delta under the Portfolio C actions. However, CVP San Luis and SWP San Luis storage levels were significantly higher than in the Baseline, reflecting the greater capability for exporting water under Portfolio C. Finally, NODOS storage operations in C4 tended to be lower than those in which NODOS operated on its own in B2, reflecting increased releases from the reservoir because of increased opportunities to export the incremental supply increase with Delta conveyance in place.

7.3.2.2 Delta Exports and Delta Outflow

Figures 7-155 through 7-160 show the annual exceedance plots of exports at Banks PP and Jones PP, as well as total Delta exports under scenarios CT-Q5, EG Q2, and SG-Q4 along with the change in annual average flows relative to the Baseline at these locations under all 18 socioeconomic scenarios. Figures 7 161 and 7-162 show the same information for Delta outflow. Relative to the Baseline, total average annual Delta exports increased significantly with the addition of Delta conveyance ranging from +648 to 1,099 TAF/year in C2. Additional increases in exports occurred with the addition of Shasta enlargement in C3 and NODOS in C4. The increases in exports from C2 to C3 were greater than those seen in B1 without the addition of Delta conveyance in C2, and the increases from C3 to C4 were greater than those seen in B2. These results indicated that the potential benefits from Enlarged Shasta

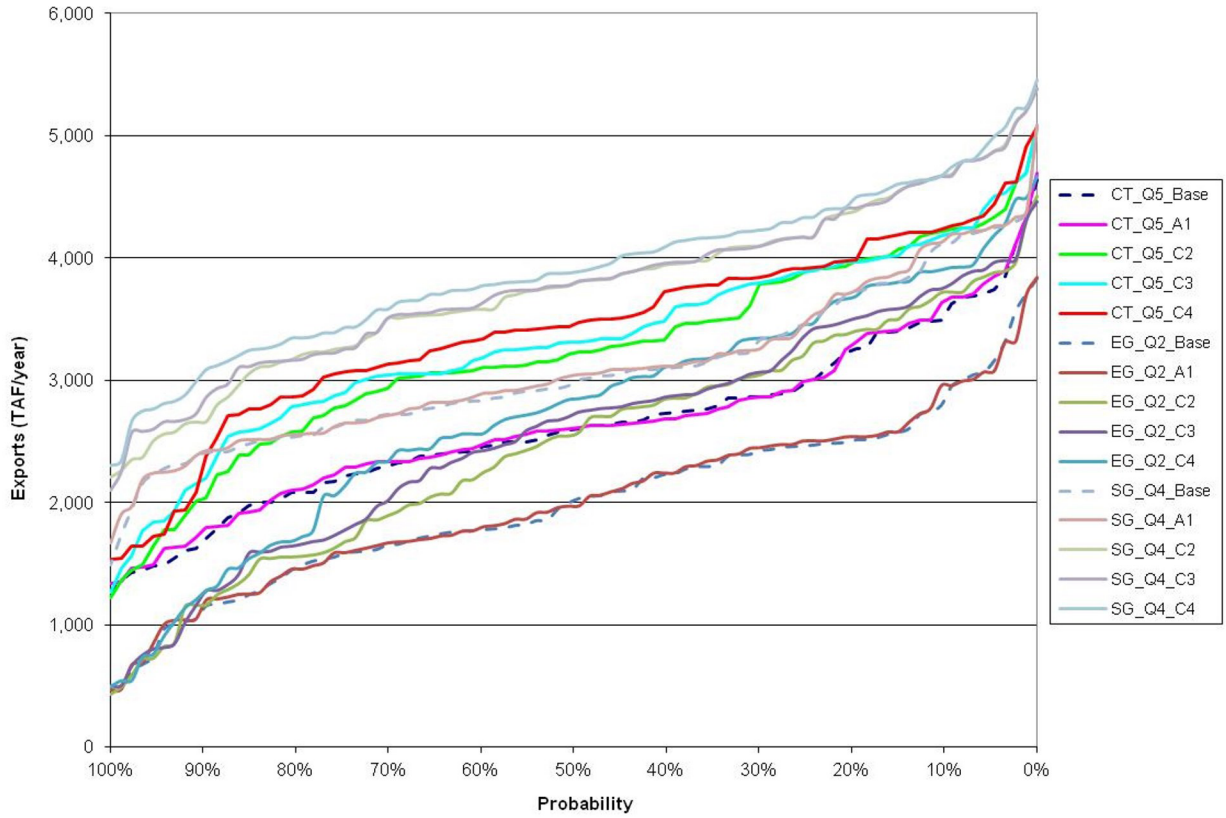

Figure 7-155. Exceedance of NODOS End-of-May Storage in Portfolio C

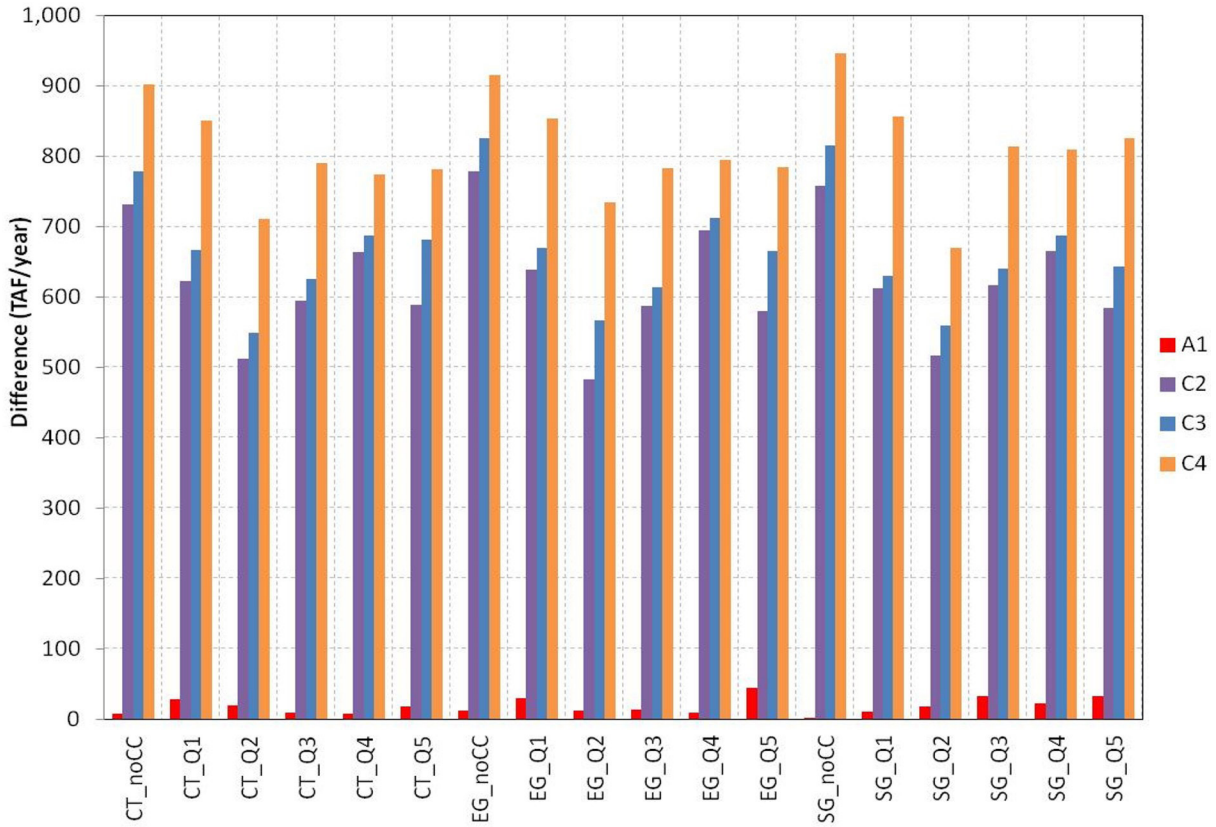

Figure 7-156. Average Annual Change in Banks Pumping for Portfolio C Relative to the Baseline in Each Scenario

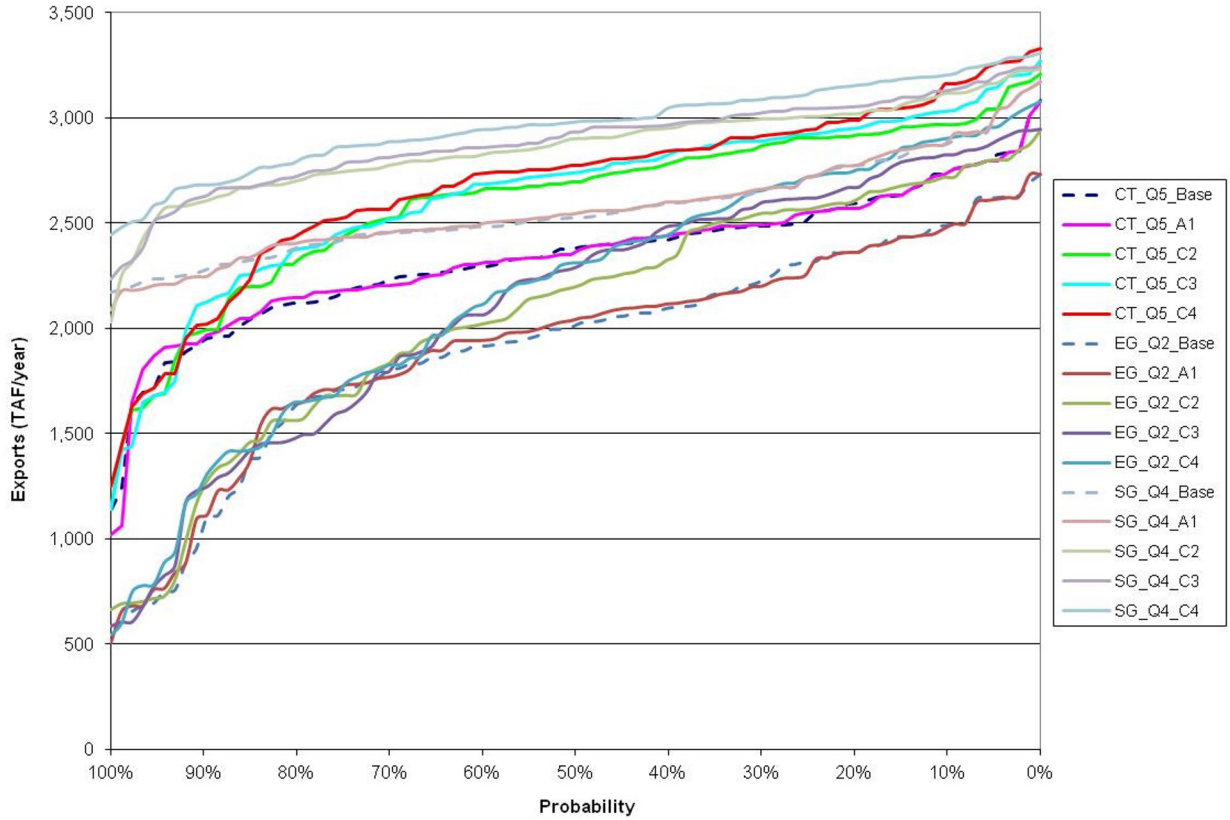

Figure 7-157. Annual Exceedance of Jones Pumping in Portfolio C

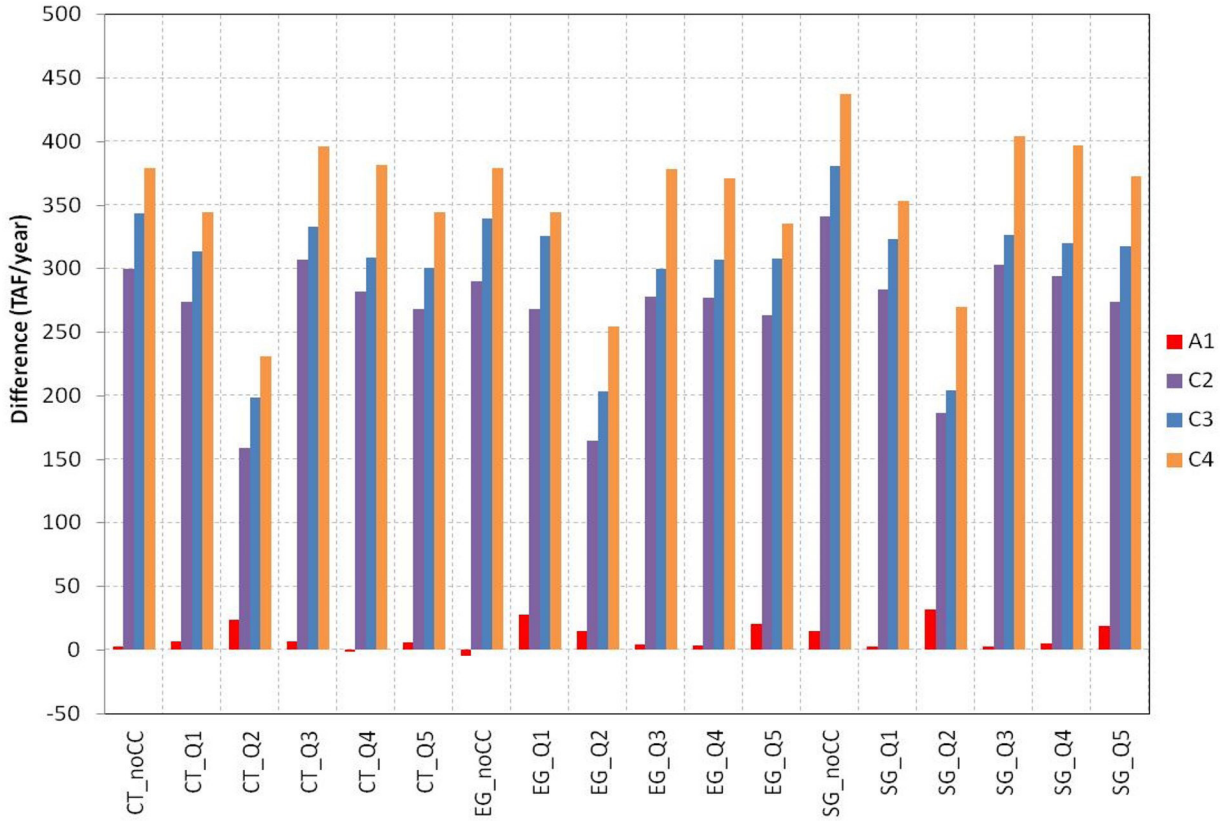

Figure 7-158. Average Annual Change in Jones Pumping for Portfolio C Relative to the Baseline in Each Scenario

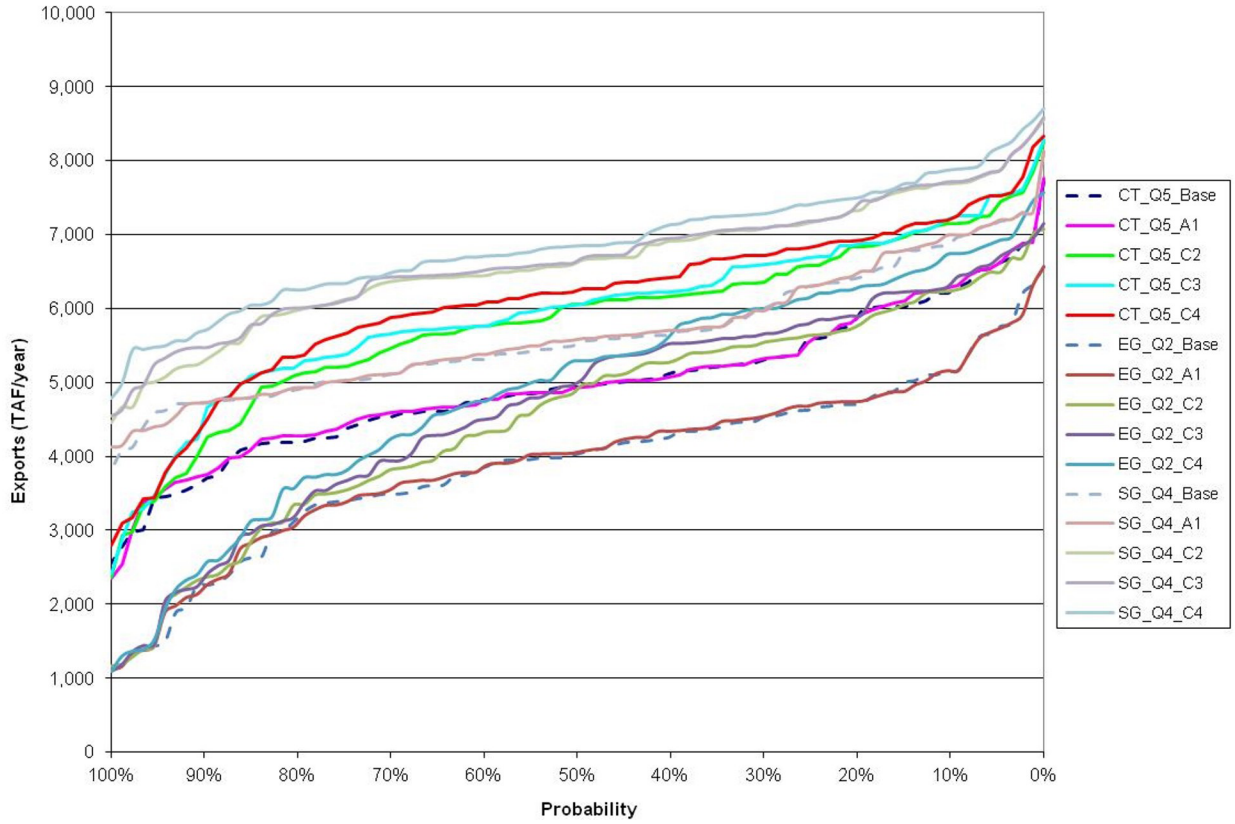

Figure 7-159. Annual Exceedance of Total Delta Exports in Portfolio C

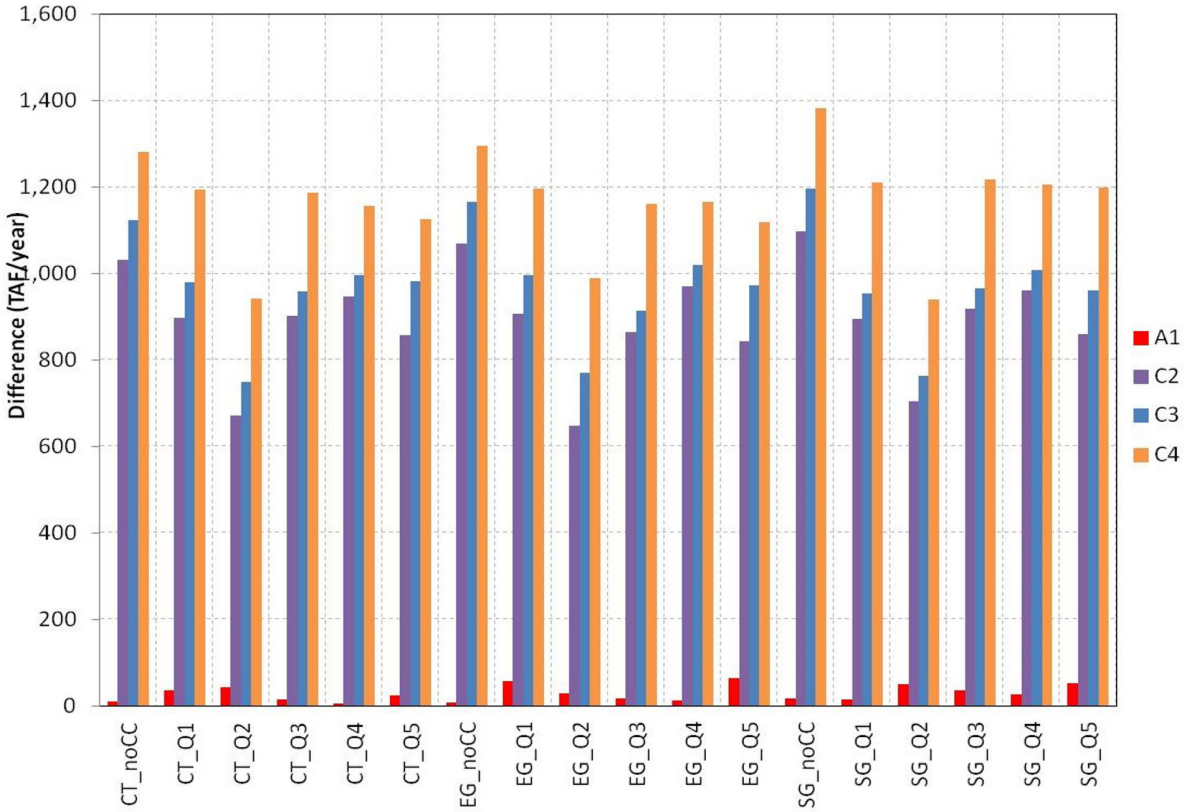

Figure 7-160. Average Annual Change in Total Delta Exports for Portfolio A Relative to the Baseline in Each Scenario

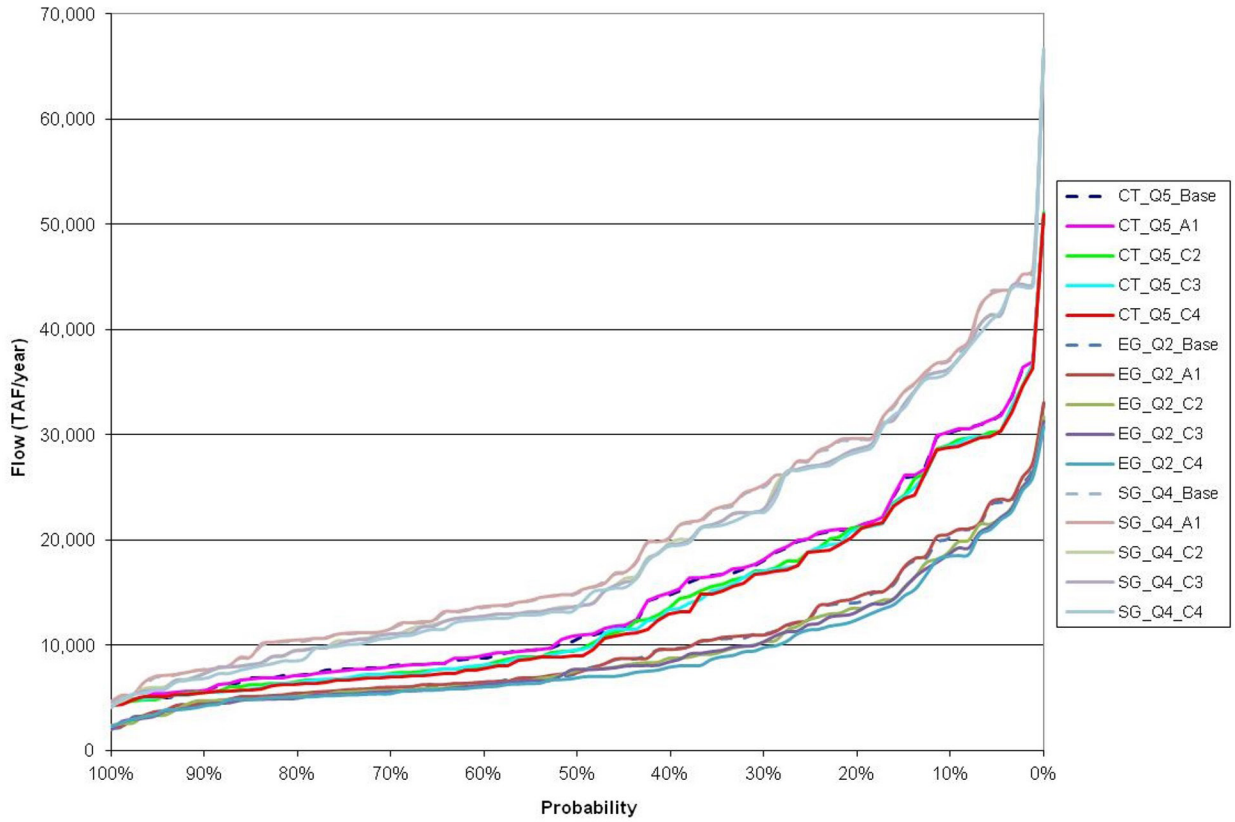

Figure 7-161. Annual Exceedance of Delta Outflow in Portfolio C

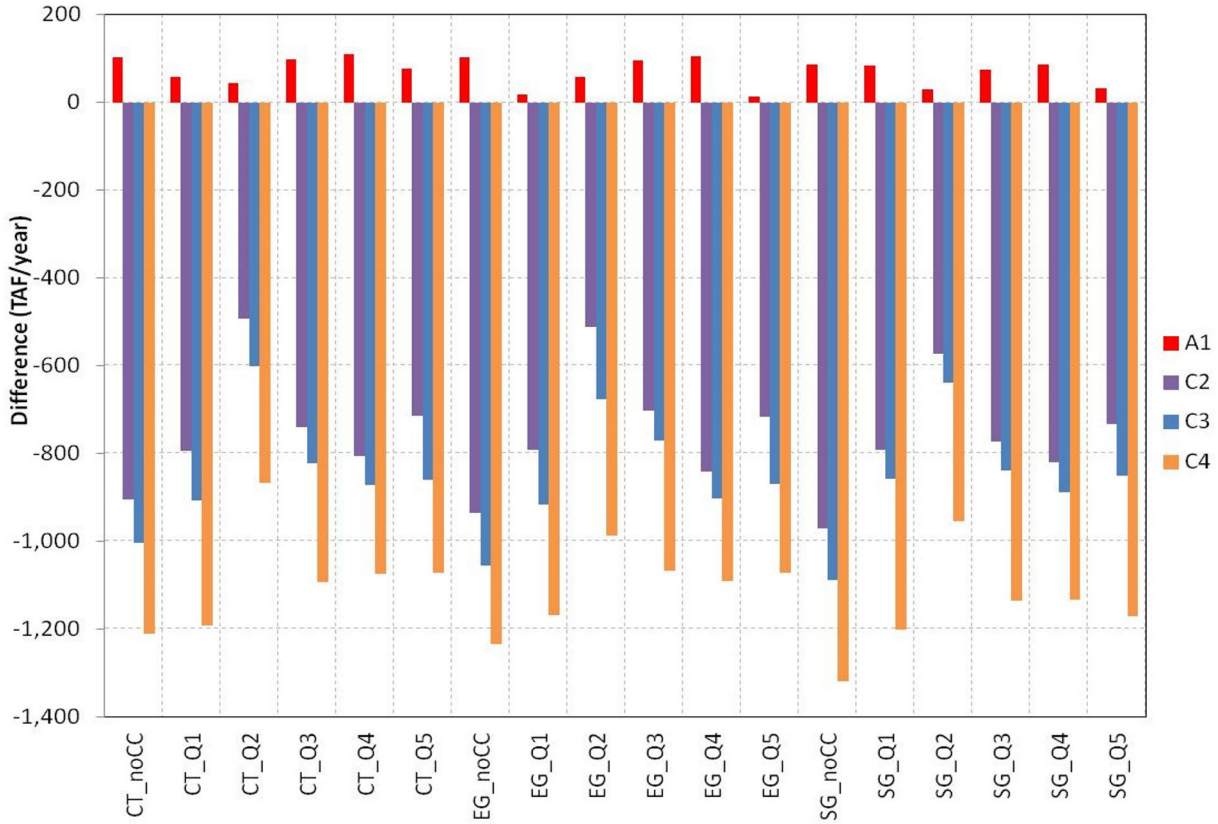

Figure 7-162. Average Annual Change in Delta Outflow for Portfolio C Relative to the Baseline in Each Scenario

and NODOS were greater with Delta conveyance than under the Baseline condition. Total exports in C4 exceeded the Baseline values ranging from 940 to 1,295 TAF/year across the range of socioeconomic-climate scenarios.

Delta outflows decreased in C2, C3, and C4 by amounts consistent with the increases in Delta exports. Whereas A1 had small increases in Delta outflow, Delta outflows ranged from 513 to 936 TAF/year less in C2 than in the Baseline across the range of all scenarios. When both Enlarged Shasta and NODOS actions were included in C4, the reduction in Delta outflows ranged from between 867 and 1,319 TAF/year across the range of all scenarios.

7.3.2.3 Delta Salinity

Figure 7-163 shows the average X2 position from February through June in each scenario with Portfolio C actions. Figure 7-164 shows the exceedance plot of average X2 position from February through June under scenarios CT-Q5, EG-Q2, and SG-Q4. Relative to the Baseline, the average X2 position increased by about 1 to 2 km in C2, C3, and C4, reflecting the increases in salinity conditions in the Delta resulting from the reductions in Delta outflow.

7.3.3 Other Performance Assessments

7.3.3.1 Economics

Figures 7-165 through 7-168 show the changes in net water supply system costs from the urban economic models LCPSIM and OMWEM, the net change in avoided cost from the water quality economic model SBWQM, and the change in net agricultural revenue from SWAP for each of the Portfolio C simulation suites corresponding to CT-Q5, EG-Q2, and SG-Q4 socioeconomic-climate scenarios with the 2025, 2055, and 2085 LODs.

The South Bay urban economic model results from LCPSIM showed substantial economic benefits in the CT-Q5 and EG-Q2 scenarios with the Portfolio C actions, with values in C4 ranging up to $127 million per year in CT-Q5 and up to $460 million per year in EG-Q2. These benefits resulted from the reductions in shortage costs due to the increased deliveries to the South Bay region, and were larger in EG-Q2 because the South Bay has very high unmet demands and, therefore, high marginal shortage costs in the EG-Q2 Baseline due to the increased population in the Expansive Growth socioeconomic scenario and reduced water supplies in the Q2 climate scenario. However, there was very little change in the economic values in the SG-Q4 scenario, despite an increase in SWP and CVP deliveries to the South Bay region, because the lower population increases combined with the high deliveries in the SG-Q4 Baseline resulted in very little marginal value from additional water supplies.

Figure 7-169 shows the long-term average salinity at CCWD and SBA diversion locations with the Portfolio C actions. South Bay region water quality costs reported by SBWQM showed substantial economic benefits with C2, C3, and C4 actions in the CT-Q5 and EG-Q2 scenarios because the increases in Delta exports caused a large reduction in salinity at the export locations, thereby significantly reducing the cost of treatment. In C4, there were about $16 million per year in avoided salinity costs in CT-Q5 and about $20 million in EG-Q2. In SG-Q4, the already low salinity levels in the Baseline resulted in much smaller incremental improvements in salinity for the Portfolio C actions, resulting in very little change in salinity costs relative to the Baseline.

The changes in Central Valley net agricultural revenue results from SWAP and urban economic results from OMWEM showed substantial benefits with C2, C3, and C4 actions as compared to the Baseline (see Figure 7-168). The average annual economic benefits in C4 across the different socioeconomic-climate scenarios and LODs ranged from $34–102 million per year net agriculture revenue and from about $3–109 million per year in urban water supply costs. As with LCPSIM, the OMWEM results showed substantially less benefit in SG-Q4 than in the other two scenarios because the marginal incremental benefits relative to the Baseline were smaller.

7.3.3.2 Water Temperature

Figures 7-170 through 7-173 show exceedance plots and average changes of daily water temperatures relative to the Baseline from July through September for CT-Q5, EG-Q2, and SG-Q4 scenarios in the Sacramento River at Keswick and at Jelly's Ferry. With the addition of Delta conveyance in the C2 action, there were only minimal changes in water temperatures relative to A1. With the addition of North-of-Delta surface

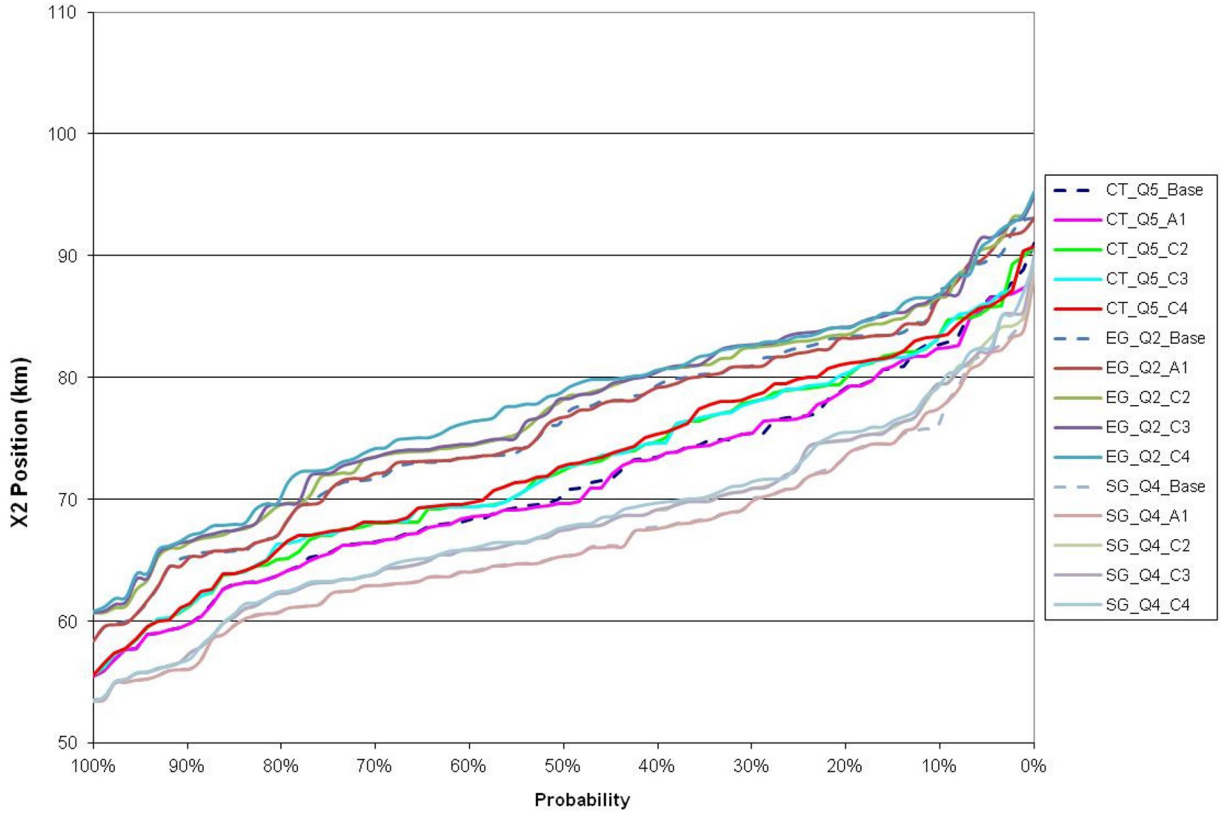

Figure 7-163. Exceedance of Average February-to-June X2 Position in Portfolio C

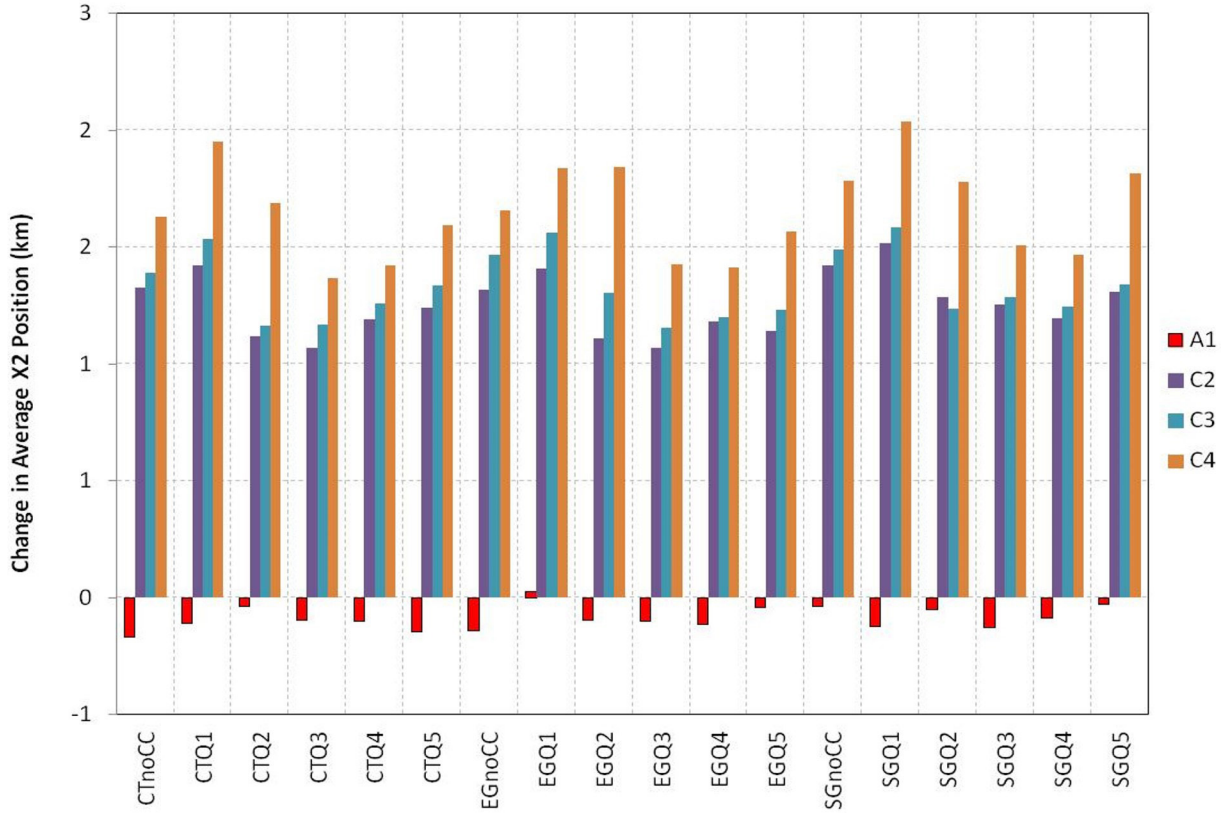

Figure 7-164. Change in Average February-to-June X2 Position for Portfolio C Relative to the Baseline in Each Scenario

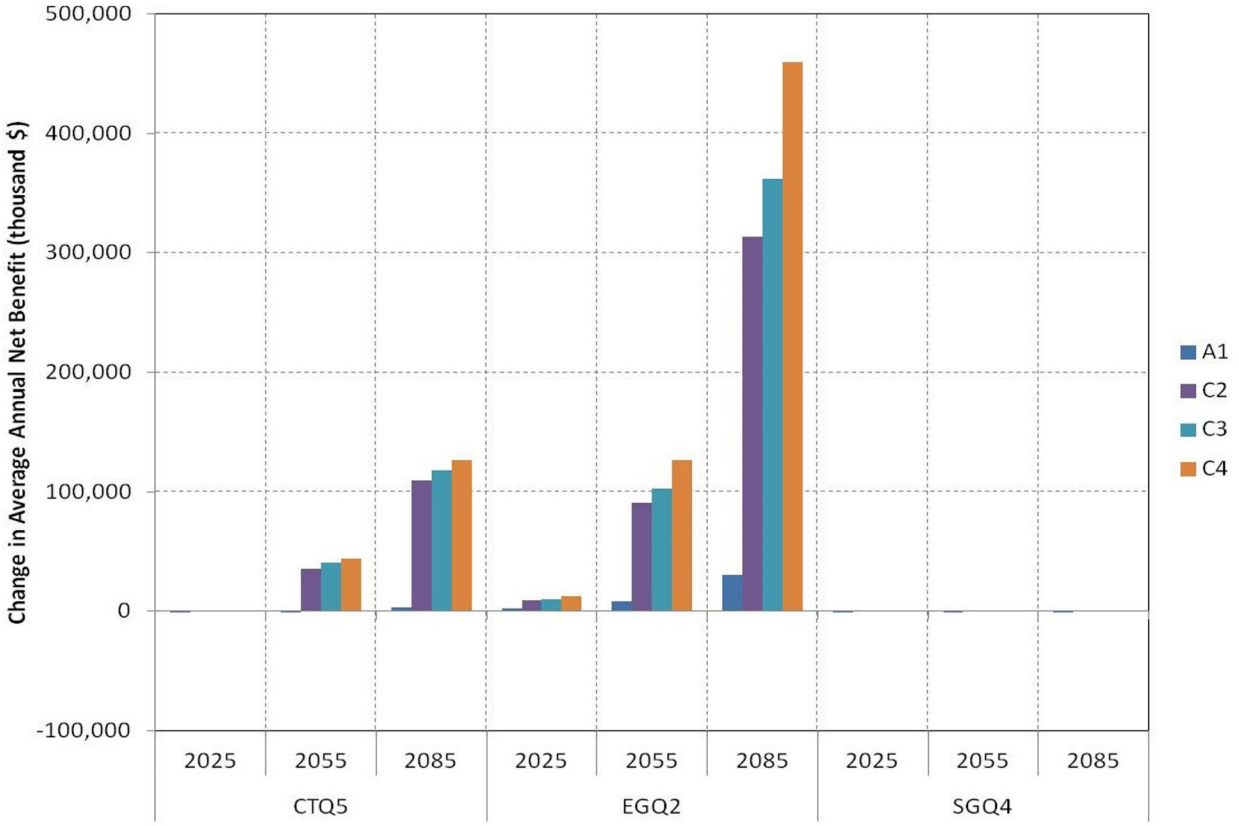

Figure 7-165. Improvement in Average Annual Urban Net Water Supply System Costs in South Bay Region from LCPSIM in Portfolio C

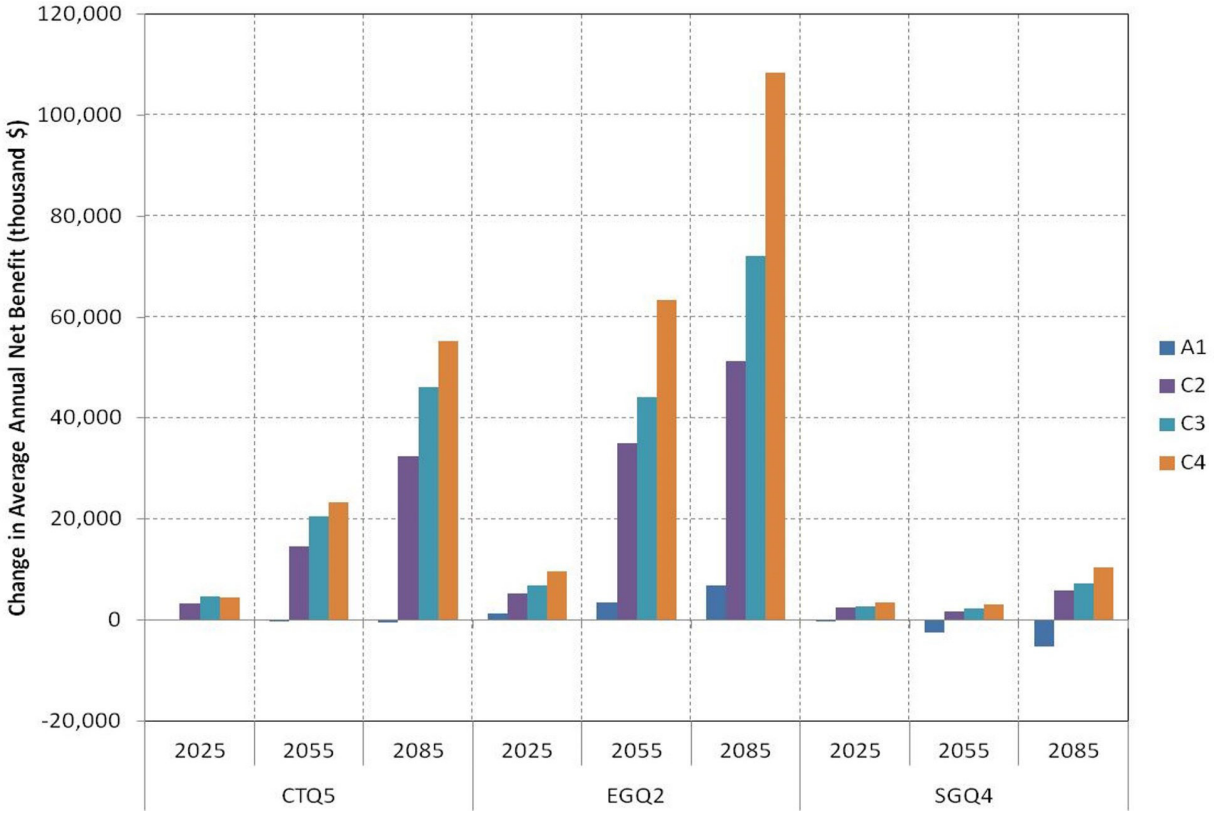

Figure 7-166. Improvement in Average Annual Urban Net Water Supply System Costs in Central Valley from OMWEM in Portfolio C

Figure 7-167. Improvement in Average Annual Avoided Water Quality Costs in South Bay Region from SBWQM in Portfolio C

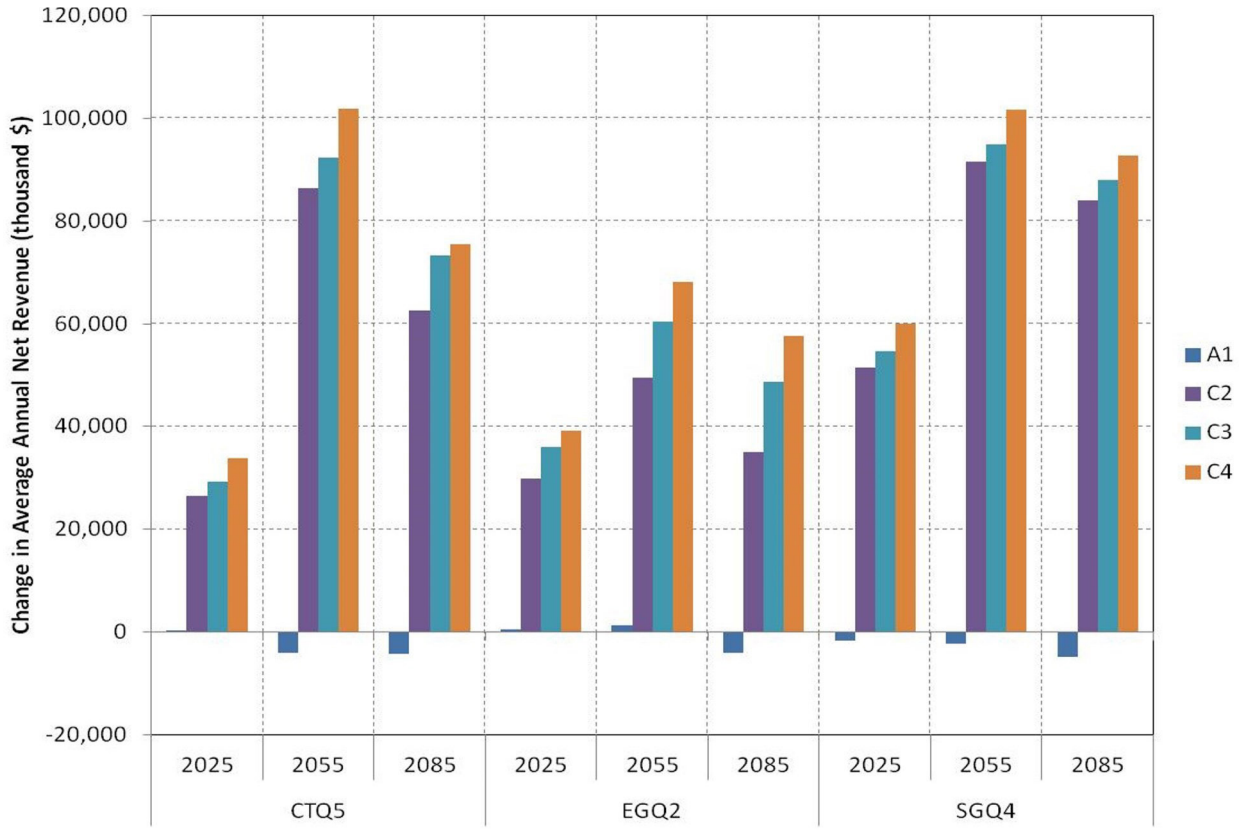

Figure 7-168. Improvement in Average Annual Agricultural Net Revenue in Central Valley from SWAP in Portfolio C

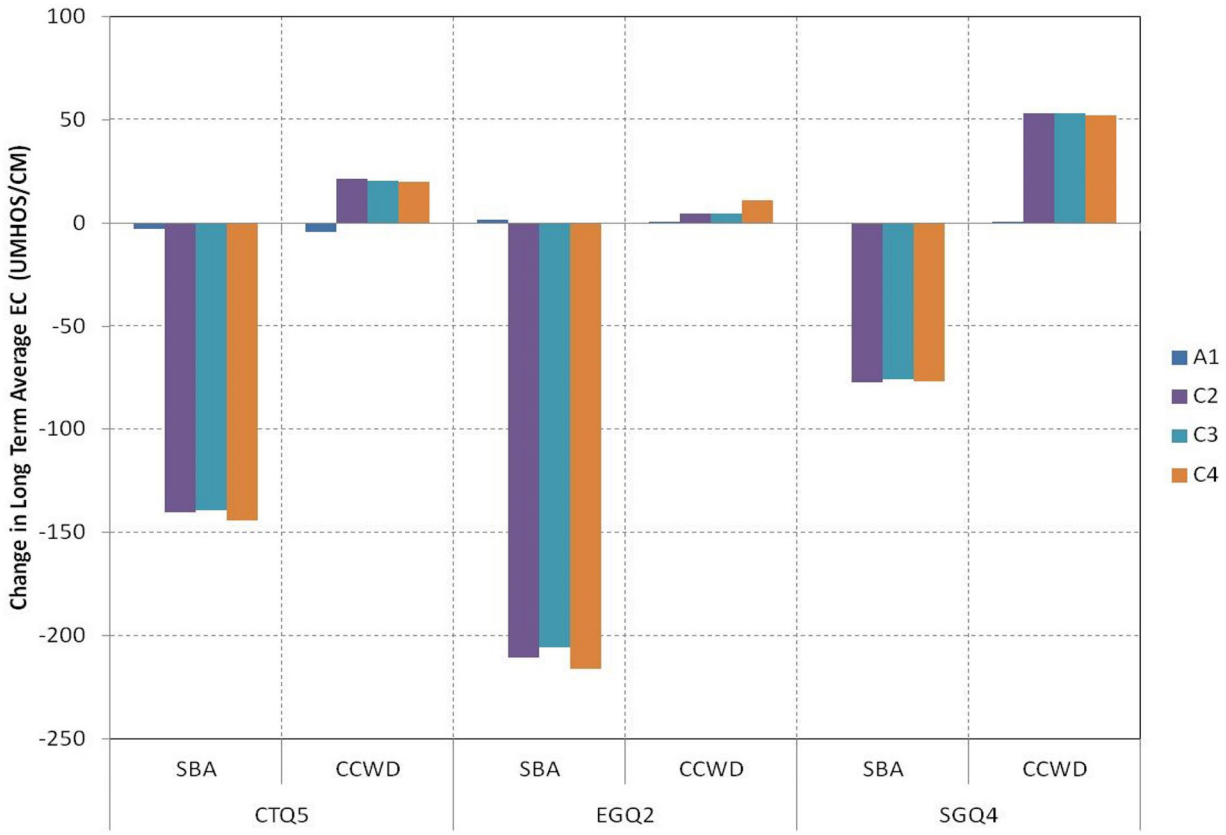

Figure 7-169. Long-Term Average Salinity at CCWD and SBA Diversion Locations in Portfolio C

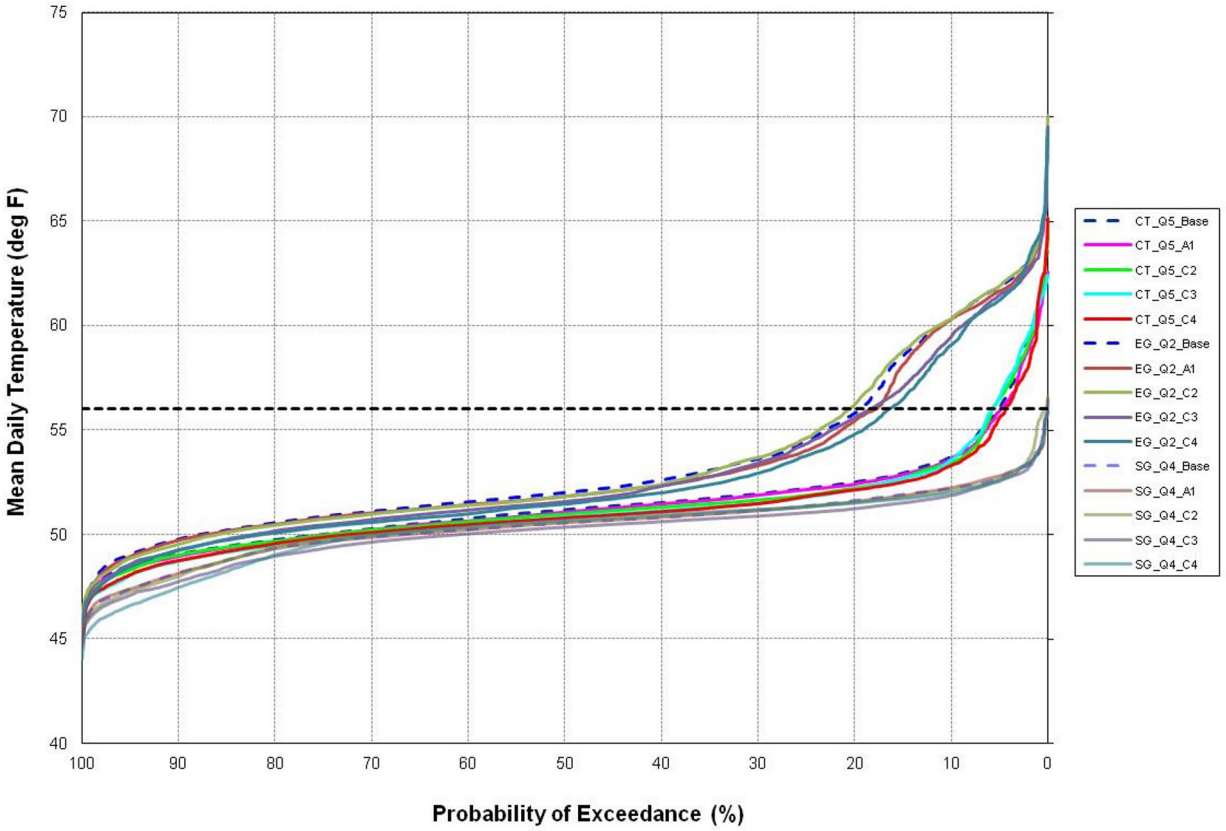

Figure 7-170. Exceedance of Mean Daily Temperature on Sacramento River at Keswick from July to September in Portfolio C

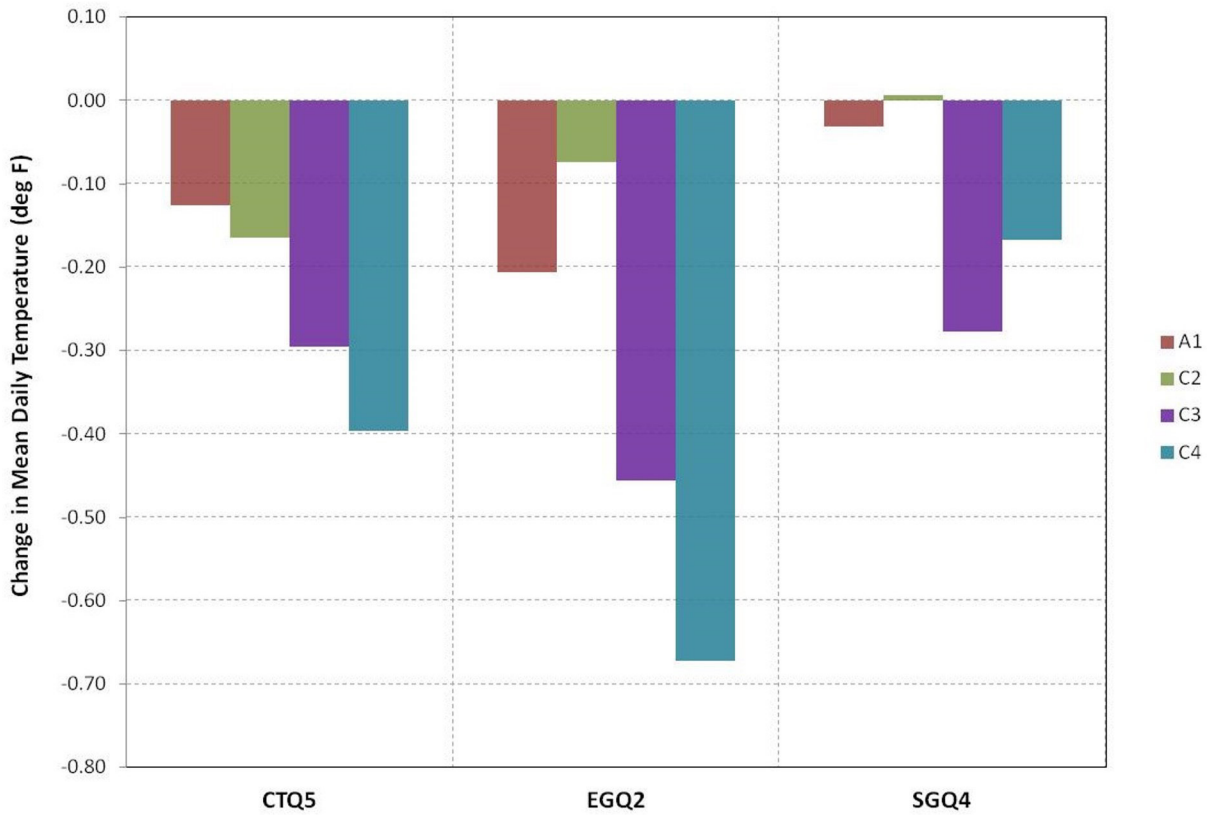

Figure 7-171. Change in Mean Daily Temperature on Sacramento River at Keswick from July to September in Portfolio C

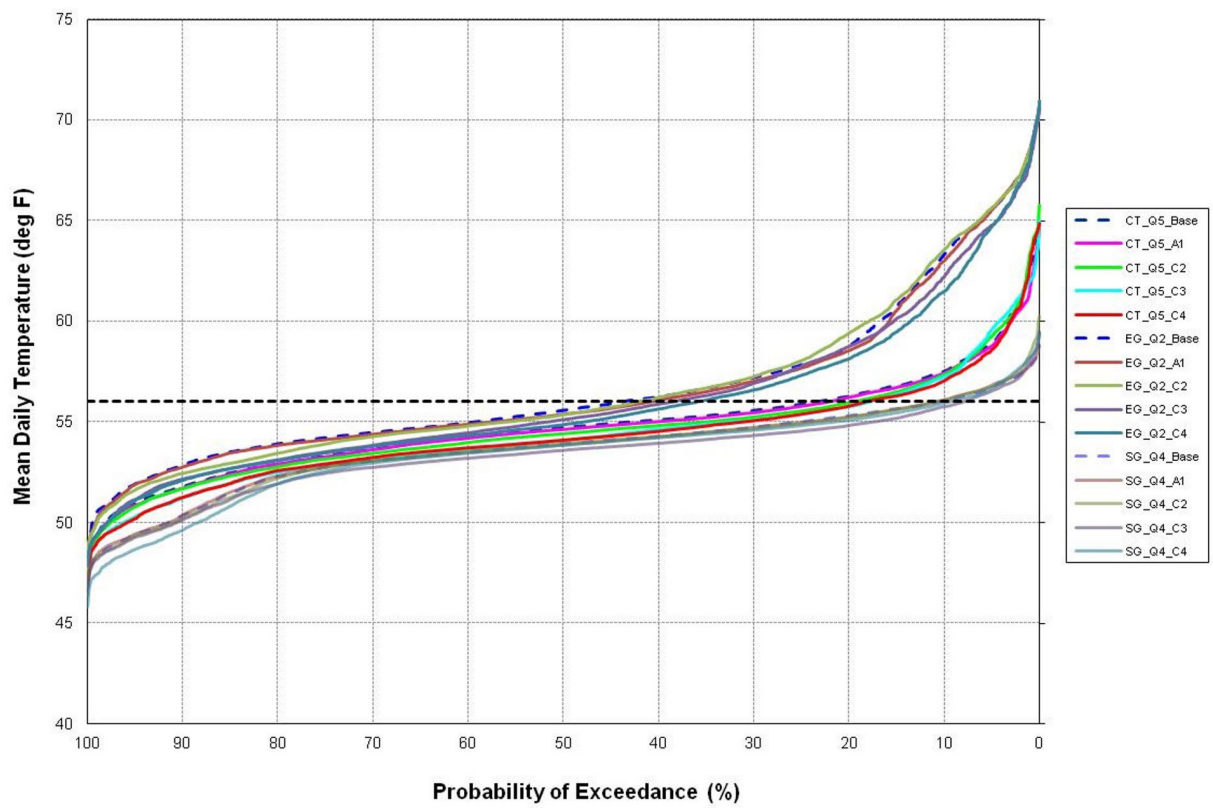

Figure 7-172. Exceedance of Mean Daily Temperature on Sacramento River at Jelly's Ferry from July to September in Portfolio C

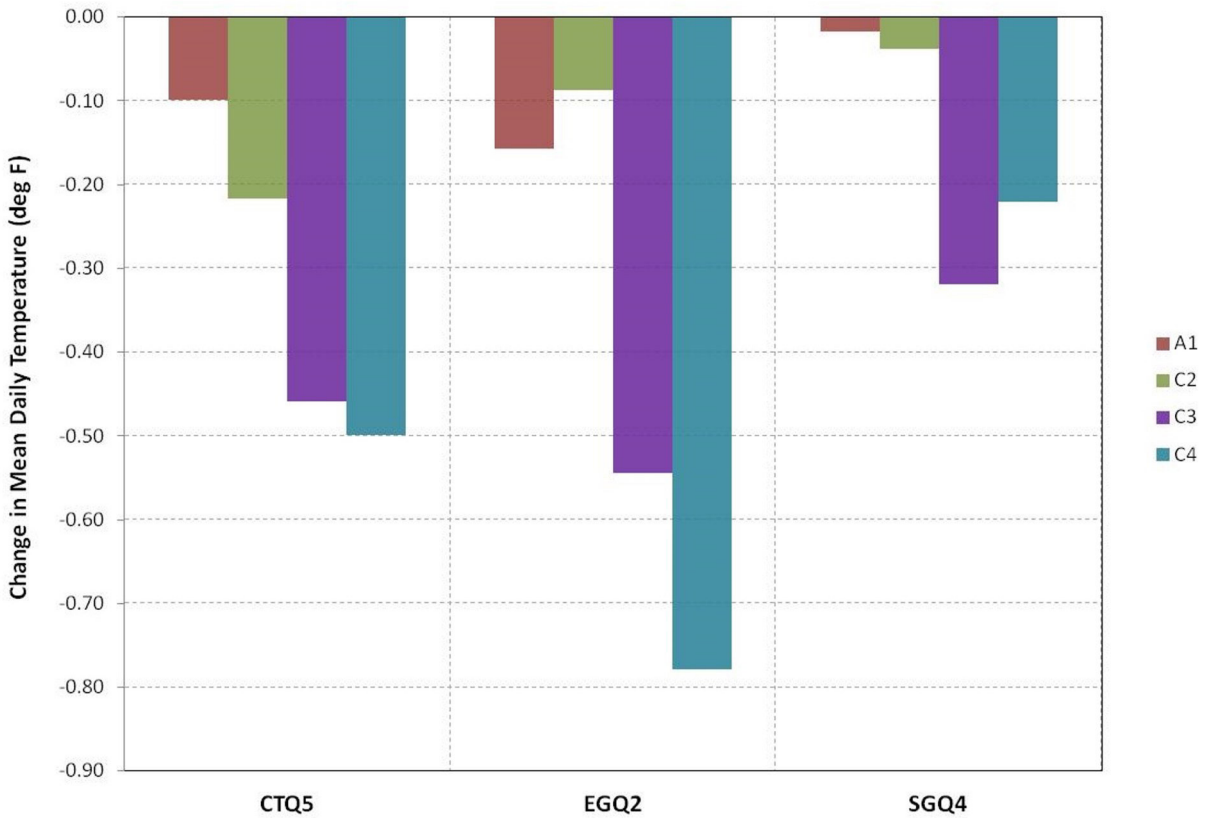

Figure 7-173. Change in Mean Daily Temperature on Sacramento River at Jelly's Ferry from July to September in Portfolio C

storage facilities in C3 and C4, there were modest reductions in water temperature relative to C2 due to the increased storage and available coldwater pool in the Enlarged Shasta Lake. The mean daily water temperatures in the Sacramento River at Keswick in C3 and C4 were about 0.2 0.7°F lower than in the Baseline, and the mean daily water temperatures at Jelly's Ferry in C3 and C4 were about 0.2–0.8°F lower than the Baseline across the range of scenarios. As observed in the baseline cases, the SG-Q4 (wetter) scenario had the lowest water temperatures, and the EG-Q2 (drier) scenario had the highest water temperatures, with CT-Q5 falling between them.

Figures 7-174 through 7-179 show exceedance plots and average changes of daily water temperatures in the San Joaquin River for the same three scenarios with the Portfolio C actions relative to the Baseline at Lost Lake, Gravelly Ford, and Vernalis from August through November. Under all scenarios with the C2, C3, and C4 actions, there were only minimal changes in water temperatures at all three San Joaquin River locations relative to the Baseline. Therefore, as observed in Portfolio B, increased storage in the Sacramento River system and additional Delta conveyance had negligible impacts on water temperatures in the San Joaquin River.

7.3.3.3 Hydropower and Greenhouse Gas Emissions

Figures 7-180 and 7-181 show the changes in net hydropower generation and in GHG emissions (that is, increase in GHG emissions in the SWP system or reduction in potential GHG offsets in the CVP system) for the CVP and SWP systems with Portfolio C actions relative to the Baseline. In the SWP system, there were substantial reductions in net power generation and increases in GHG emissions with the C2, C3, and C4 actions due to the large increases in Delta export pumping. In C4, net hydropower generation ranged from about 500–1,000 GWh/year less than in the Baseline; and GHG emissions ranged from about 113,000–134,000 mTCO2e higher than in the Baseline. In the CVP system, the reductions in net hydropower generation ranged from about 100 to 160 GWh/year with corresponding reductions in GHG offsets of about 29,000–47,000 mTCO2e

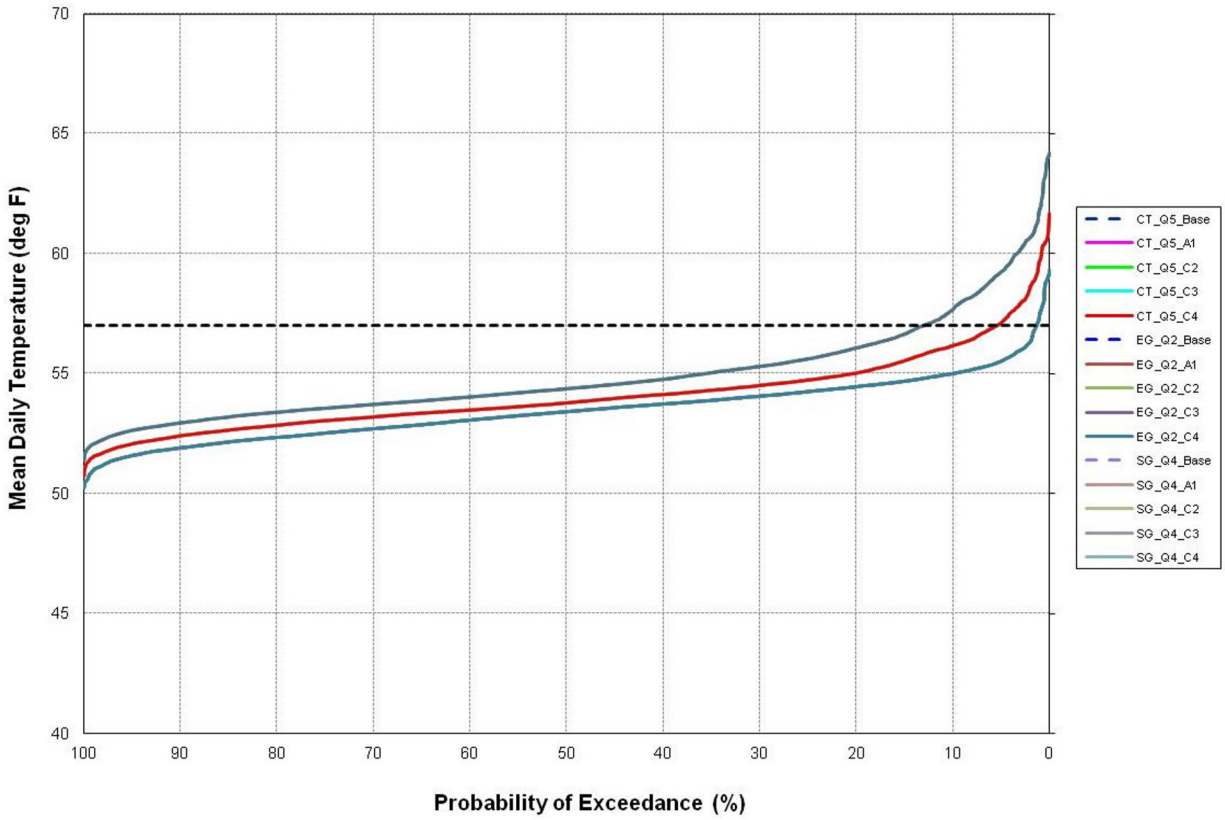

Figure 7-174. Exceedance of Mean Daily Temperature on San Joaquin River at Lost Lake from August to November in Portfolio C

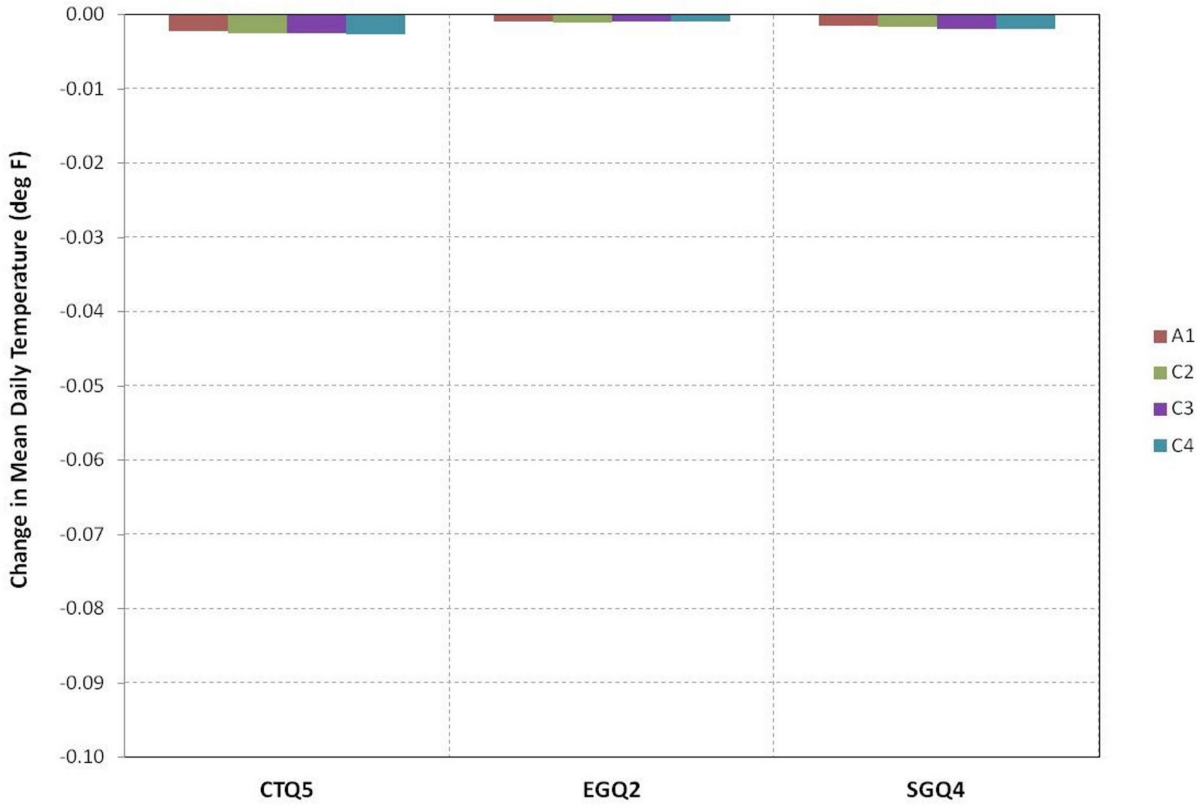

Figure 7-175. Change in Mean Daily Temperature on San Joaquin River at Lost Lake from August to November in Portfolio C

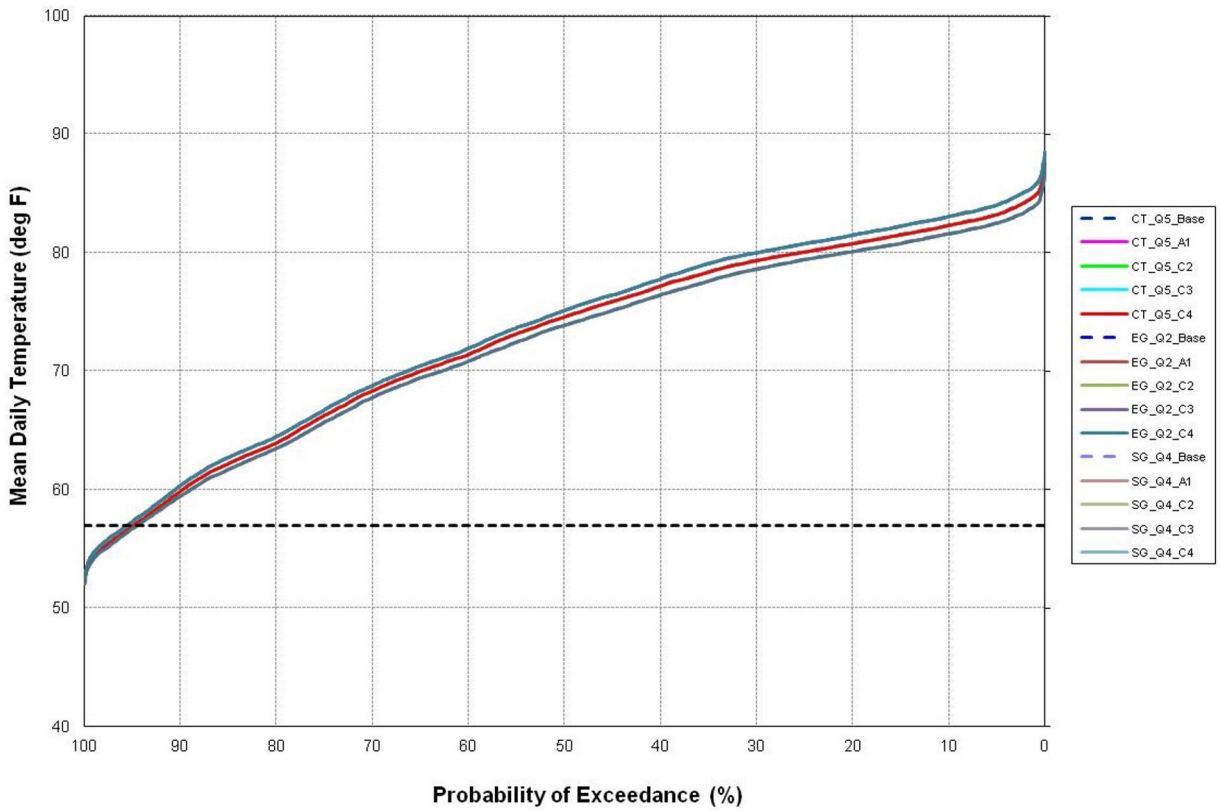

Figure 7-176. Exceedance of Mean Daily Temperature on San Joaquin River at Gravelly Ford from August to November in Portfolio C

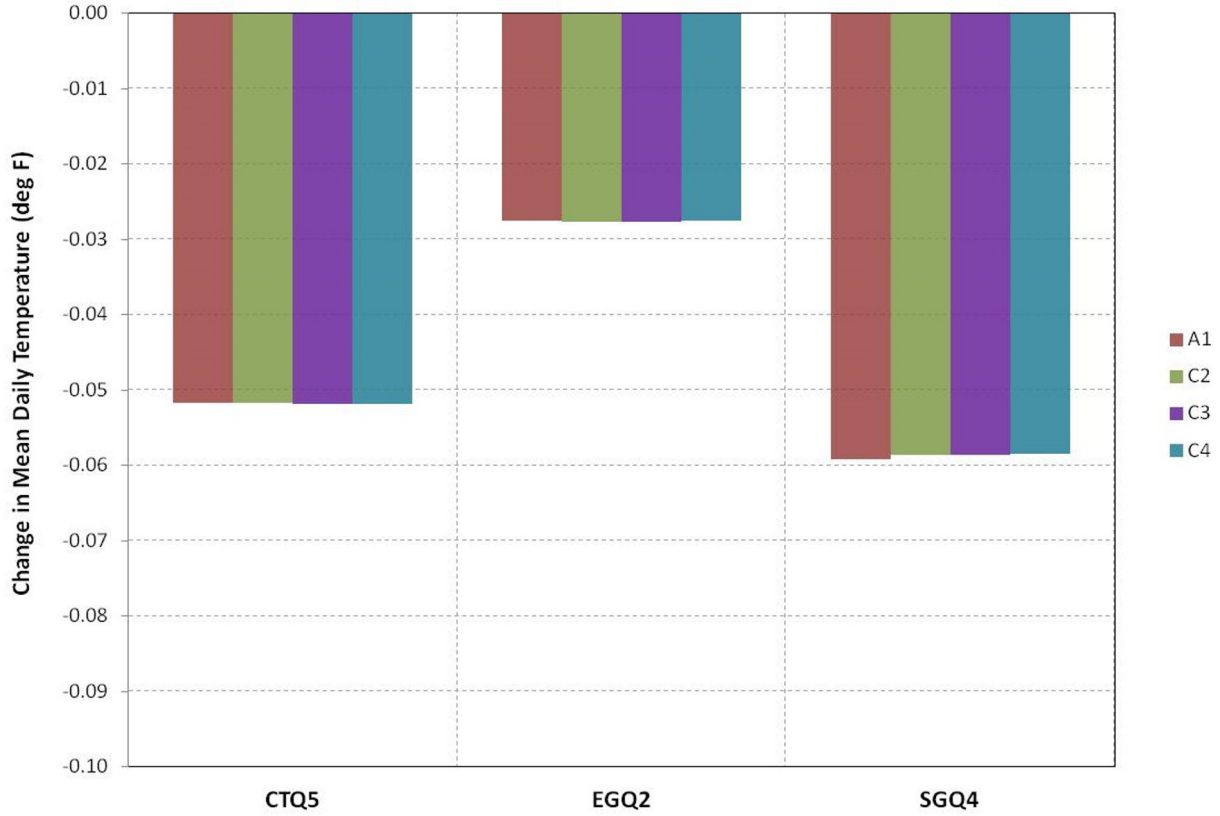

Figure 7-177. Change in Mean Daily Temperature on San Joaquin River at Gravelly Ford from August to November in Portfolio C

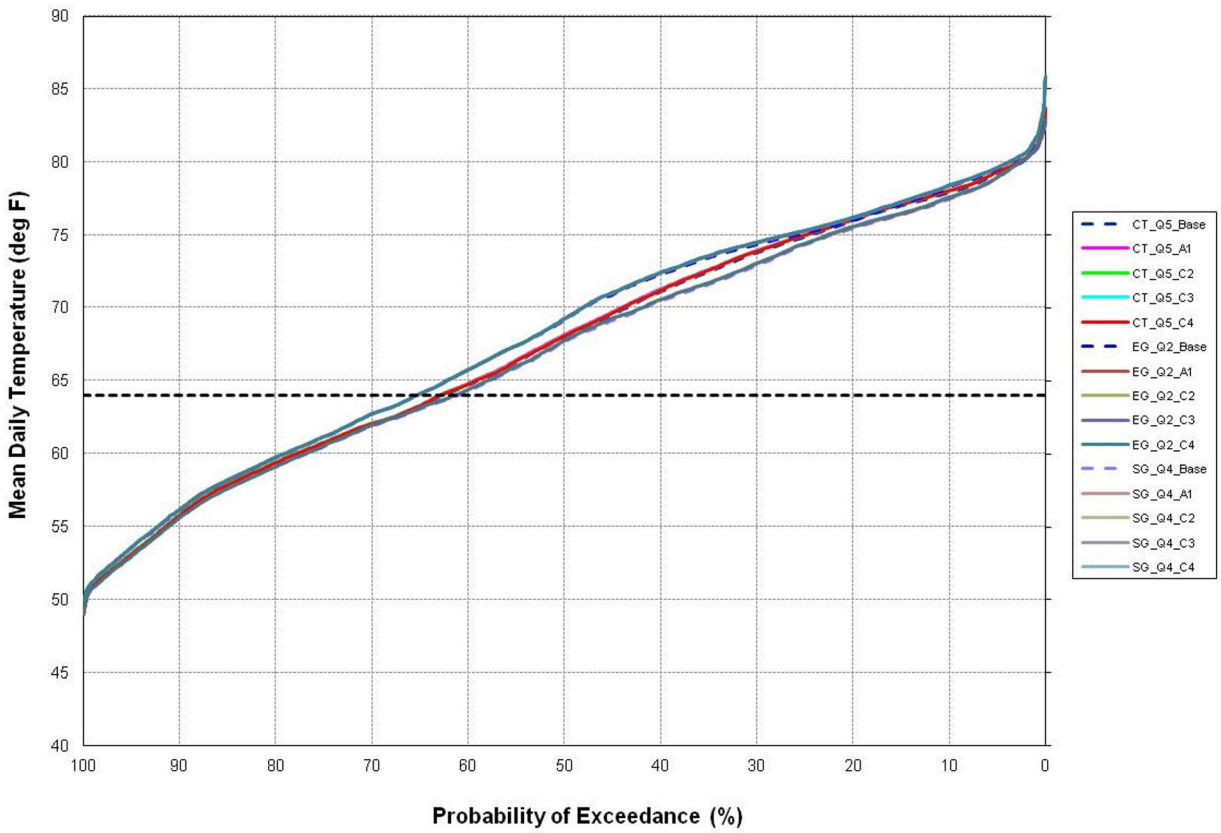

Figure 7-178. Exceedance of Mean Daily Temperature on San Joaquin River at Vernalis from August to November in Portfolio C

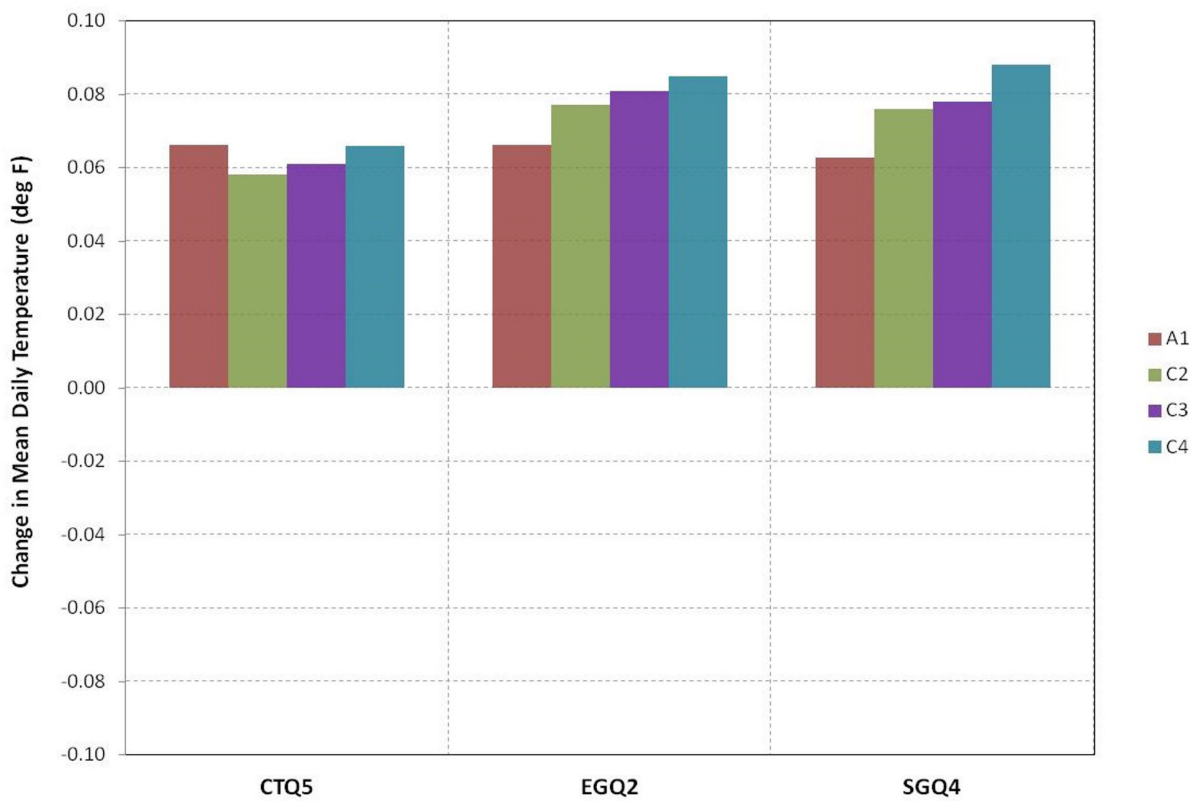

Figure 7-179. Change in Mean Daily Temperature on San Joaquin River at Vernalis from August to November in Portfolio C

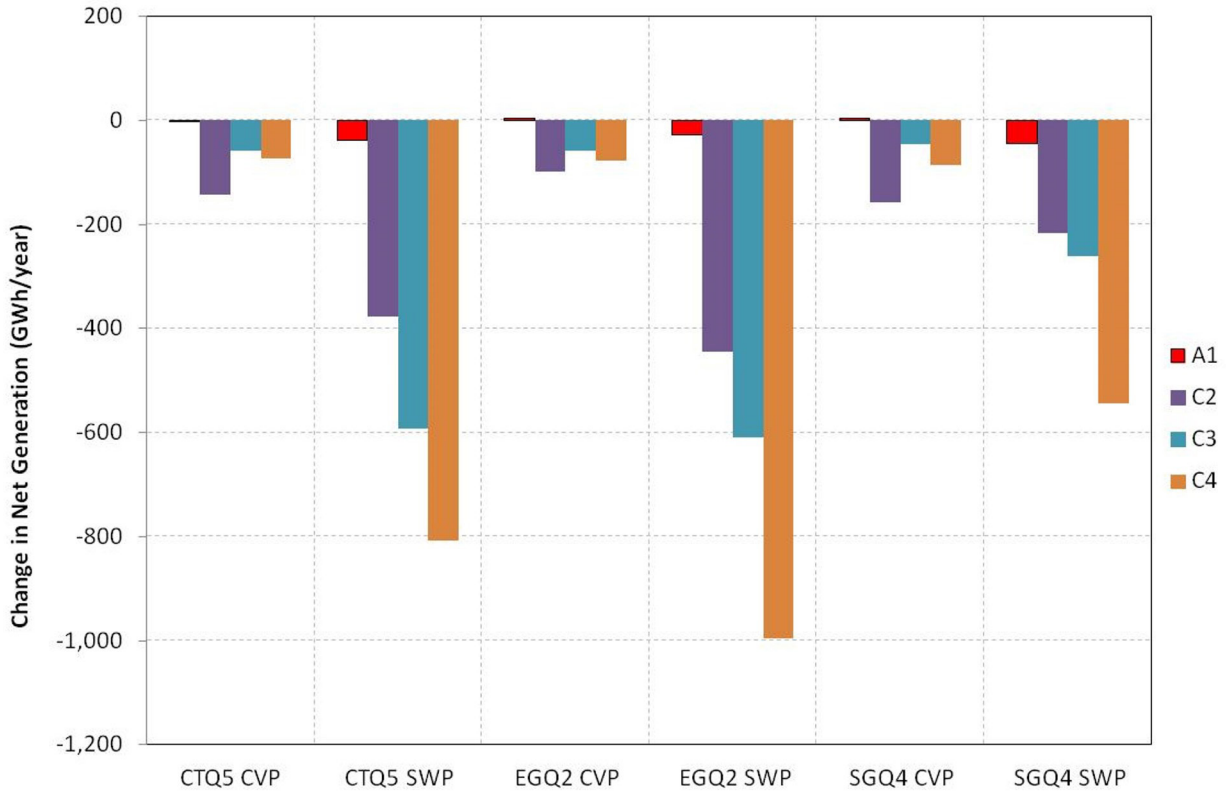

Figure 7-180. Change in Average Annual Net Energy Generation for the CVP and SWP Systems in Portfolio C

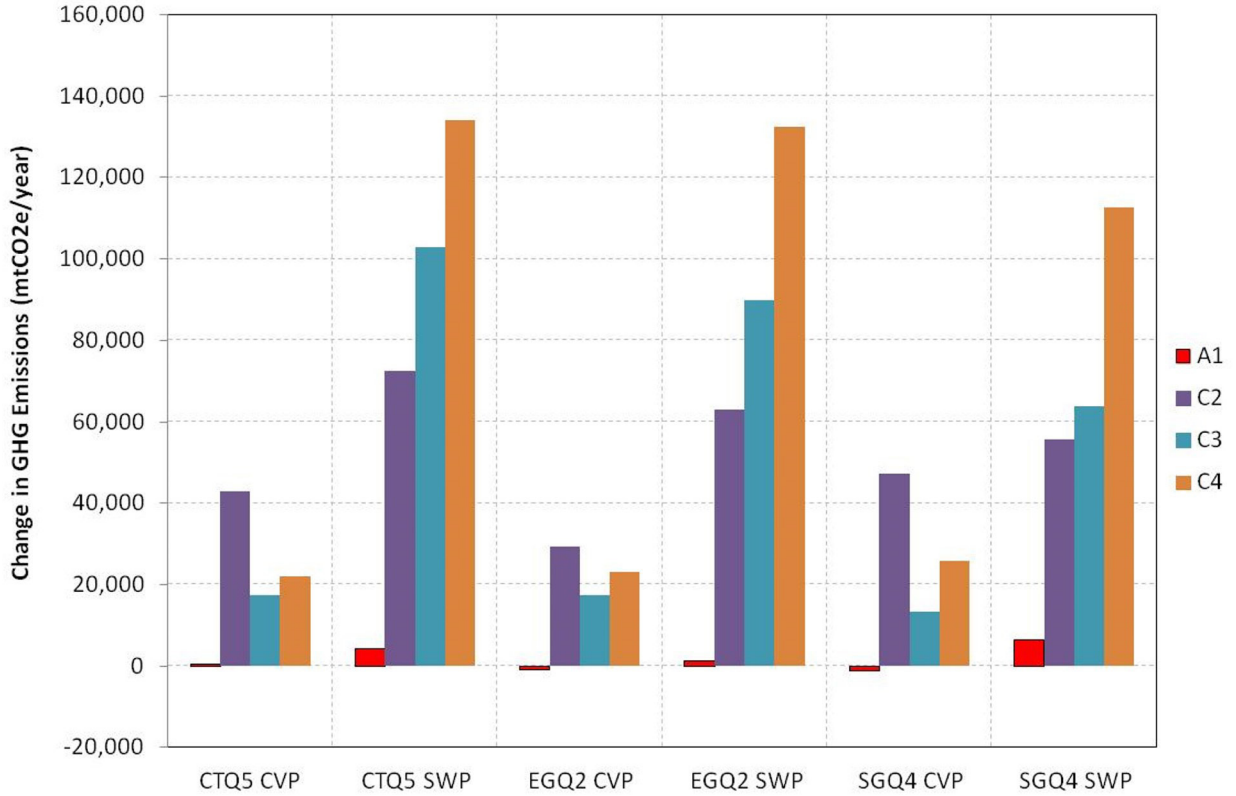

Figure 7-181. Change in Average Annual Greenhouse Gas Emissions for the CVP and SWP Systems in Portfolio C

with Portfolio C2 actions. Both of these changes were reduced with C3 and C4 actions because the implementation of Enlarged Shasta resulted in increased CVP hydropower generation.

7.4 Portfolio D: Delta Conveyance and South-of-Delta Storage

Portfolio D, which focused on Delta conveyance and South-of-Delta storage, was designed to investigate potential improvements in water supply reliability by combining modest agricultural and urban conservation with Delta conveyance and additional South-of-Delta storage. Detailed descriptions of these actions are provided in Section 6.3. Portfolio D included simulation Suites A1 and C2 as the first and second action steps. The addition of South-of-Delta storage was subsequently added, resulting in the following sequence of three steps:

1. Modest agricultural and urban conservation (same as A1)
2. Delta Conveyance (same as C2)
3. South-of-Delta Surface or Groundwater Storage

Table 7-4 shows the assumptions that are included in each simulation suite.

7.4.1 Supplies and Demands in CVP Divisions

Figure 7-182 shows the average reduction in unmet demand in the CVP Service Area with each of the Portfolio D simulation suites for each socioeconomic scenario. Figures 7-183 through 7-191 show the same information for each of the CVP Divisions. As discussed in Portfolios A and C above, the reduction in unmet demand in the CVP Service Area ranged from 297 to 814 TAF/year (8–16 percent of Baseline unmet demands) with the A1 modest demand-reduction actions and decreased further with the C2 Delta conveyance action to 364 to 947 TAF/year (9–19 percent of Baseline unmet demands) across the range of all scenarios. There were further reductions in unmet demand up to 383 to 1,024 TAF/year (10–19 percent of Baseline unmet demands) with the addition of the South-of-Delta storage action in D3.

Figures 7-192 through 7-194 show the annual time series of groundwater, surface water, and local project supplies, and the unmet demands for the CVP Service Area under CT-Q5, EG-Q2, SG-Q4 scenarios under Portfolio D Suite D3. This information was previously shown for Suites A1 and C2 in the discussions on Portfolios A and C above. Unmet demands in A1 ranged from 800 to 10,900 TAF/year in CT-Q5, from 800 to 14,600 TAF/year in EG-Q2, and from 700 to 7,000 TAF/year in SG-Q4. Unmet demands in C2 ranged from 800 to 10,800 TAF/year in CT-Q5, from 800 to 14,500 TAF/year in EG-Q2, and from 700 to 6,700 TAF/year in SG-Q4. Suite D3 showed additional reductions in unmet demand relative to C2 due to the increased surface water deliveries that resulted from new South-of-Delta storage

Table 7-4. Simulation Suites and Assumptions Included in Portfolio D

	Simulation Suite A1	Simulation Suite C2	Simulation Suite D3
Baseline Assumptions	x	x	x
Local Actions			
Modest Ag and M&I Conservation	x	x	x
Municipal Recycling and Desalination			
Aggressive Ag and M&I Conservation			
Systemwide Actions			
Delta Conveyance		x	x
Shasta Lake Enlargement			
North-of-Delta Offstream Storage			
South-of-Delta SW or GW Storage			x
Enhanced Environmental Flows			

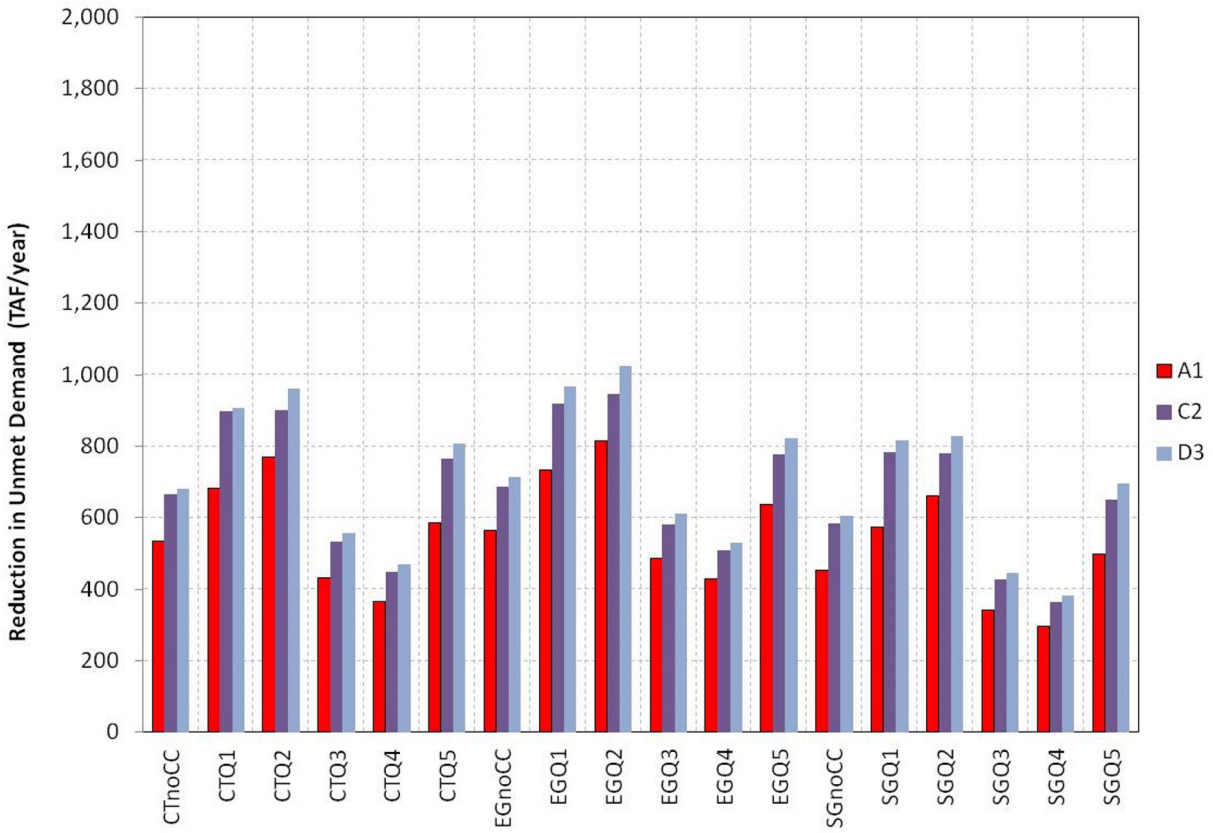

Figure 7-182. Average Annual Reduction in Unmet Demand in the CVP Service Area for Portfolio D in Each Scenario

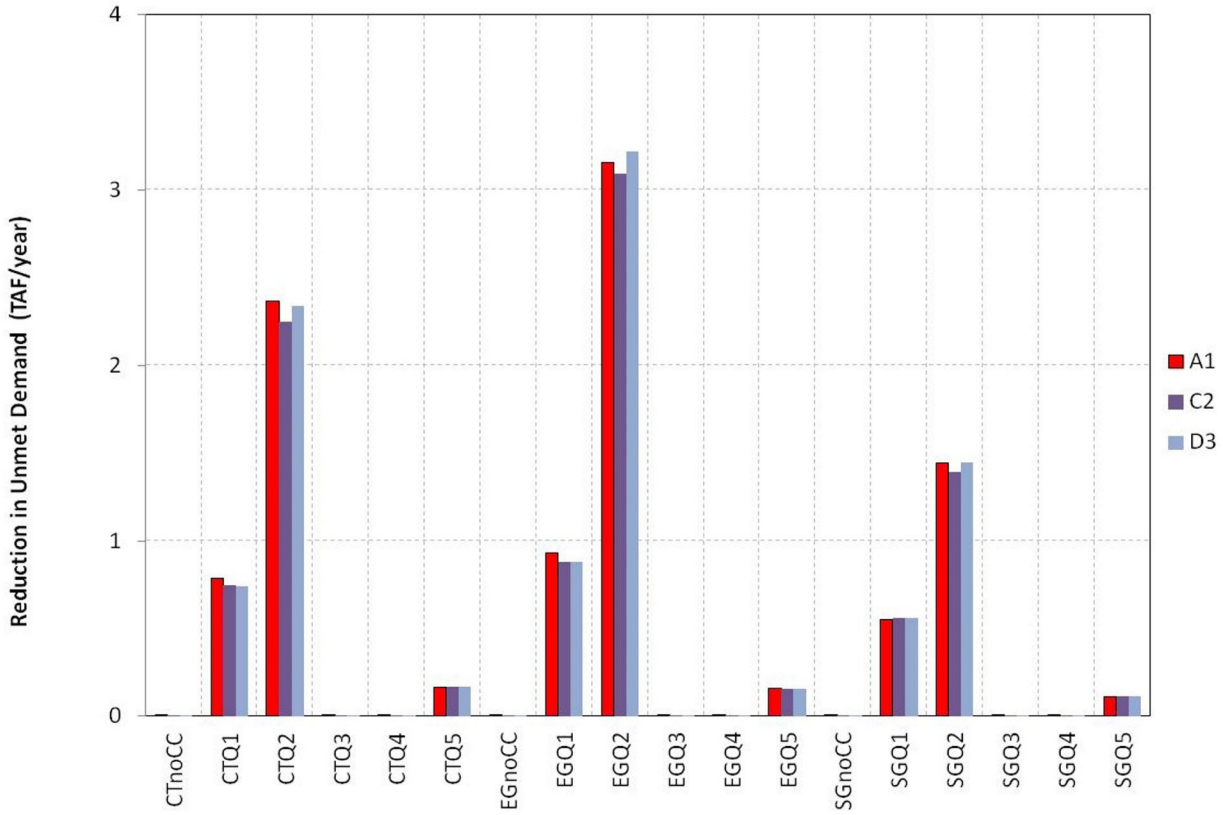

Figure 7-183. Average Annual Reduction in Unmet Demand in the American River Division for Portfolio D in Each Scenario

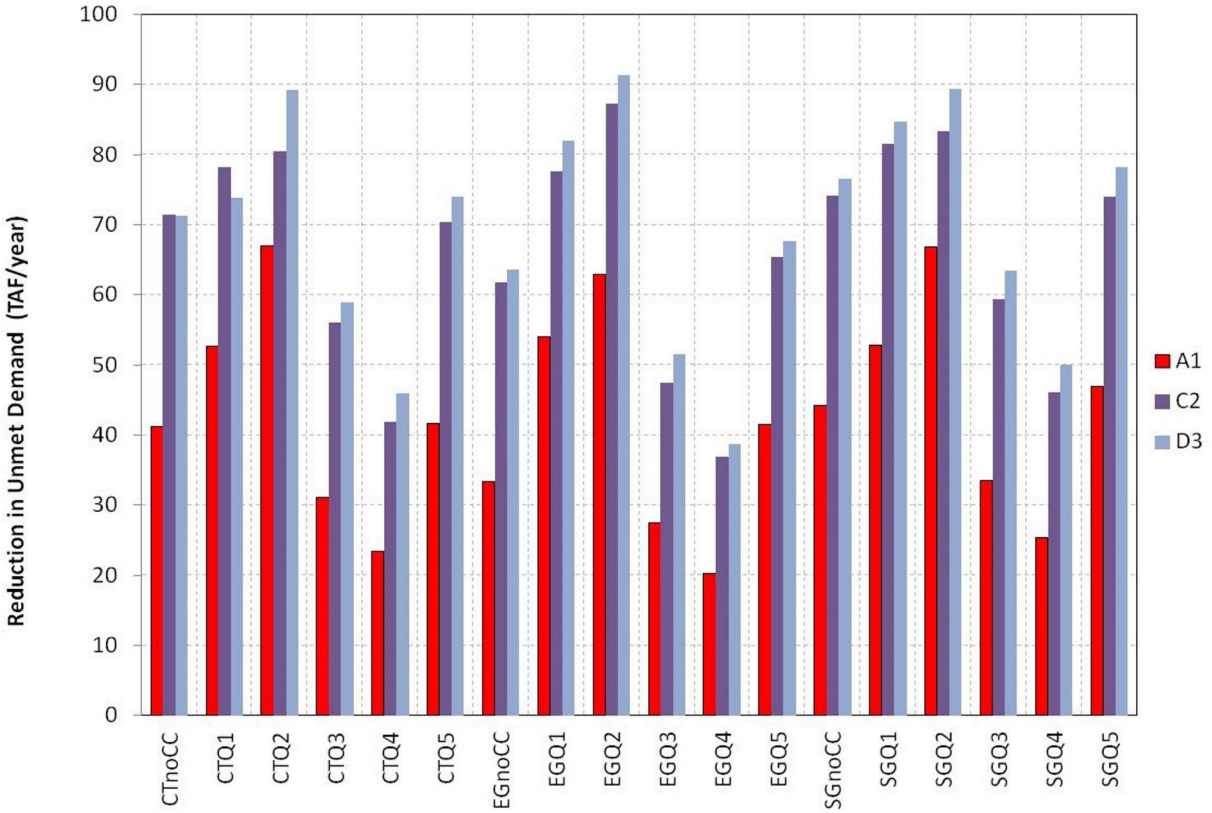

Figure 7-184. Average Annual Reduction in Unmet Demand in the Delta Division for Portfolio D in Each Scenario

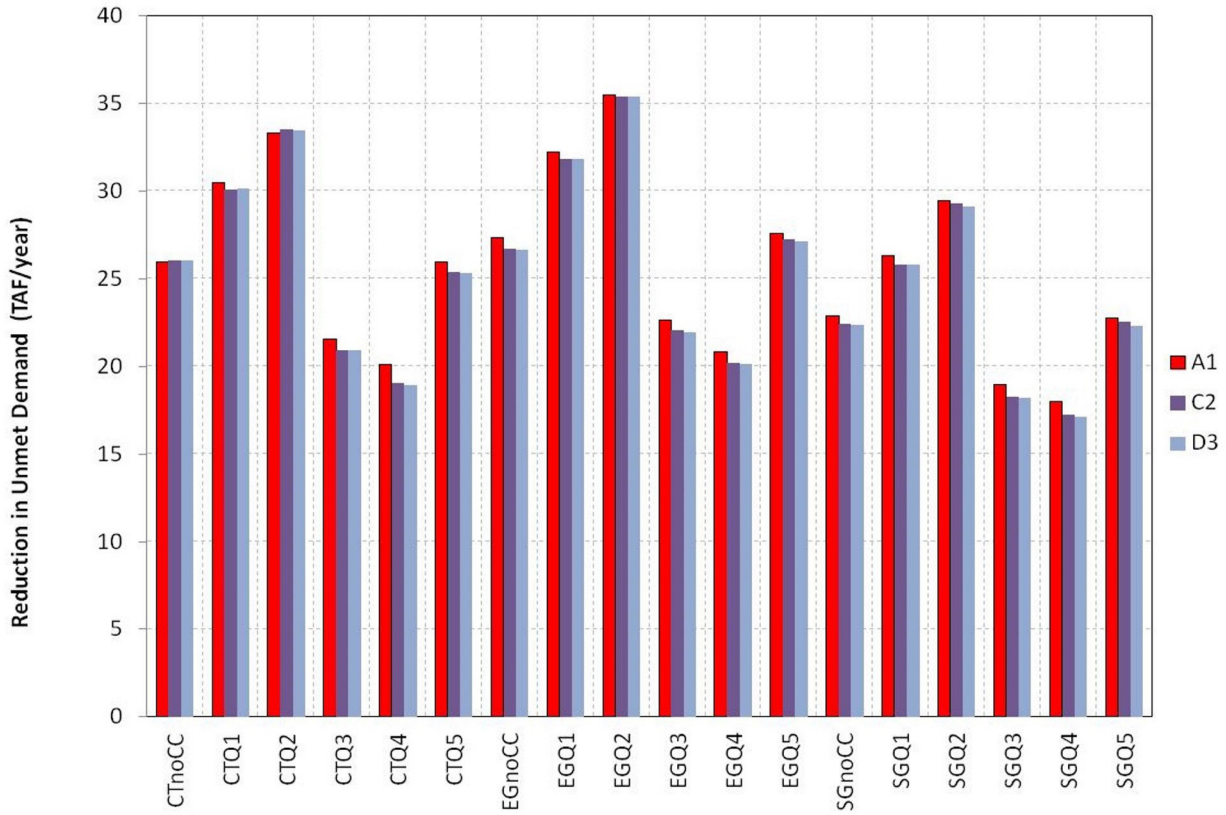

Figure 7-185. Average Annual Reduction in Unmet Demand in the East Side Division for Portfolio D in Each Scenario

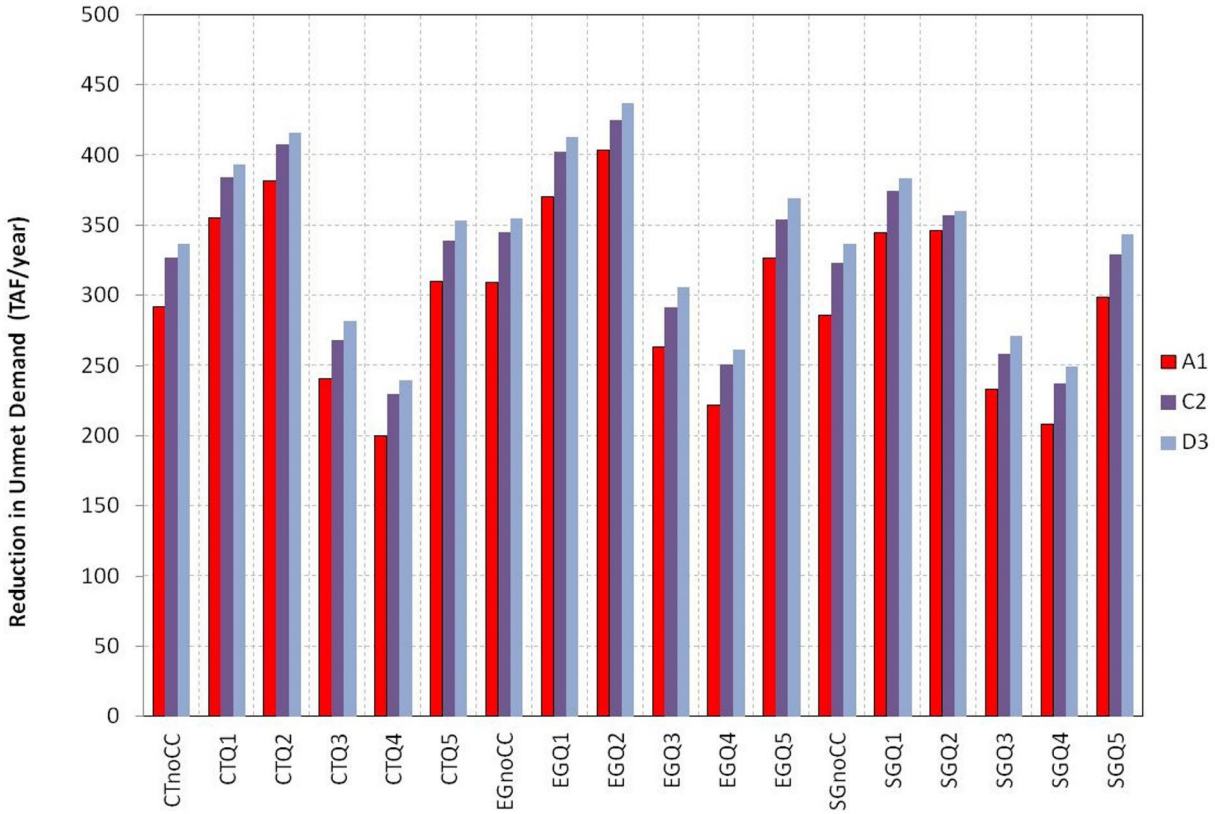

Figure 7-186. Average Annual Reduction in Unmet Demand in the Friant Division for Portfolio D in Each Scenario

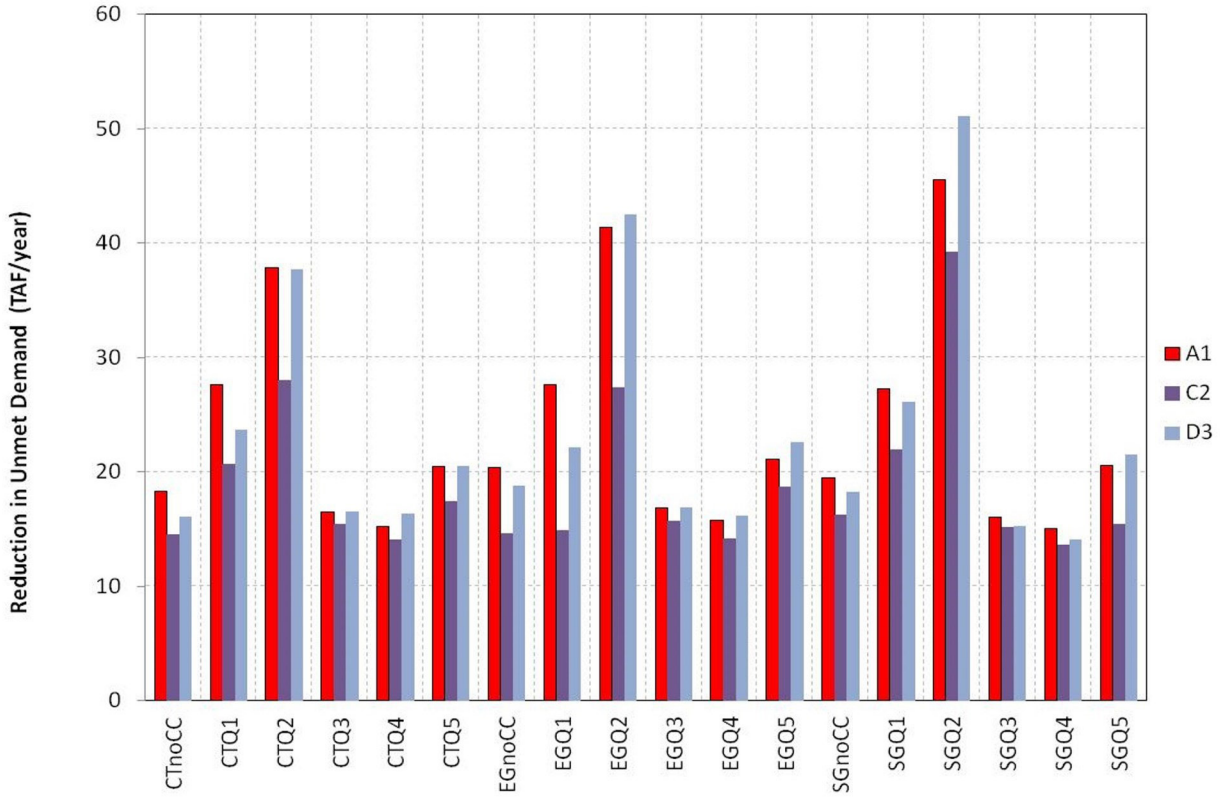

Figure 7-187. Average Annual Reduction in Unmet Demand in the Sacramento River Division for Portfolio D in Each Scenario

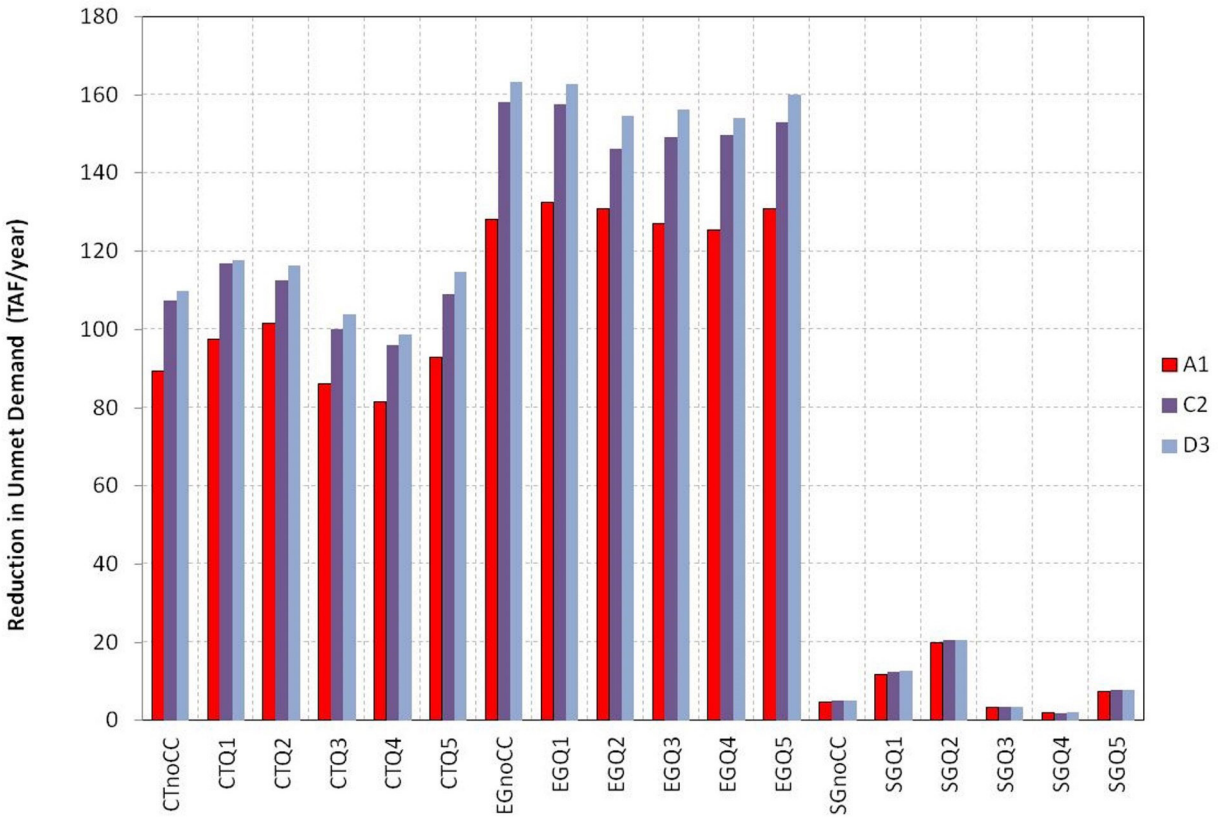

Figure 7-188. Average Annual Reduction in Unmet Demand in the San Felipe Division for Portfolio D in Each Scenario

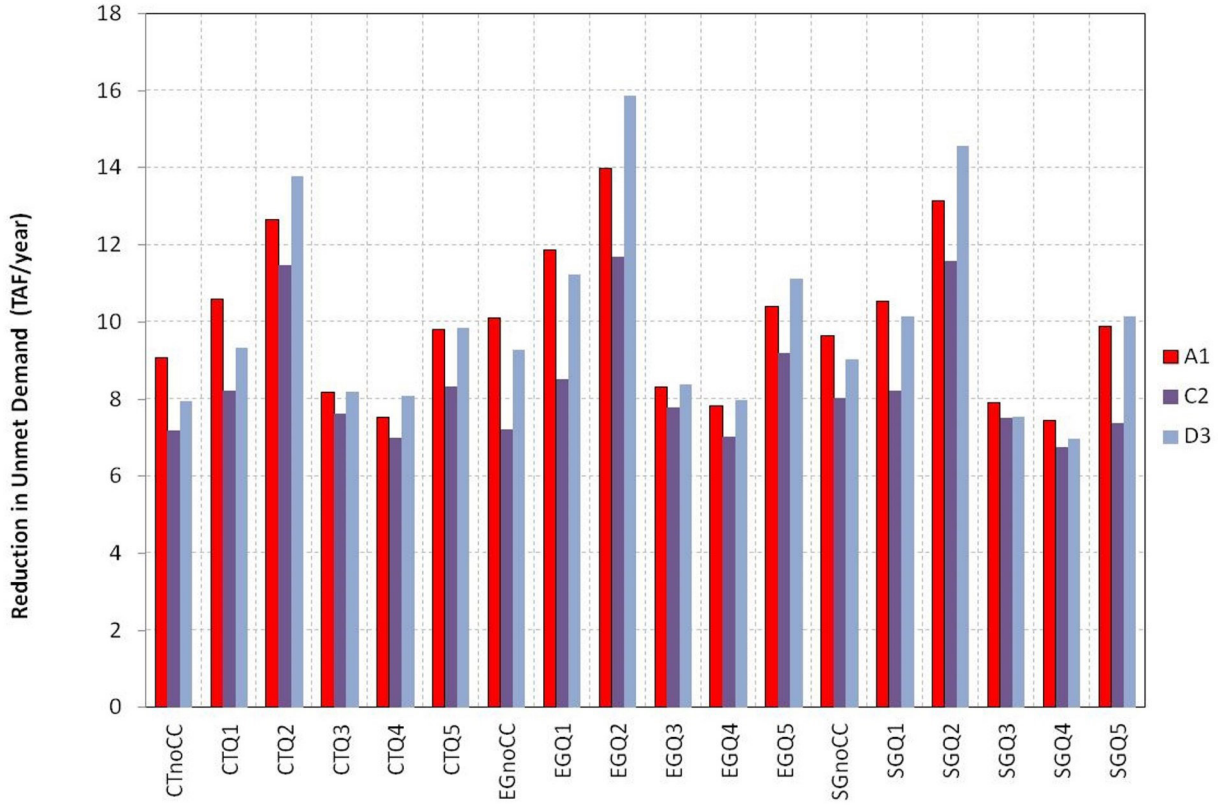

Figure 7-189. Average Annual Reduction in Unmet Demand in the Shasta Division for Portfolio D in Each Scenario

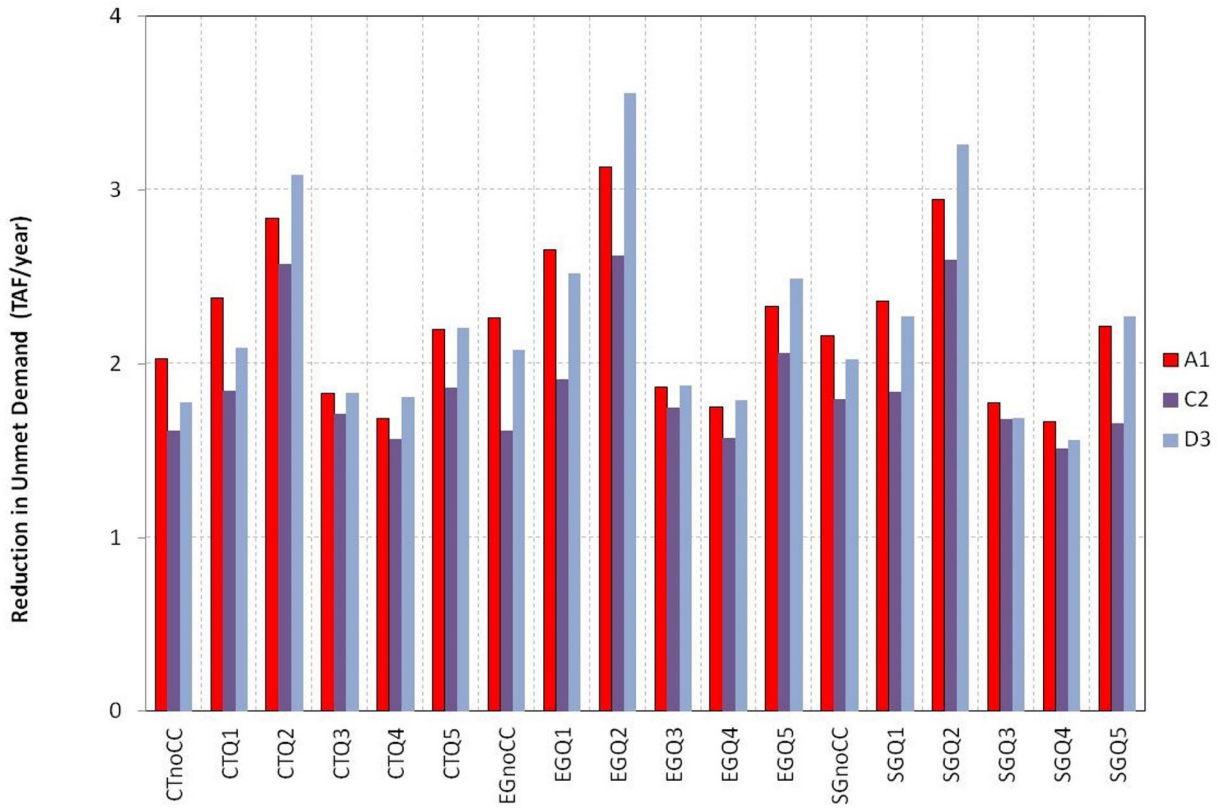

Figure 7-190. Average Annual Reduction in Unmet Demand in the Trinity Division for Portfolio D in Each Scenario

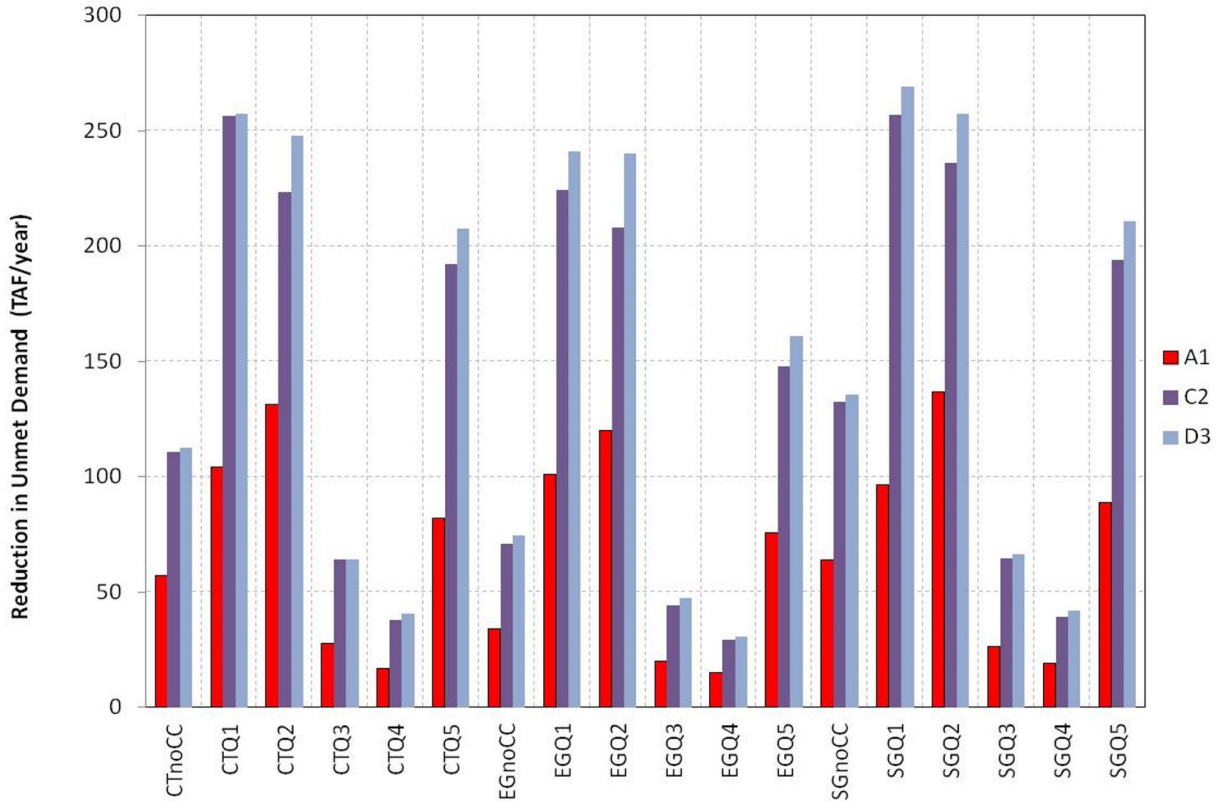

Figure 7-191. Average Annual Reduction in Unmet Demand in the West San Joaquin Division for Portfolio D in Each Scenario

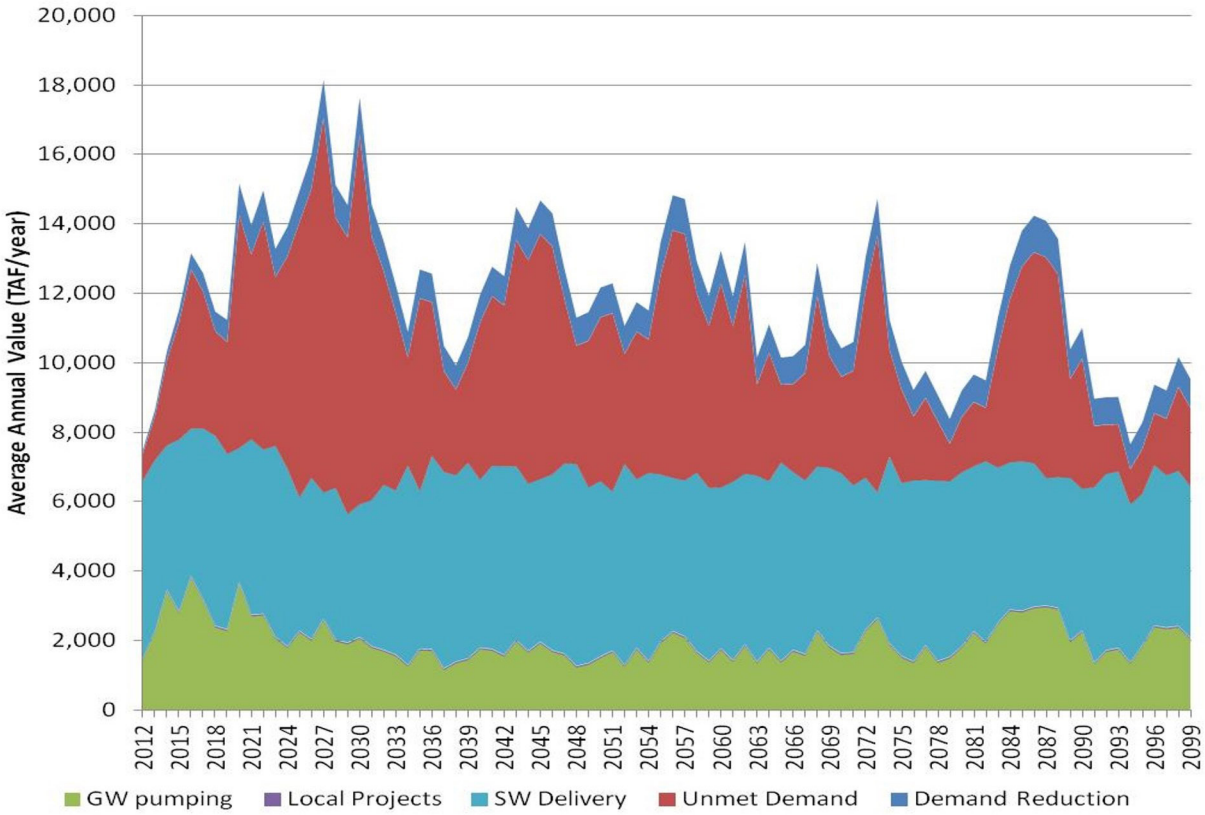

Figure 7-192. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite D3 in the CT-Q5 Scenario

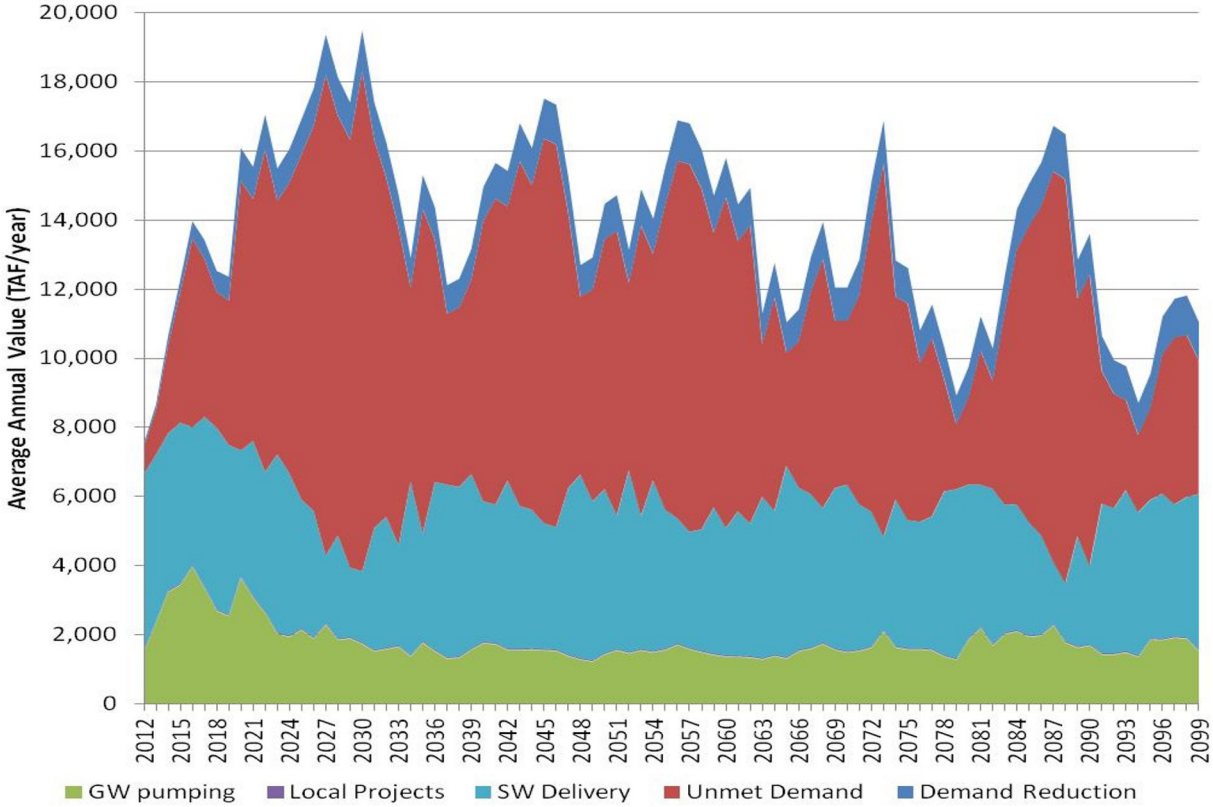

Figure 7-193. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite D3 in the EG-Q2 Scenario

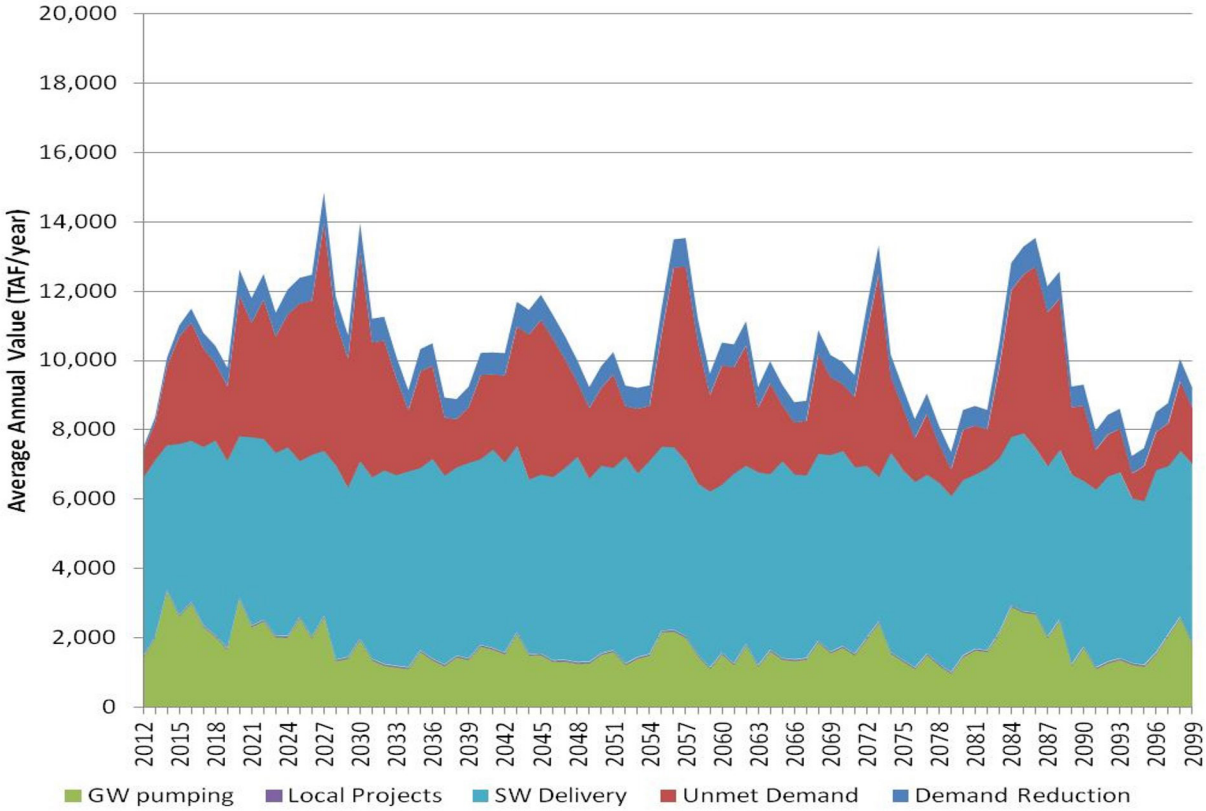

Figure 7-194. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite D3 in the SG-Q4 Scenario

added in addition to new Delta conveyance. Unmet demands in D3 ranged from 800 to 10,800 TAF/year in CT Q5, from 800 to 14,500 TAF/year in EG-Q2, and from 700 to 6,600 TAF/year in SG-Q4.

7.4.2 CVP and SWP System Operations

The following sections describe the results for the Portfolio D simulation suites.

7.4.2.1 CVP and SWP Project Storage

Figures 7-195 through 7-204 show the exceedance plots of storage in the Baseline and each of the Portfolio D simulation suites at the end of May and at the end of September in Shasta, Folsom, Oroville, New Melones, and Millerton Lakes under the CT-Q5, EG-Q2, and SG-Q4 socioeconomic scenarios. Figures 7-205 through 7-208 show the same information for CVP and SWP South-of-Delta storage (including the existing San Luis Reservoir and proposed additional storage). The Shasta, Folsom, New Melones, and Millerton storage results were similar in all Portfolio D simulation suites. As noted in the discussion of Portfolio C above, there was a moderate reduction in storage at Oroville in C2 as compared to the Baseline and A1, but Oroville storage was increased with the addition of South-of-Delta storage in Suite D3. Finally, the addition of additional South-of-Delta storage in D3 resulted in a significant increase in total South-of-Delta storage.

7.4.2.2 Delta Exports and Delta Outflow

Figures 7-209 through 7-214 show the annual exceedance plots of pumping at Banks PP and Jones PP, and of total Delta exports under scenarios CT-Q5, EG Q2, and SG-Q4, as well as changes in annual average flows relative to the Baseline at these locations for all 18 socioeconomic-climate scenarios. Figures 7-215 and 7-216 show the same information for Delta outflow. As noted in the discussion on Portfolio C above, total average annual Delta exports increased significantly and Delta outflows decreased significantly in C2 as compared to the Baseline and A1 suites. There were additional increases in exports and reductions in Delta outflows with the addition of South-of-Delta storage in D3 because additional water was moved through the pumps to fill the new storage facility.

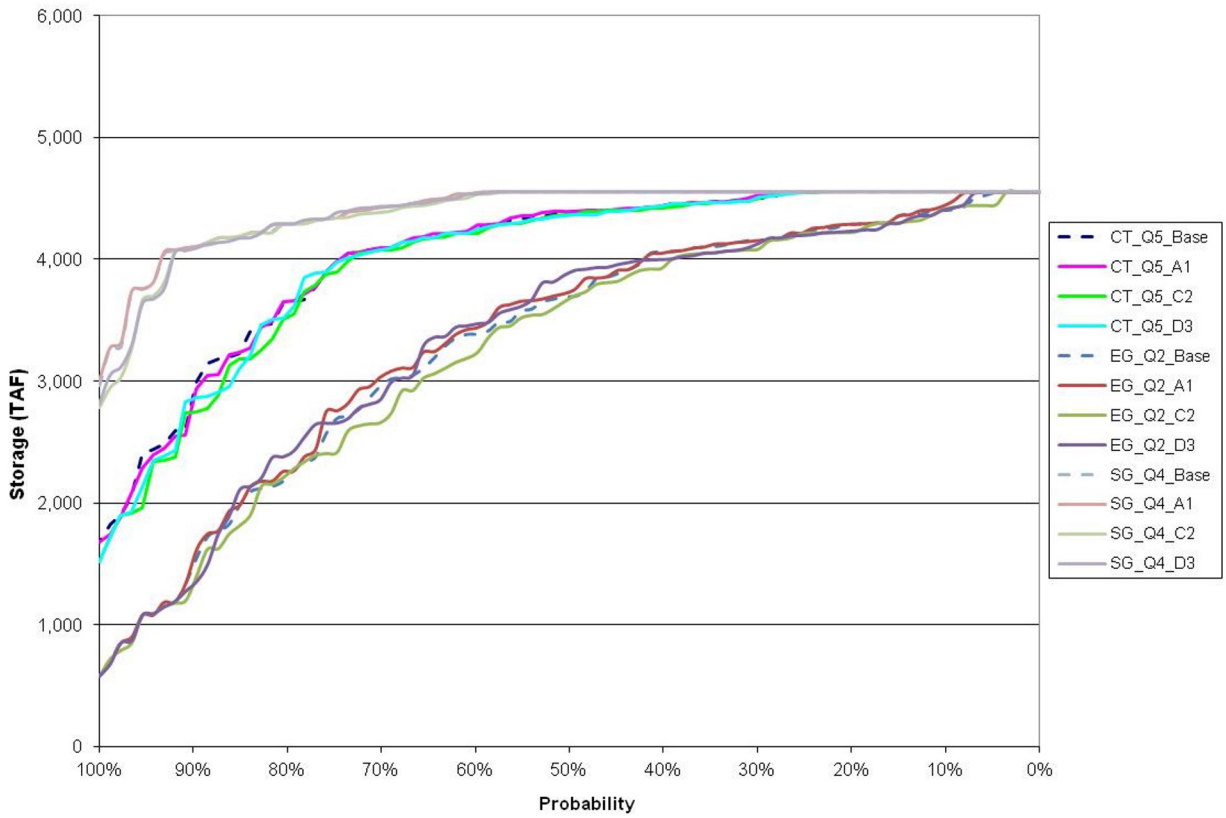

Figure 7-195. Exceedance of Lake Shasta End-of-May Storage in Portfolio D

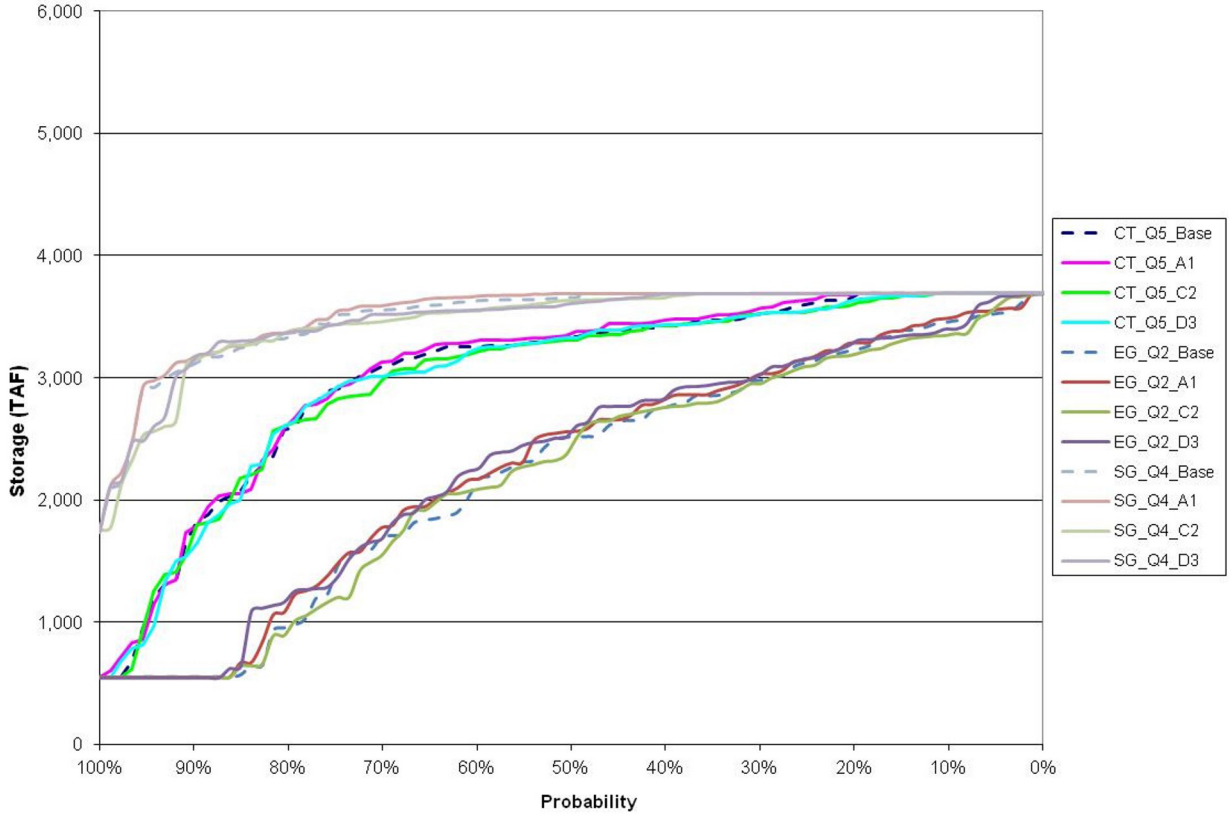

Figure 7-196. Exceedance of Lake Shasta End-of-September Storage in Portfolio D

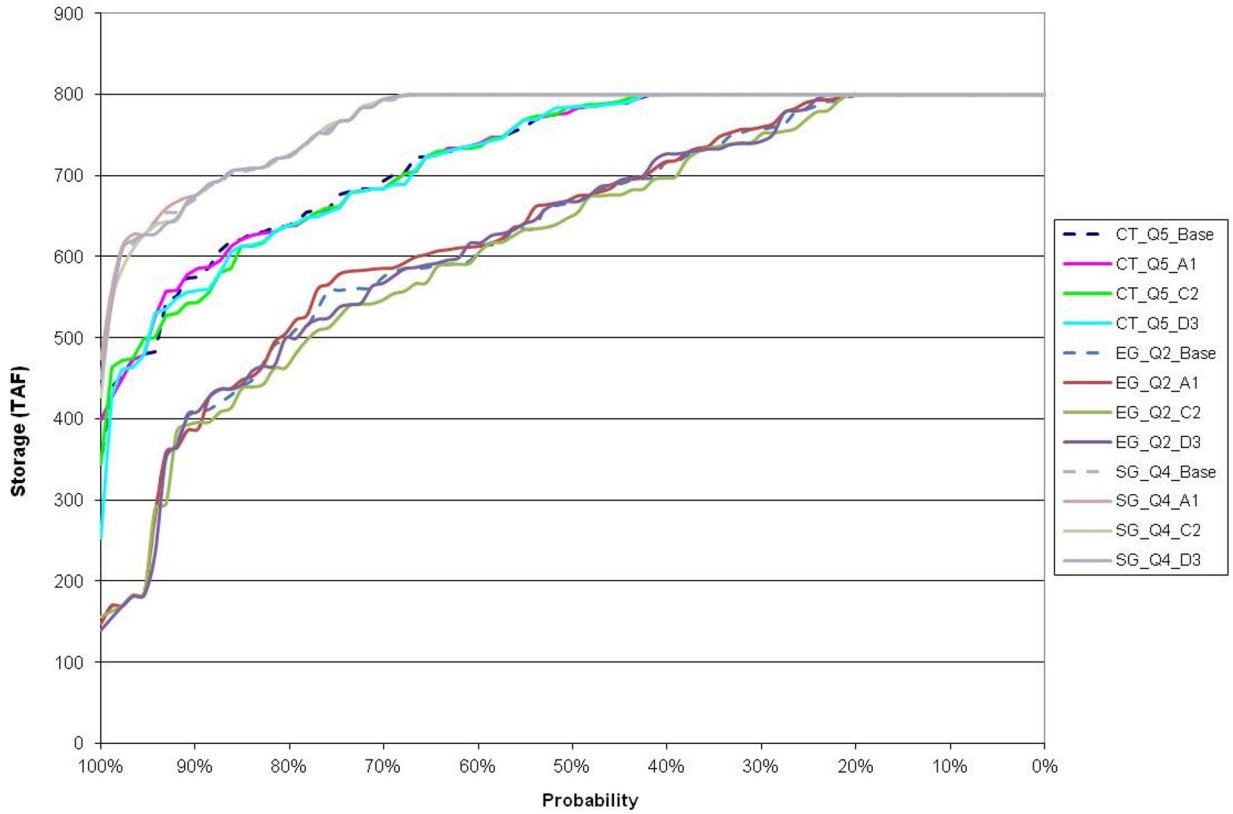

Figure 7-197. Exceedance of Folsom Lake End-of-May Storage in Portfolio D

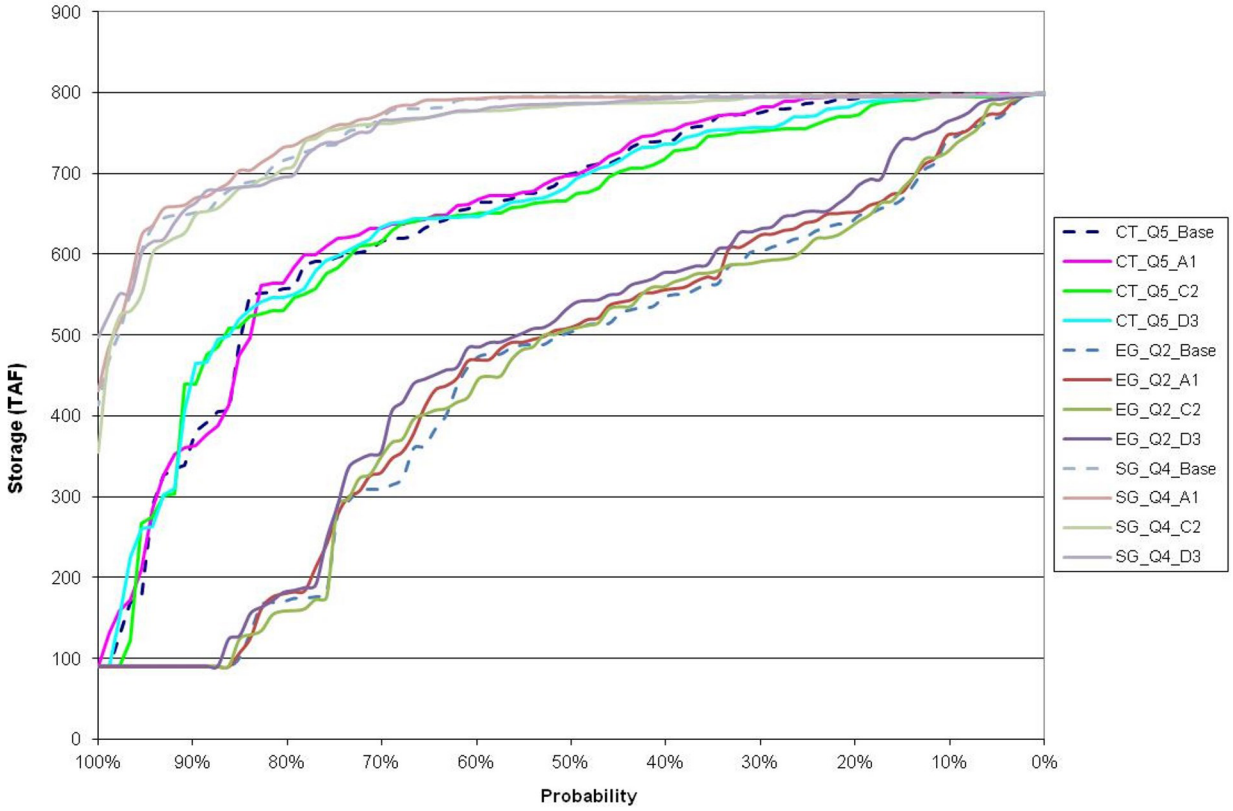

Figure 7-198. Exceedance of Folsom Lake End-of-September Storage in Portfolio D

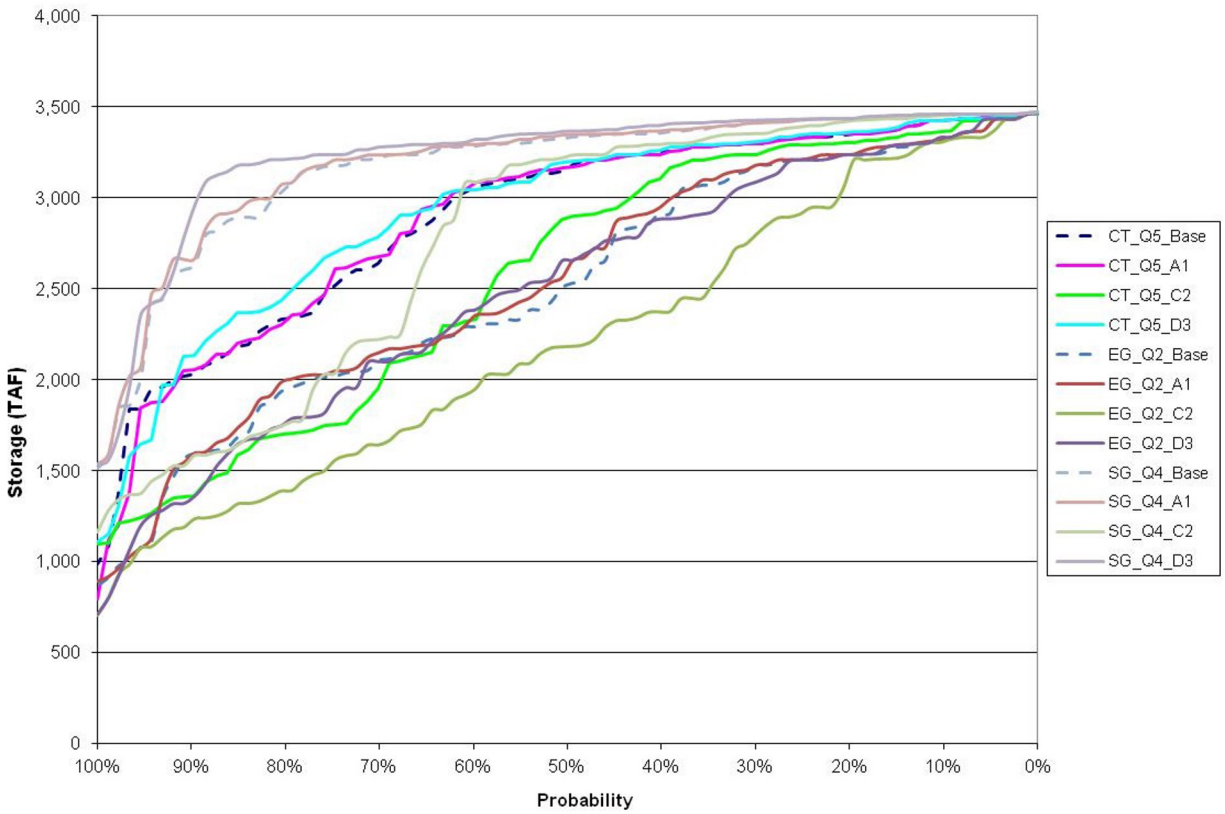

Figure 7-199. Exceedance of Lake Oroville End-of-May Storage in Portfolio D

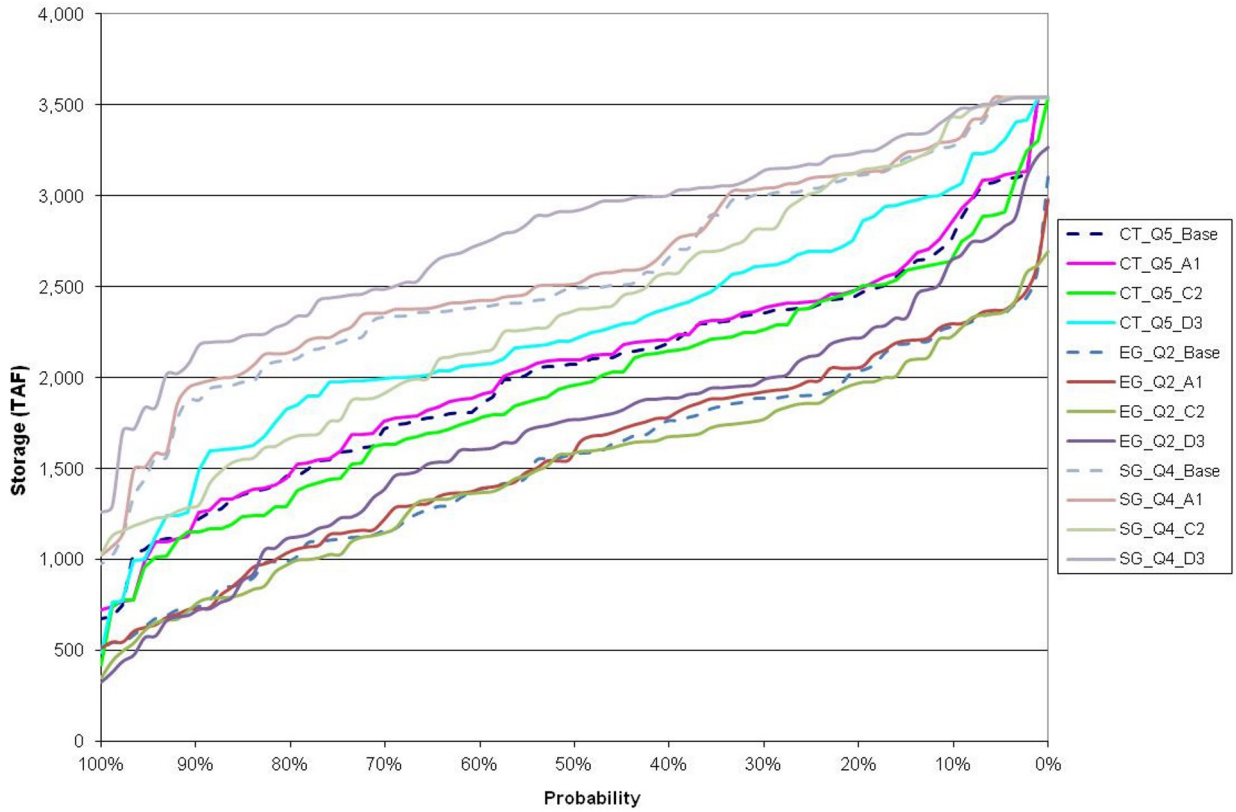

Figure 7-200. Exceedance of Lake Oroville End-of-September Storage in Portfolio D

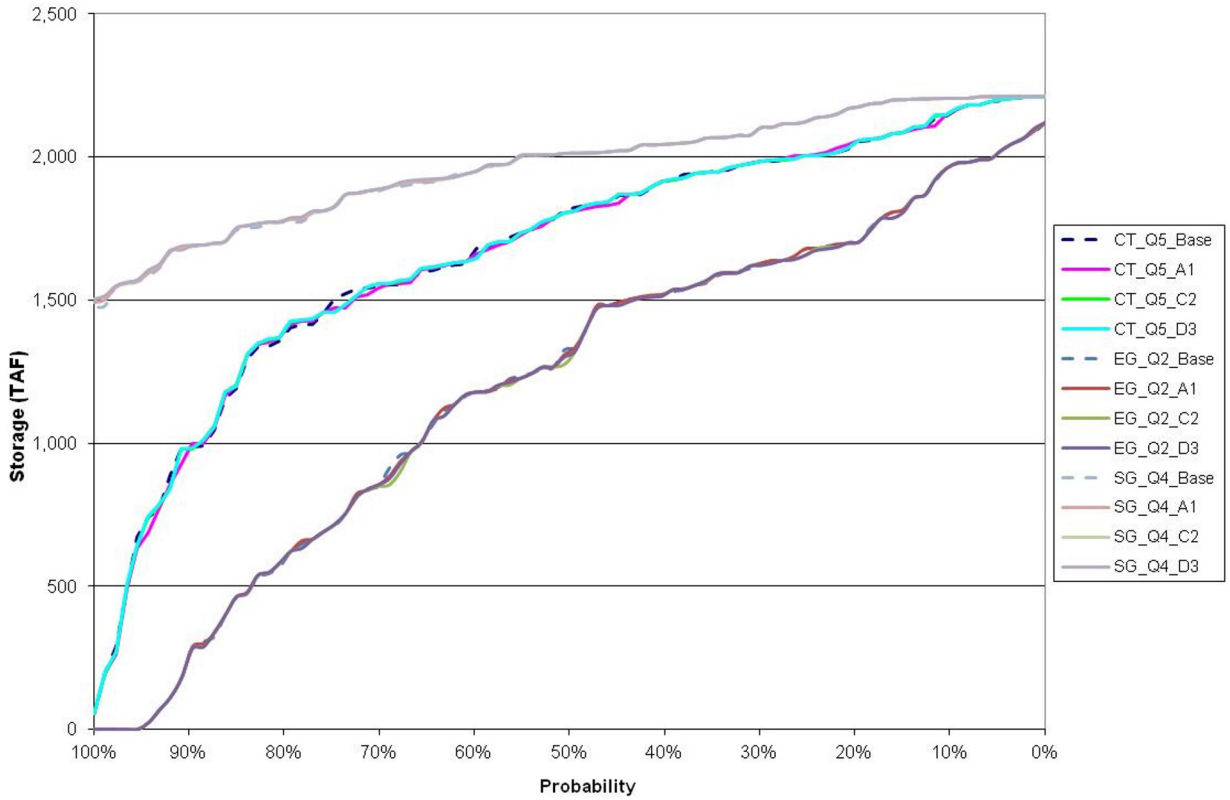

Figure 7-201. Exceedance of New Melones Reservoir End-of-May Storage in Portfolio D

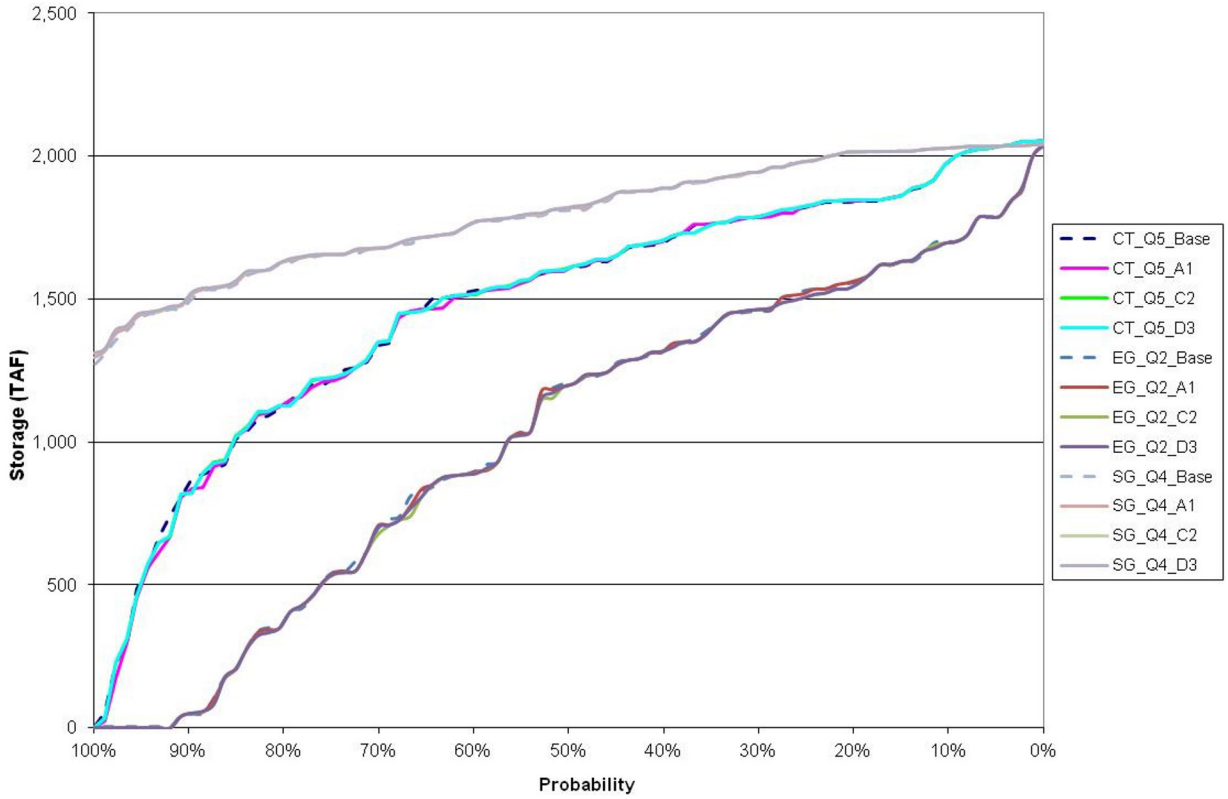

Figure 7-202. Exceedance of New Melones Reservoir End-of-September Storage in Portfolio D

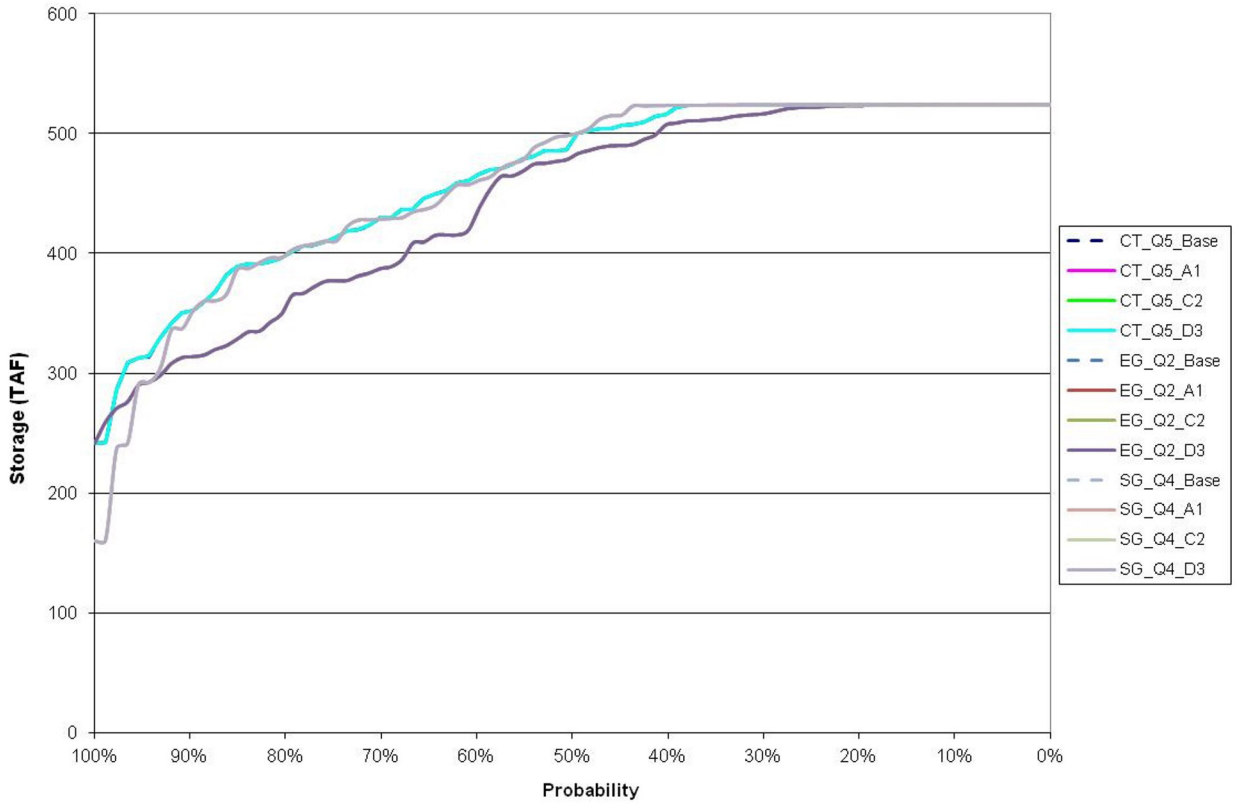

Figure 7-203. Exceedance of Millerton Lake End-of-May Storage in Portfolio D

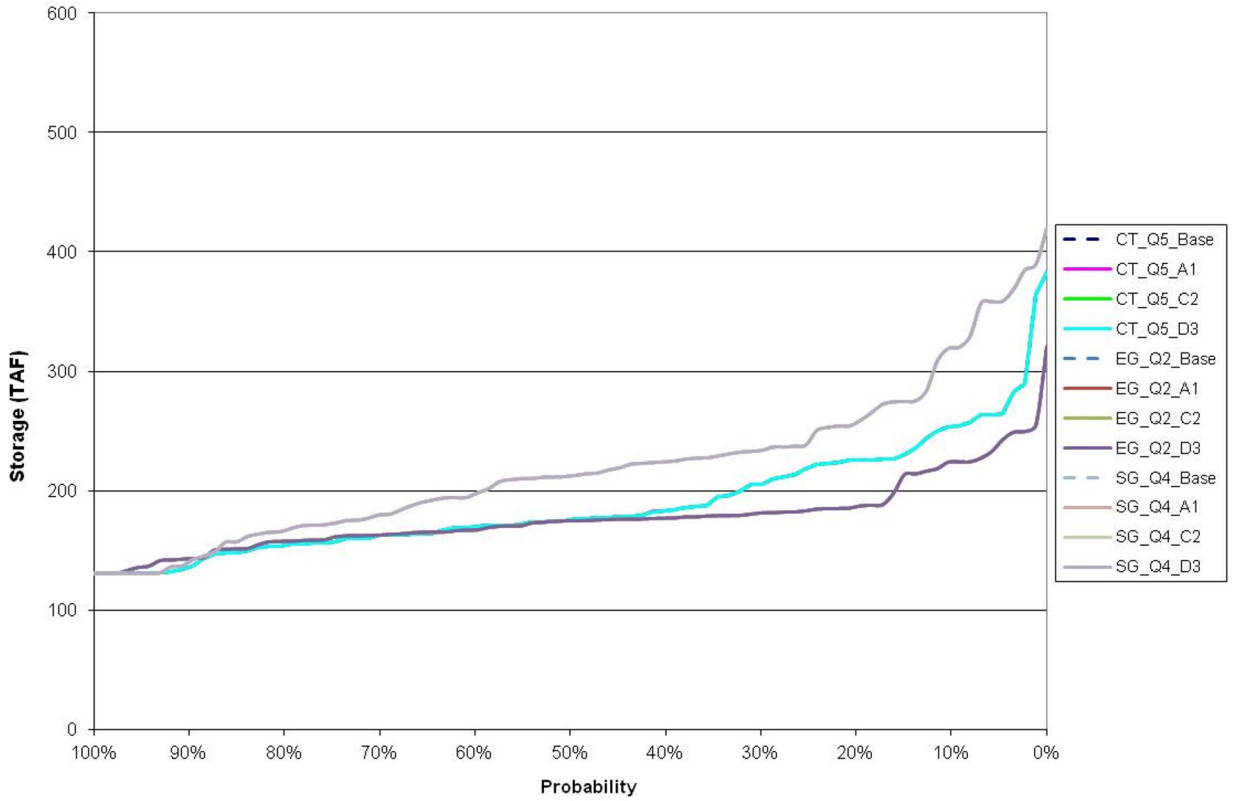

Figure 7-204. Exceedance of Millerton Lake End-of-September Storage in Portfolio D

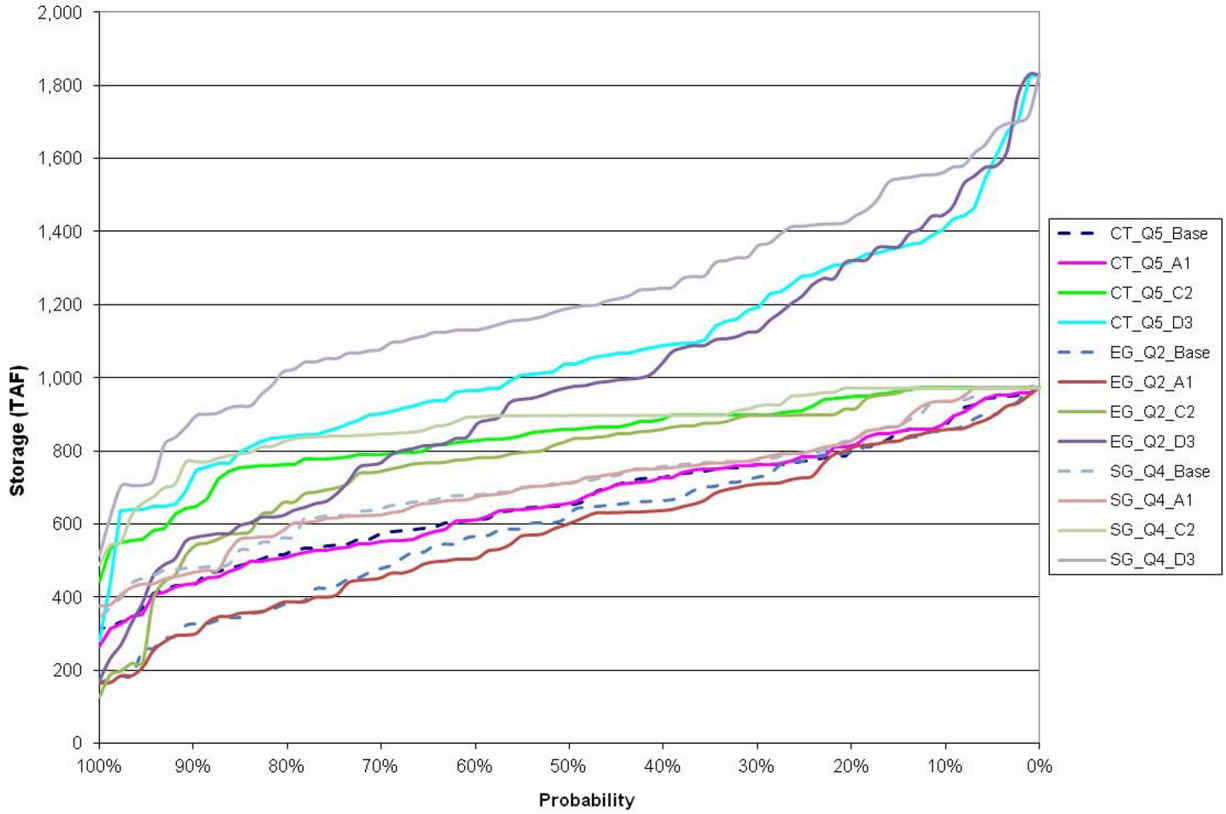

Figure 7-205. Exceedance of CVP End-of-May South-of-Delta Storage in Portfolio D

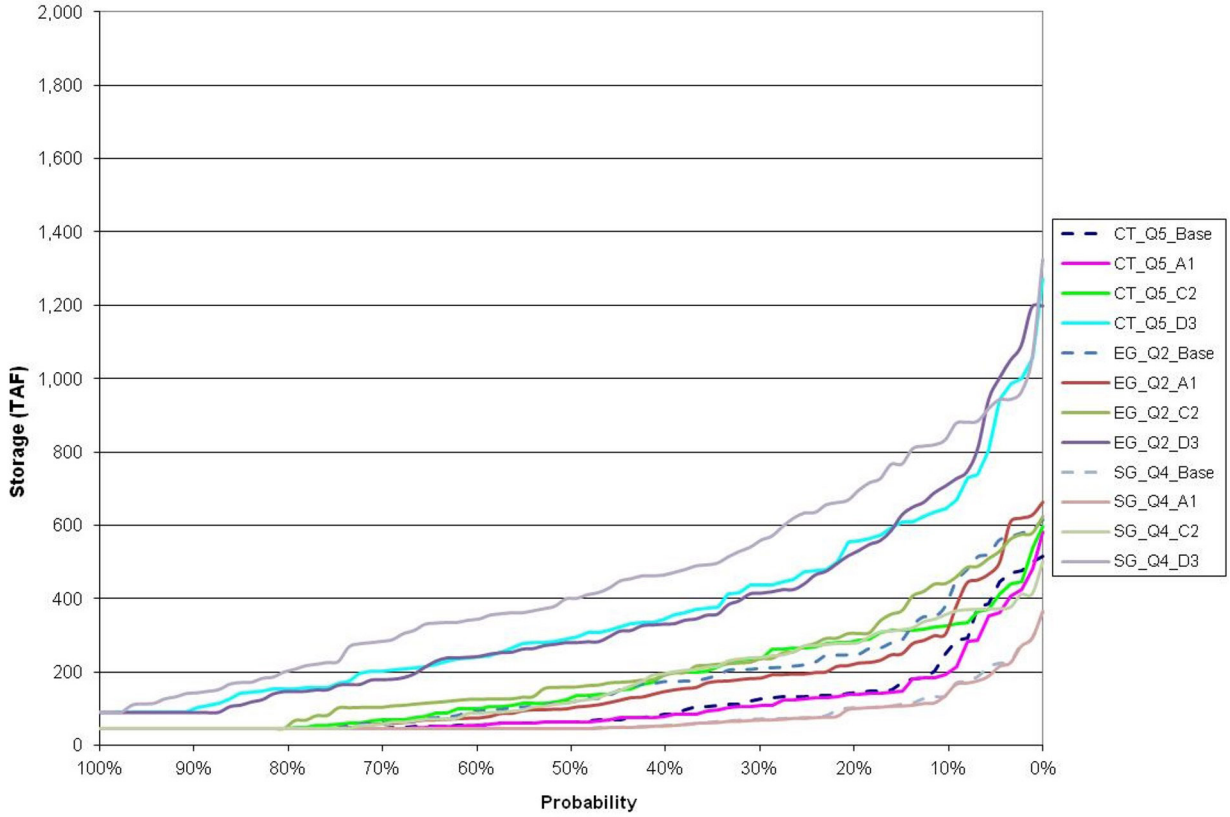

Figure 7-206. Exceedance of CVP End-of-September South-of-Delta Storage in Portfolio D

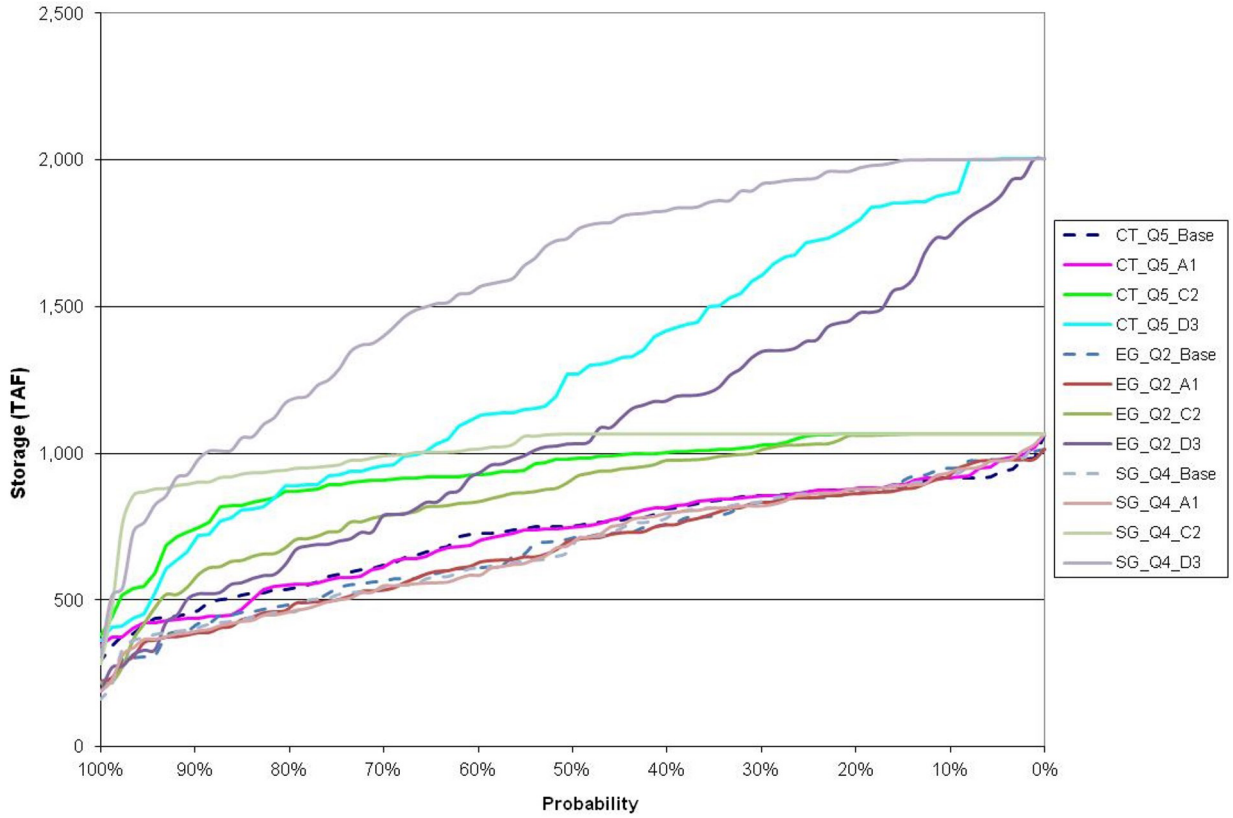

Figure 7-207. Exceedance of SWP End-of-May South-of-Delta Storage in Portfolio D

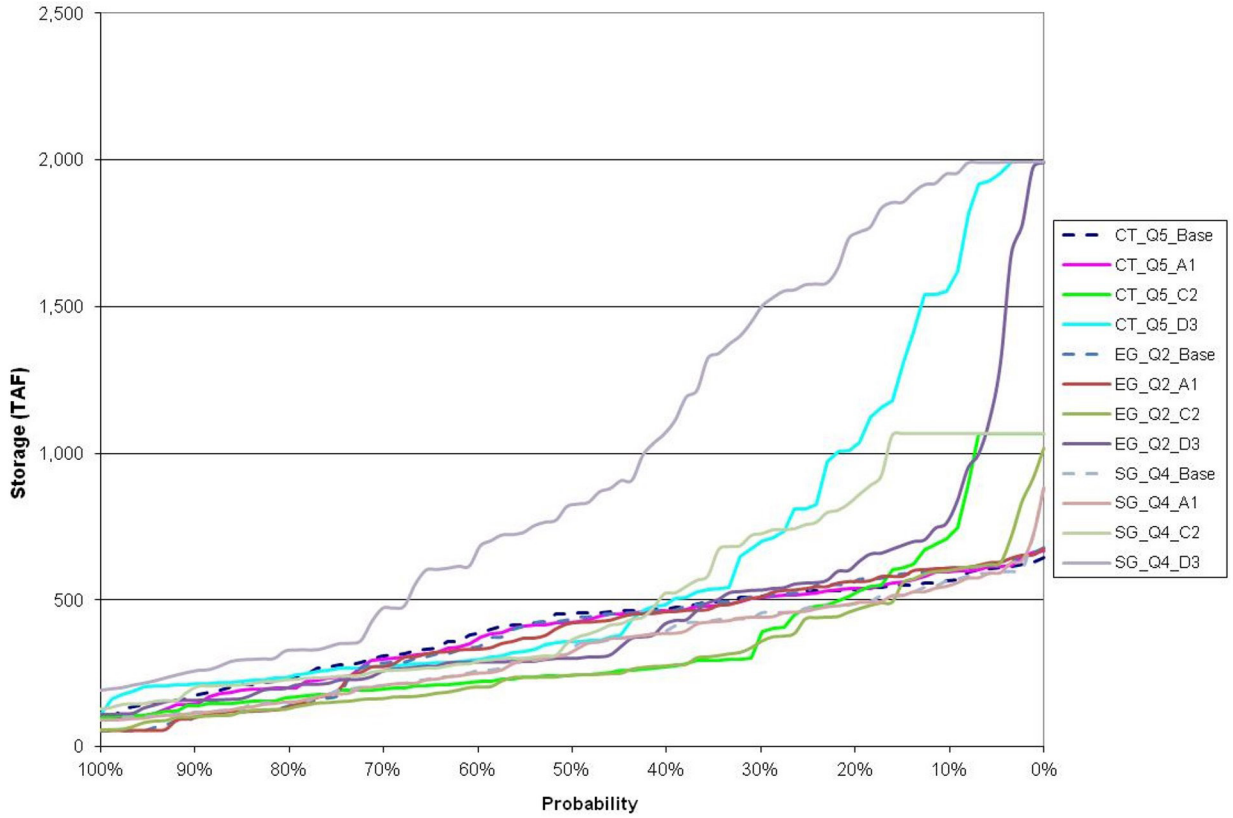

Figure 7-208. Exceedance of SWP End-of-September South-of-Delta Storage in Portfolio D

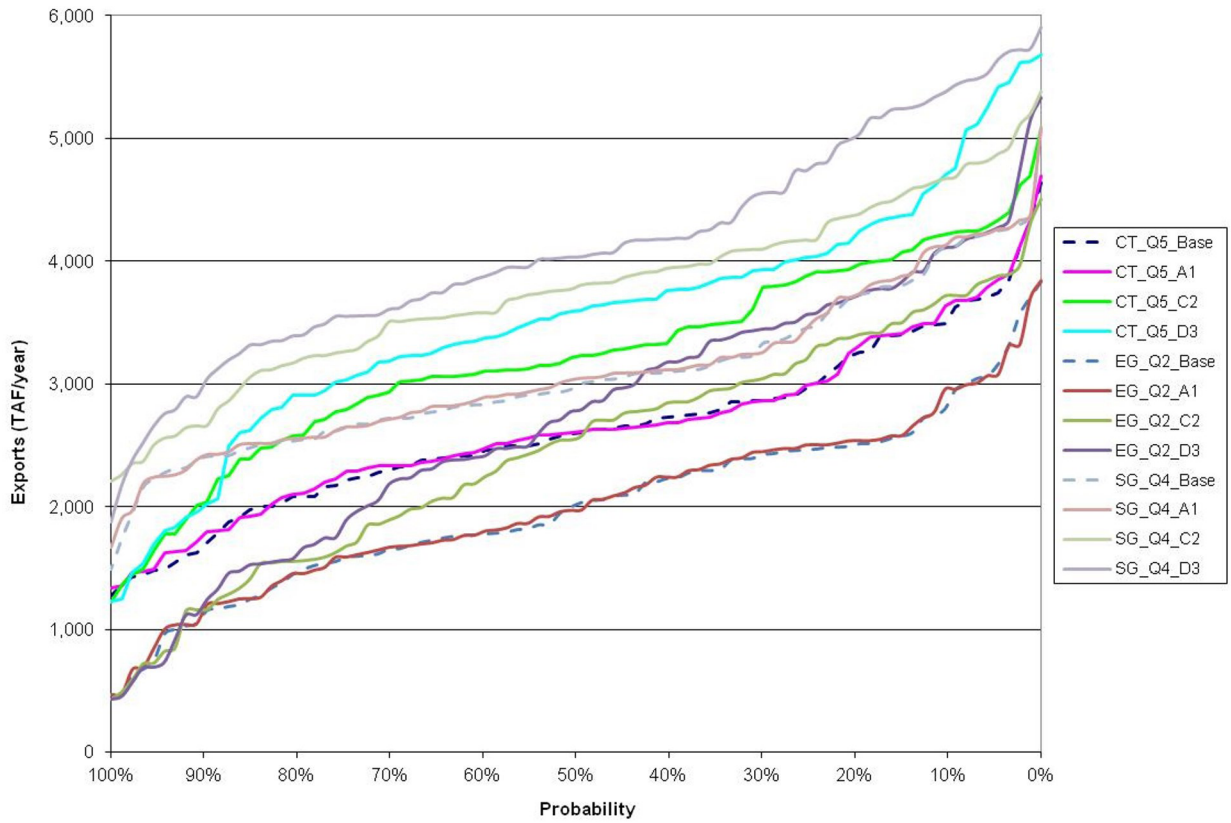

Figure 7-209. Annual Exceedance of Banks Pumping in Portfolio D

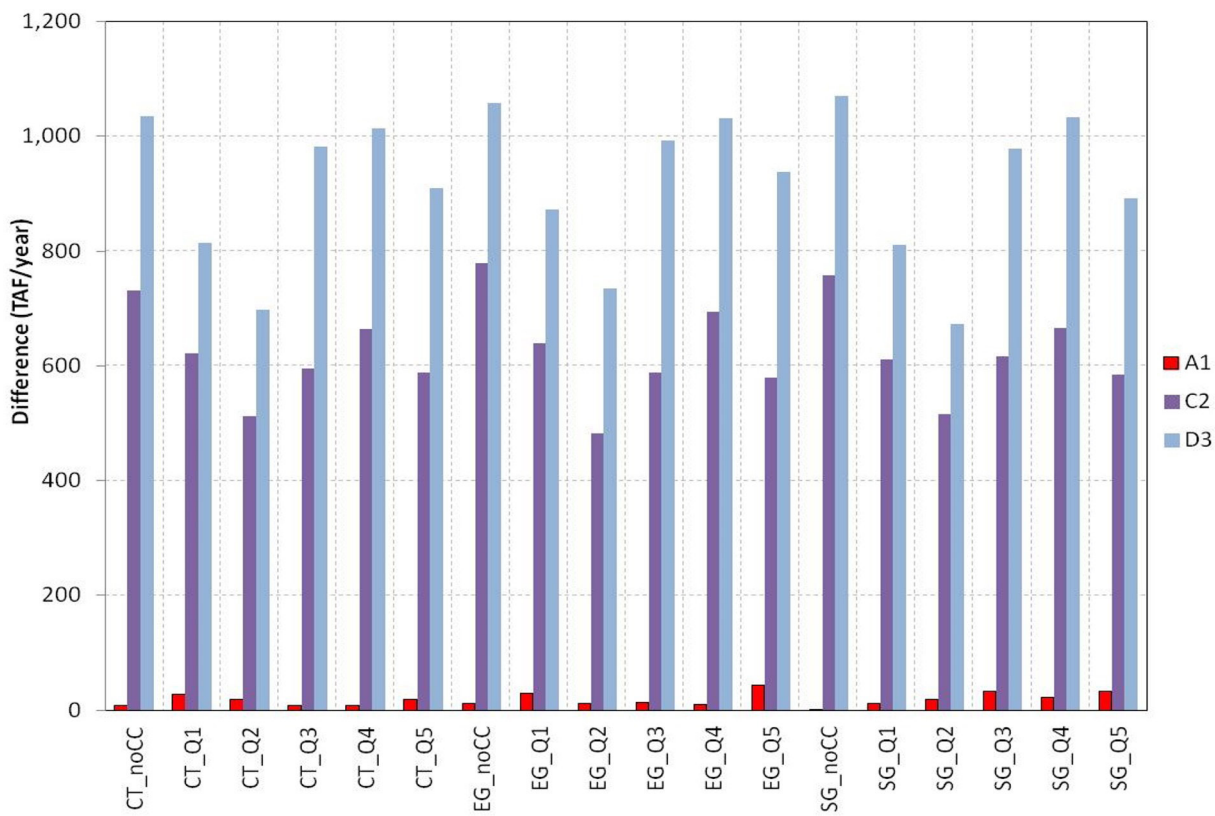

Figure 7-210. Average Annual Change in Banks Pumping for Portfolio D Relative to the Baseline in Each Scenario

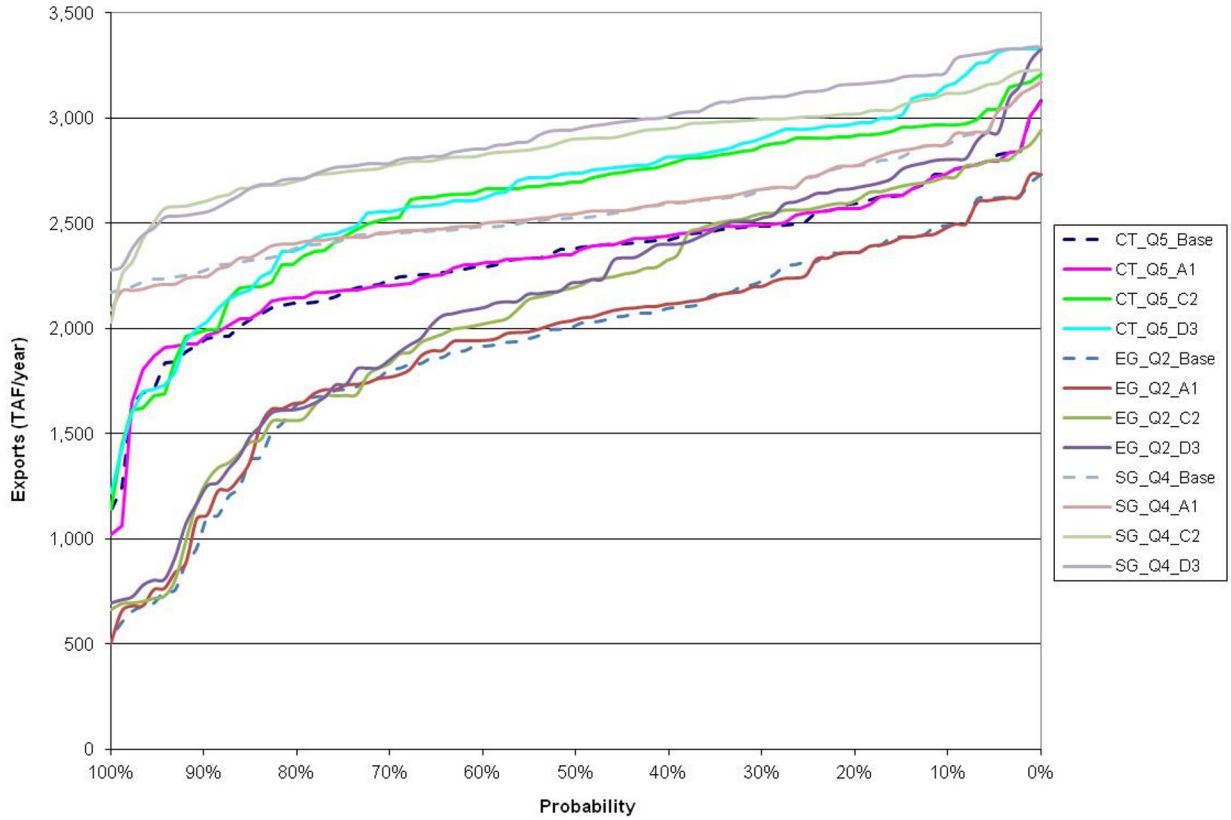

Figure 7-211. Annual Exceedance of Jones Pumping in Portfolio D

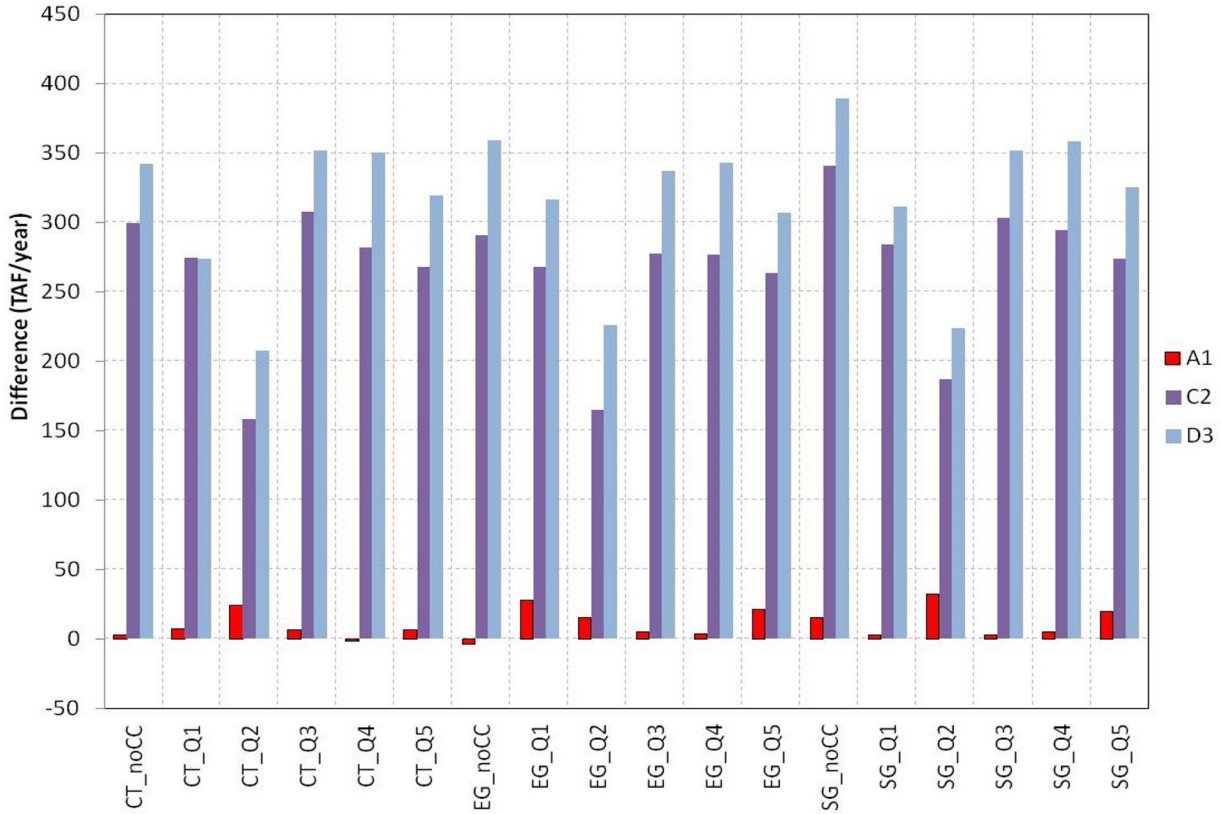

Figure 7-212. Average Annual Change in Jones Pumping for Portfolio D Relative to the Baseline in Each Scenario

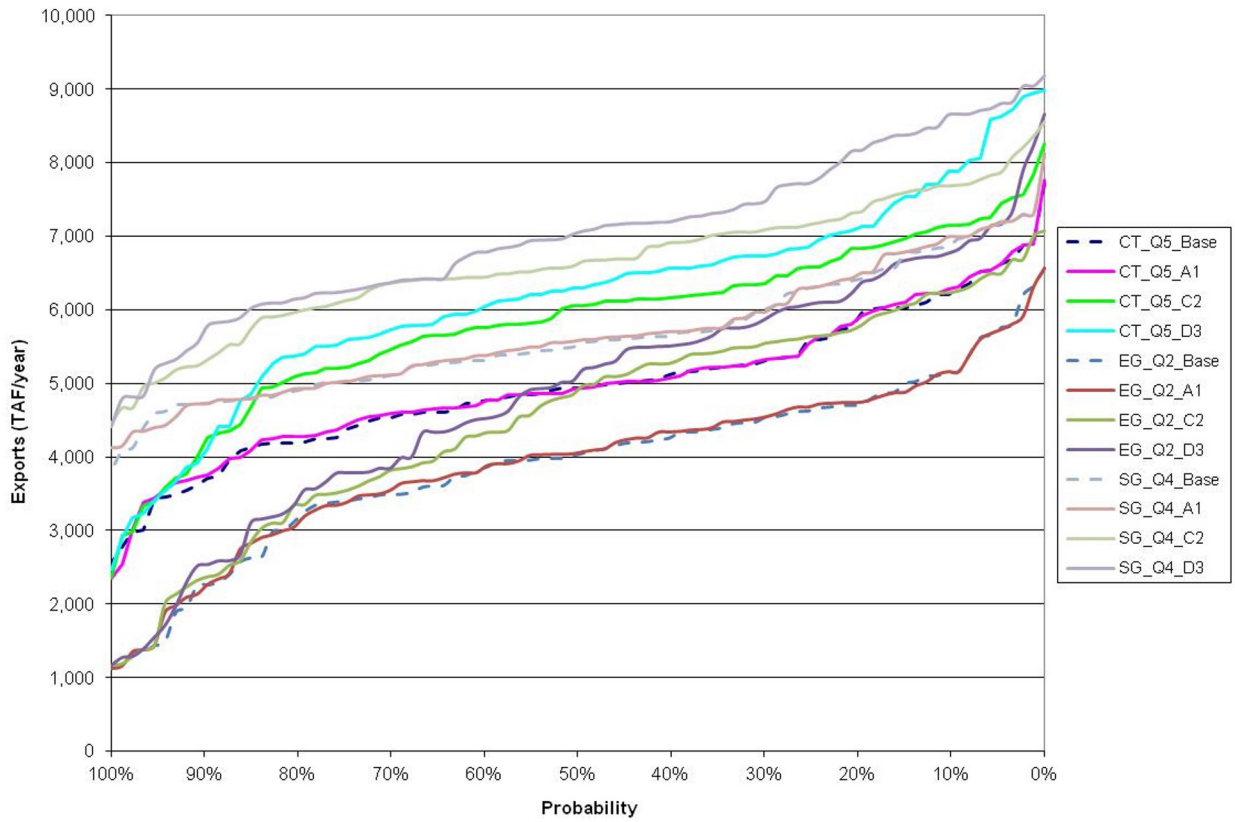

Figure 7-213. Annual Exceedance of Total Delta Exports in Portfolio D

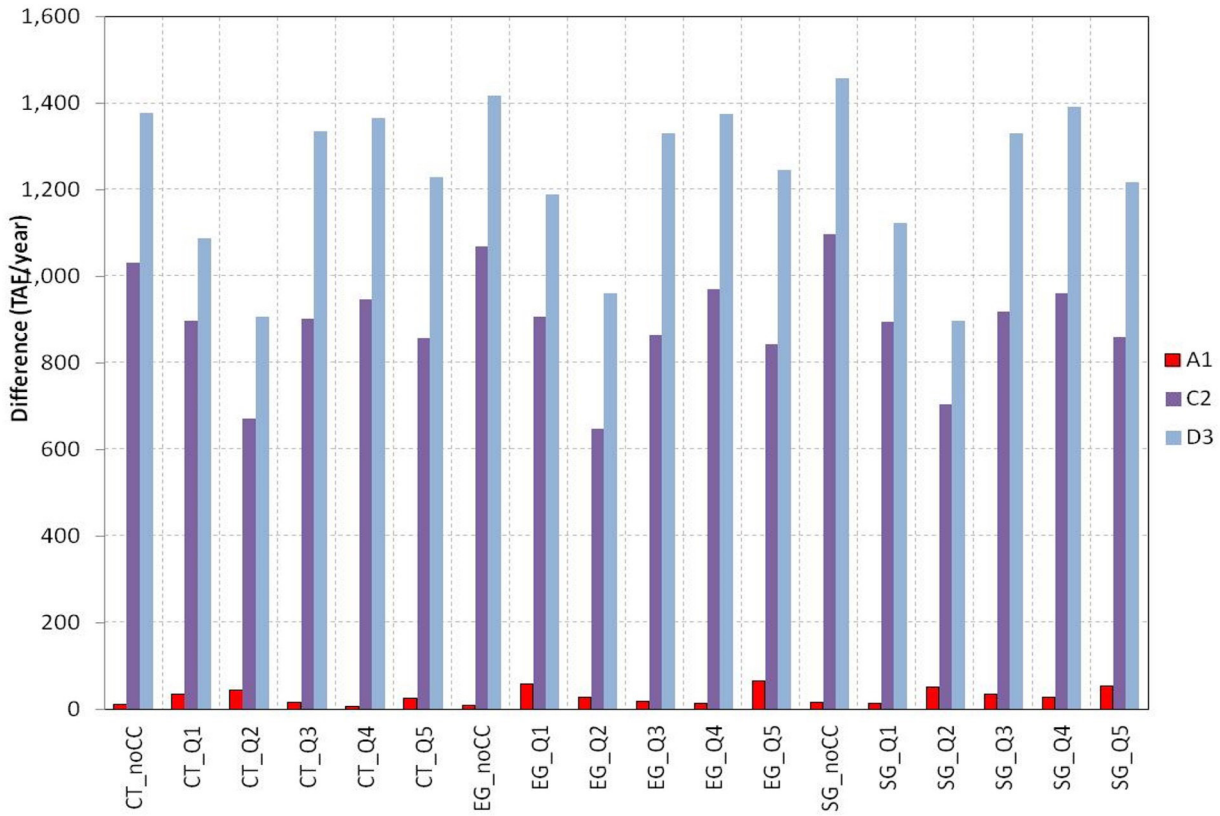

Figure 7-214. Average Annual Change in Total Delta Exports for Portfolio A Relative to the Baseline in Each Scenario

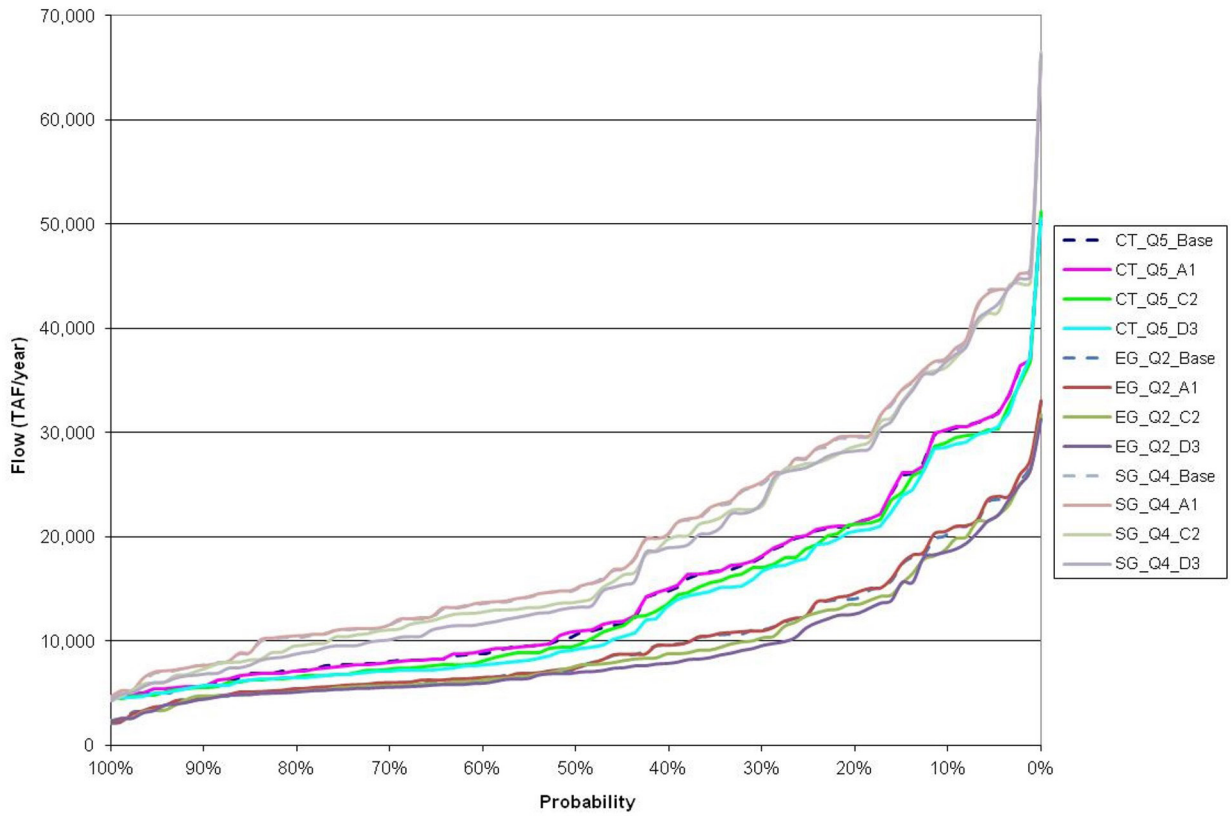

Figure 7-215. Annual Exceedance of Delta Outflow in Portfolio D

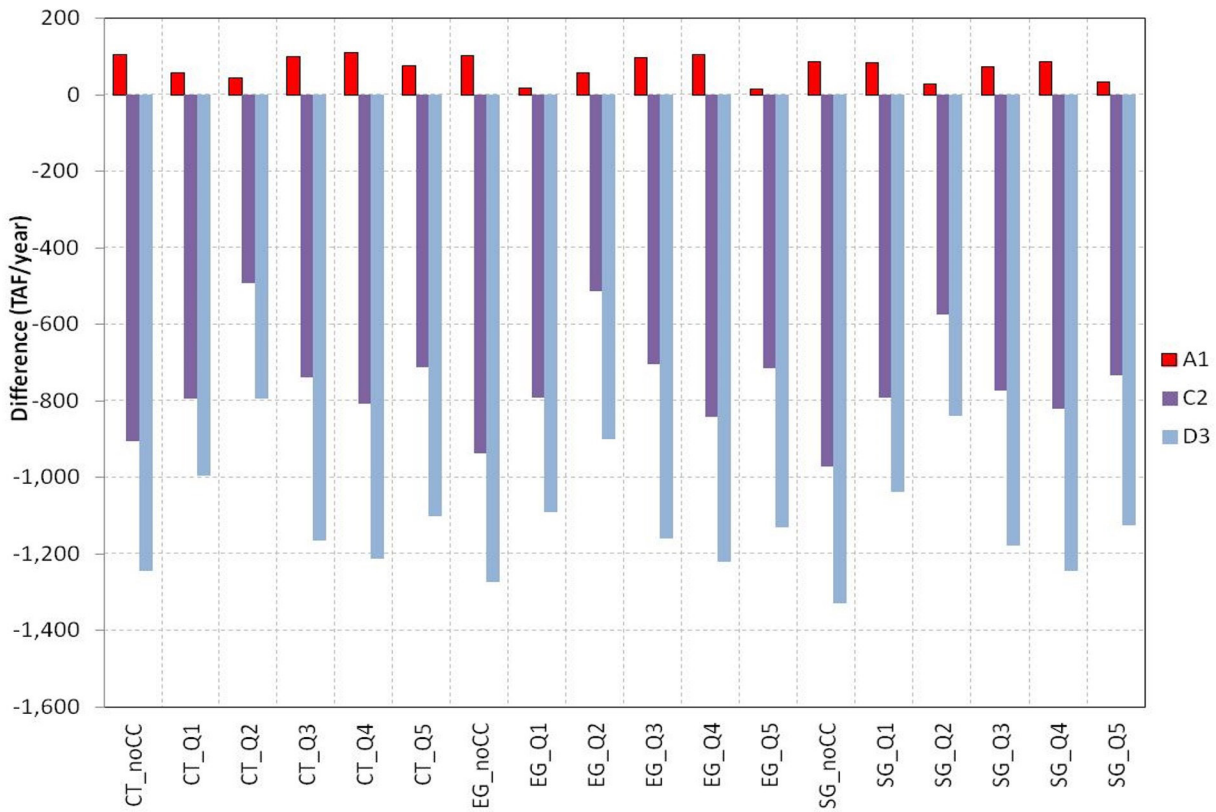

Figure 7-216. Average Annual Change in Delta Outflow for Portfolio D Relative to the Baseline in Each Scenario

Total exports with the D3 actions exceeded the Baseline values by 897 to 1,459 TAF/year across the range of scenarios. Delta outflows with the D3 actions were reduced by 794 to 1,329 TAF/year across the range of scenarios.

7.4.2.3 Delta Salinity

Figure 7-217 shows the average X2 position from February through June for each scenario with Portfolio D actions. Figure 7-218 shows the exceedance of average X2 position from February through June under the CT-Q5, EG-Q2, and SG-Q4 scenarios. The reduction in Delta outflow with D3 actions caused additional increases in salinity. Therefore, the average X2 position in D3 increased by about 1.5 to 1.9 km relative to the Baseline across the range of scenarios.

7.4.3 Other Performance Assessments

7.4.3.1 Economics

Figures 7-219 through 7-222 show the net improvement in net water supply system costs from the urban economic models LCPSIM and OMWEM, the net improvement in avoided cost from the water quality economic model SBWQM, and the change in net agricultural revenues from SWAP for each of the Portfolio D simulation suites in the CT-Q5, EG-Q2, and SG-Q4 scenarios at the 2025, 2055, and 2085 LODs.

Consistent with the results from Portfolio C, the South Bay urban economic model results from LCPSIM showed substantial economic benefits in the CT-Q5 and EG-Q2 scenarios with the D3 actions, with values ranging up to $126 million per year in CT-Q5 and up to $435 million per year in EG-Q2. These benefits resulted from the reductions in shortage costs due to the increased deliveries to the SBA from the combination of new Delta conveyance with additional South-of-Delta storage. They were larger in EG-Q2 because the South Bay has very high unmet demands and, therefore, high marginal shortage costs in the EG-Q2 Baseline due to the increased population in the Expansive Growth socioeconomic scenario and reduced water supplies in the Q2 climate scenario. However, as in Portfolio C, there continued to be very little change in the economic values in the SG-Q4 scenario.

Figure 7-223 shows the long-term average salinity at CCWD and SBA diversion locations with Portfolio D actions. Also consistent with Portfolio C, the SBA water quality costs simulated by SBWQM showed substantial economic benefits in the D3 suite of actions in the CT-Q5 and EG-Q2 scenarios because the increases in Delta exports caused a large reduction in salinity at the export locations, thereby significantly reducing the cost of treatment. In D3, there were about $15 million per year in avoided salinity costs in CT-Q5 and about $25 million in EG-Q2. In SG Q4, there continued to be very little change in salinity costs relative to the Baseline.

The changes in Central Valley net agricultural revenues results from SWAP and urban economic results from OMWEM showed substantial benefits with the combined D3 compared to the Baseline (see Figure 7-222). The average annual economic benefits in D3 across the different scenarios and LODs ranged from $31–102 million per year in net agricultural revenues and from about $5–97 million per year in the urban costs simulated by OMWEM. As with Portfolio C, the OMWEM results showed substantially less benefit in SG-Q4 than in the other scenarios because the marginal incremental benefits relative to the Baseline were smaller.

7.4.3.2 Water Temperature

Figures 7-224 through 7-227 show exceedance plots and average changes of daily water temperatures from July through September in Portfolio D relative to the Baseline for CT-Q5, EG-Q2, and SG-Q4 scenarios in the Sacramento River at Keswick and Jelly's Ferry. With the addition of South-of-Delta storage along with Delta conveyance in D3 there were only minimal changes in water temperature relative to the results with only Delta conveyance in the C2 suite. The mean daily water temperatures in the Sacramento River at Keswick in D3 were about 0–0.2°F lower than in the Baseline, and the mean daily water temperatures at Jelly's Ferry in D3 were about 0–0.2°F lower than the Baseline across the range of simulated scenarios. As observed in the Baseline cases, the SG-Q4 (wetter) scenario had the lowest water temperatures, and the EG-Q2 (drier) scenario had the highest water temperatures, with CT-Q5 falling between them.

Figures 7-228 through 7-233 show exceedance plots and average changes of daily water temperatures from August through November with the Portfolio D actions relative to the Baseline in the San Joaquin River at Lost Lake, Gravelly Ford,

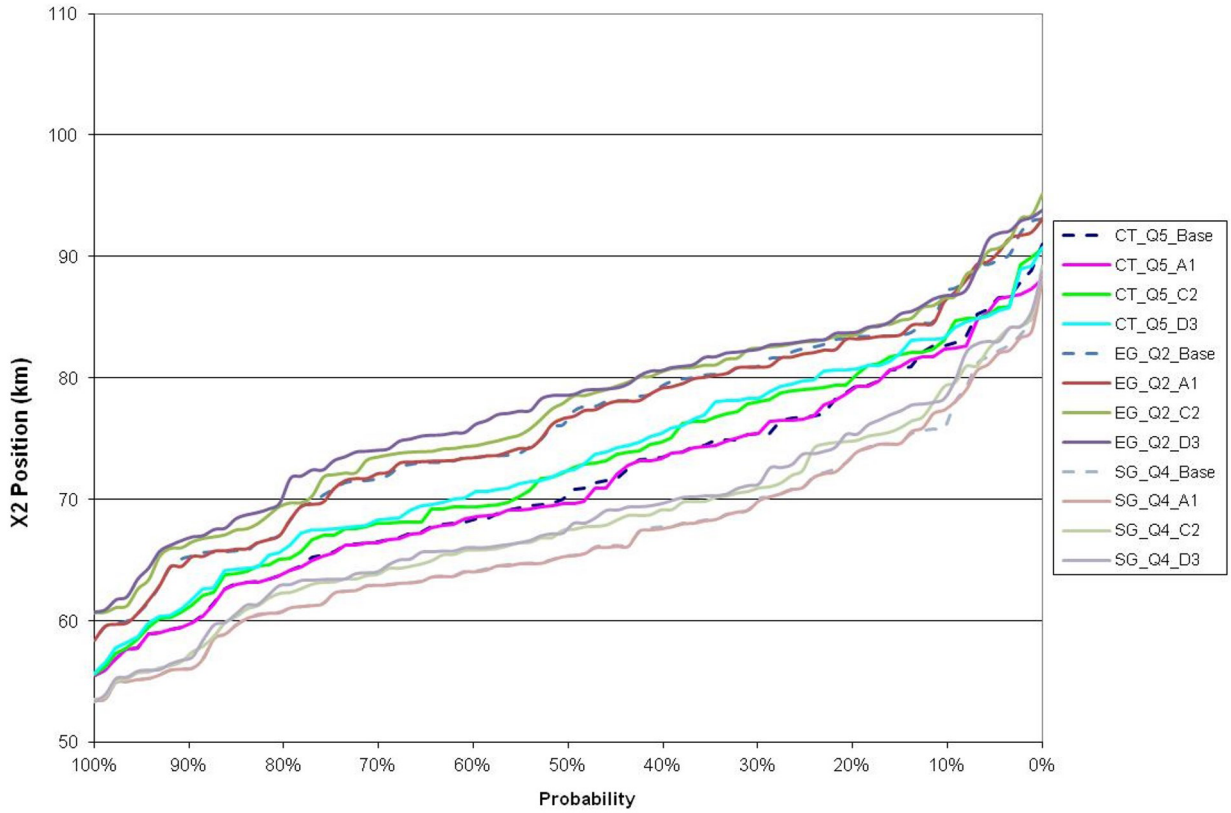

Figure 7-217. Exceedance of Average February-to-June X2 Position in Portfolio D

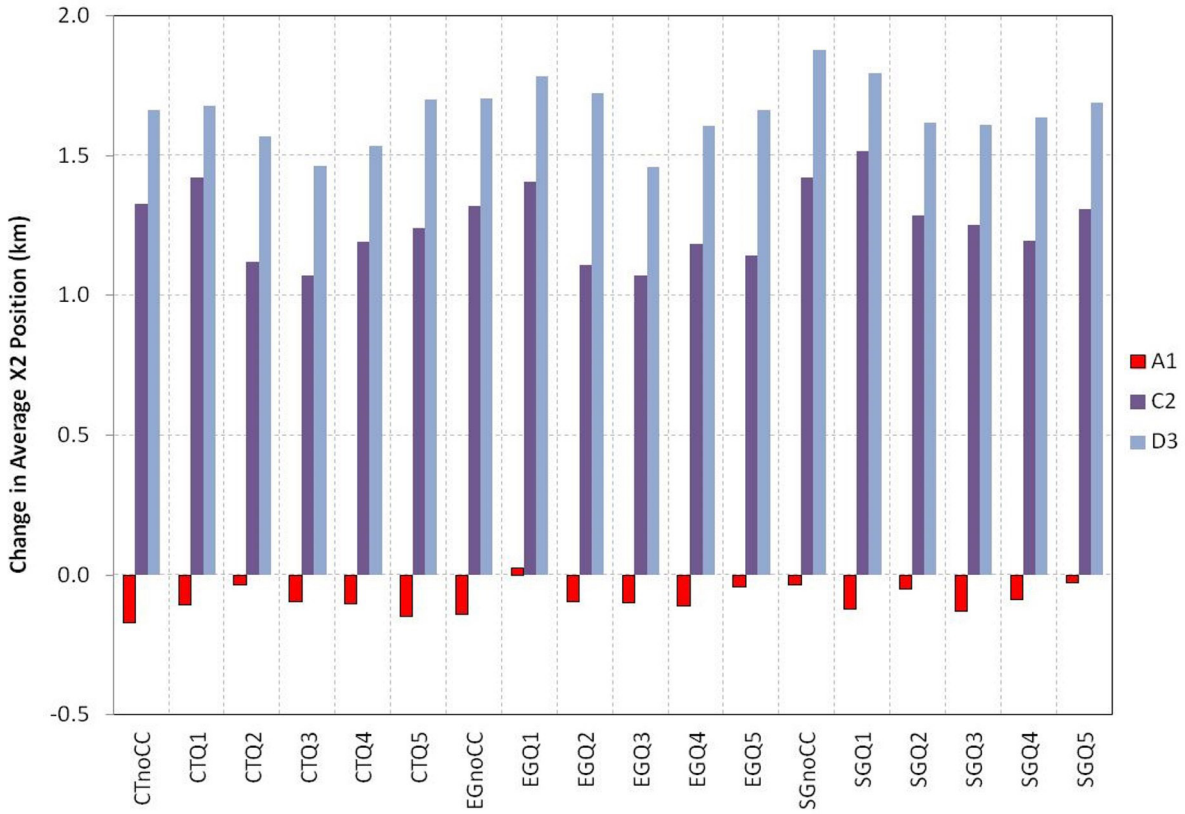

Figure 7-218. Change in Average February-to-June X2 Position for Portfolio D Relative to the Baseline in Each Scenario

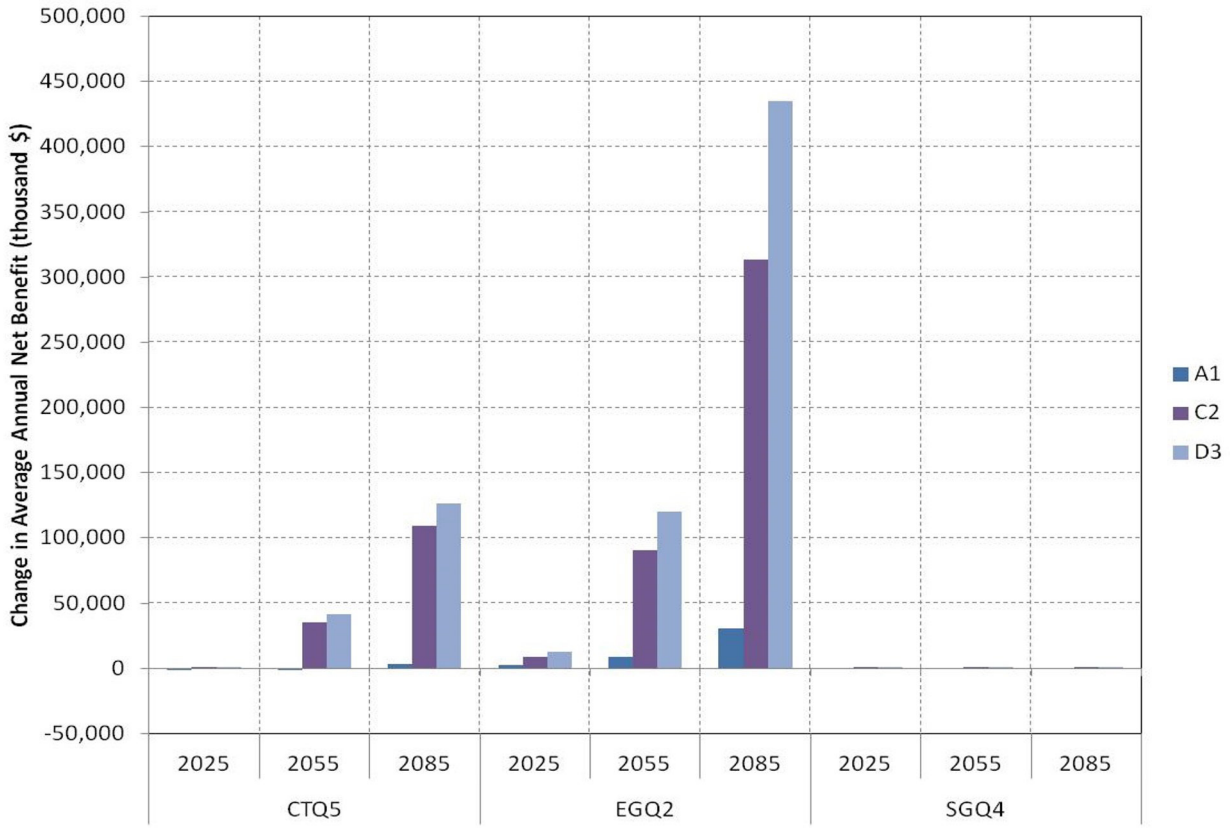

Figure 7-219. Improvement in Average Annual Urban Net Water Supply System Costs in South Bay Region from LCPSIM in Portfolio D

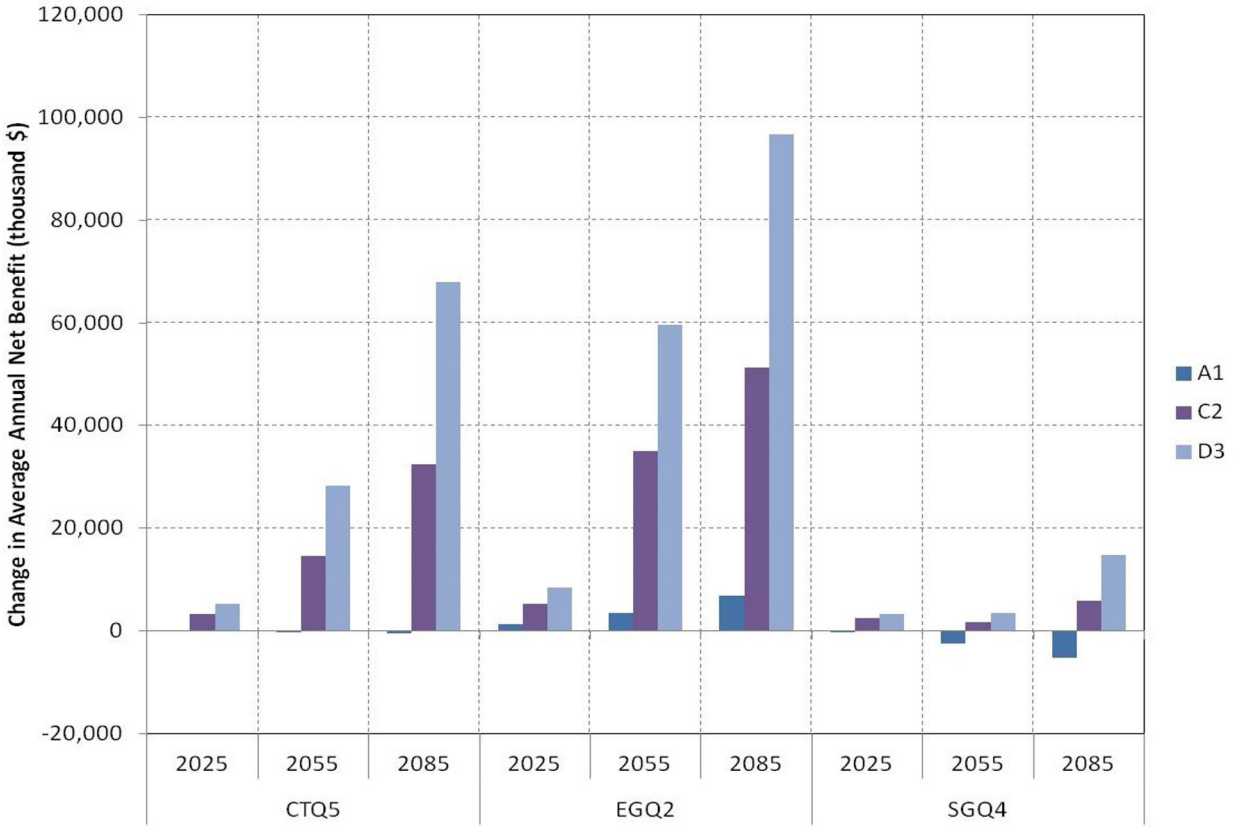

Figure 7-220. Improvement in Average Annual Urban Net Water Supply System Costs in South Bay Region from LCPSIM in Portfolio D

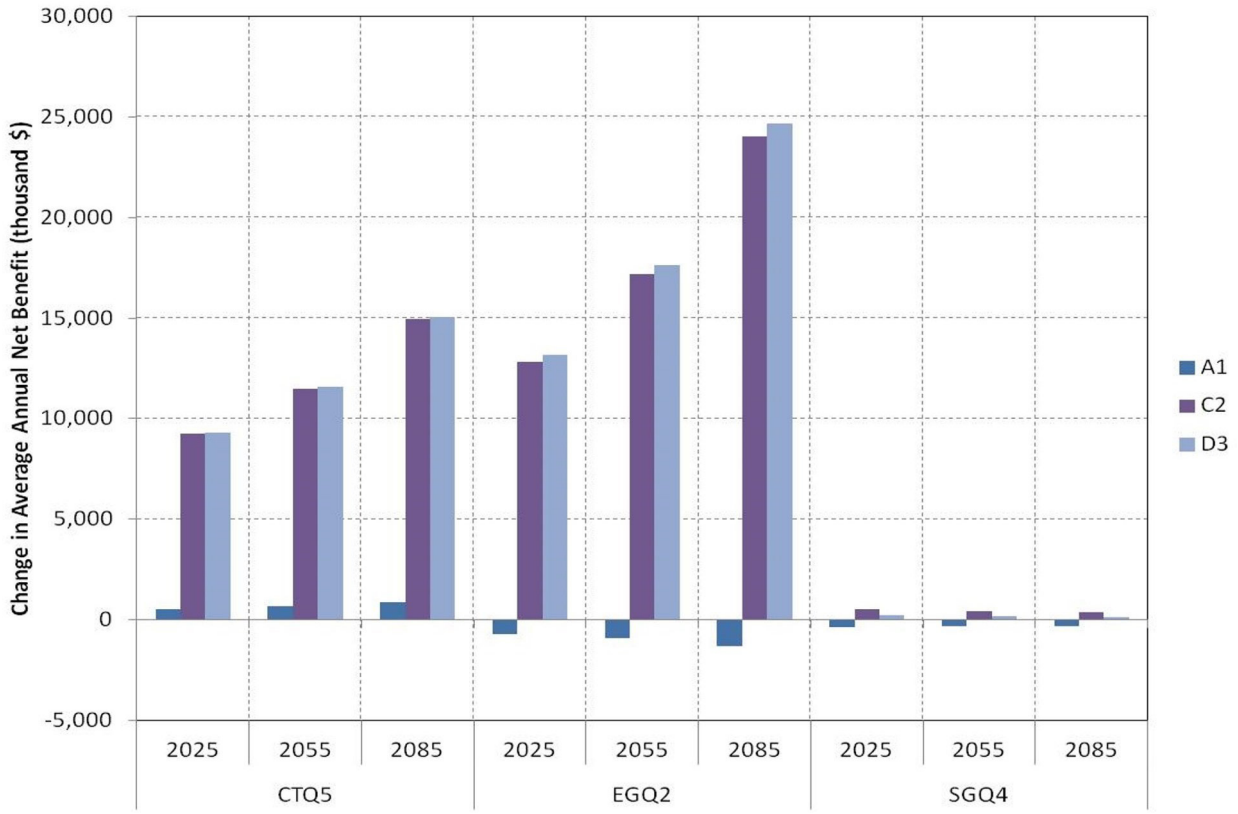

Figure 7-221. Improvement in Average Annual Avoided Water Quality Costs in South Bay Region from SBWQM in Portfolio D

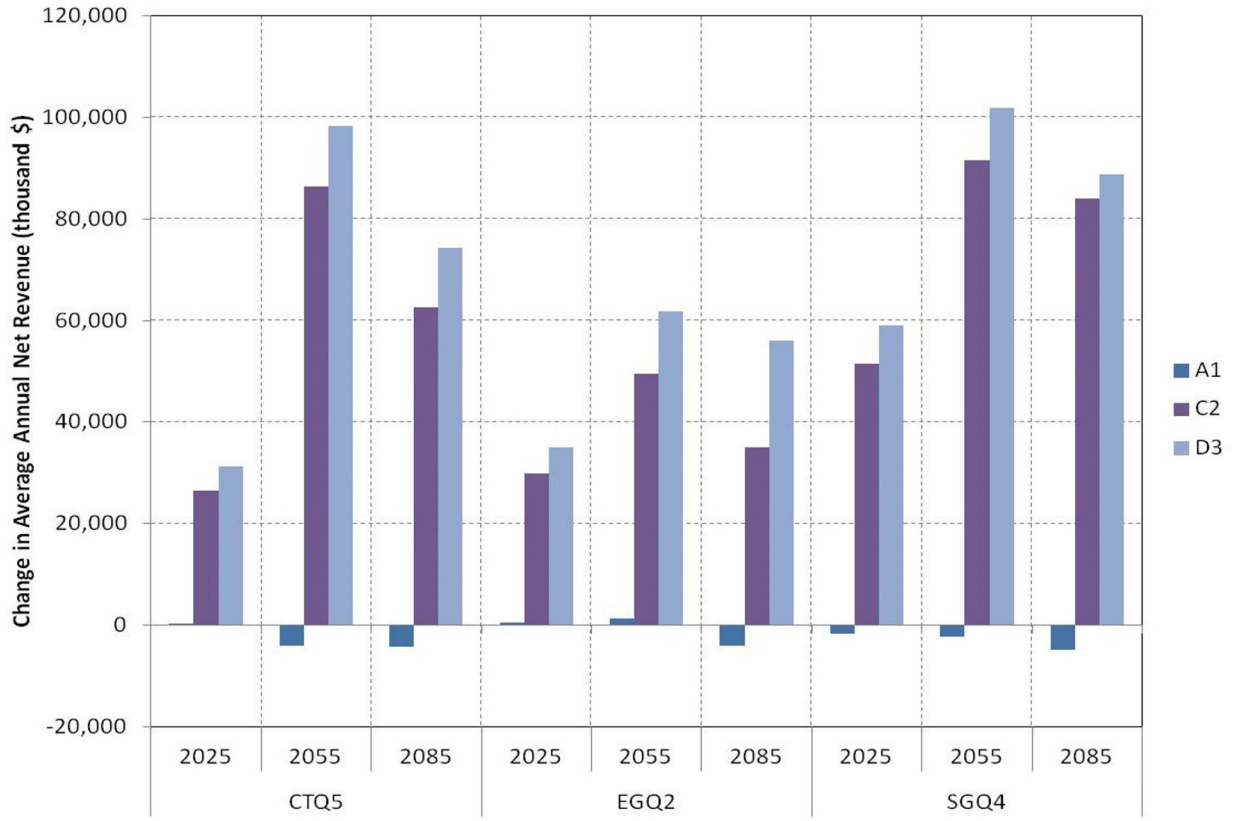

Figure 7-222. Improvement in Average Annual Agricultural Net Revenue in Central Valley from SWAP in Portfolio D

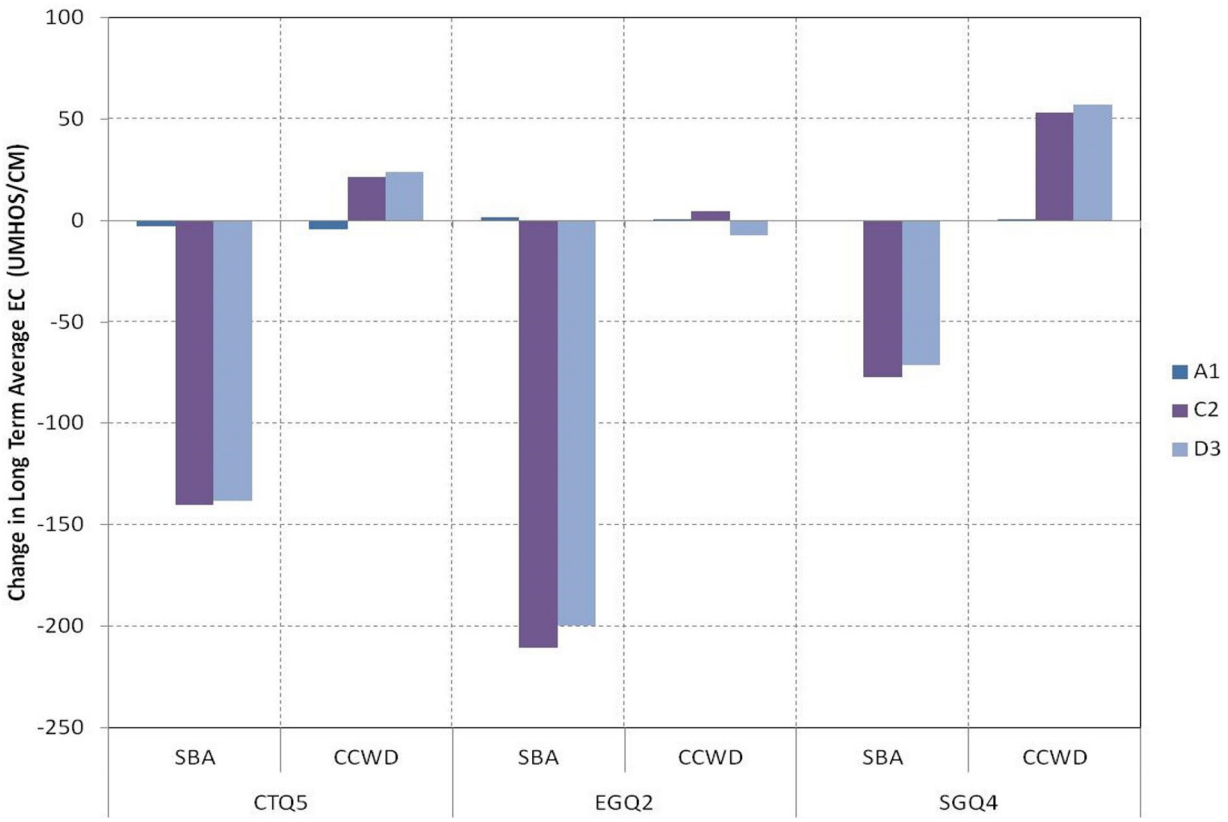

Figure 7-223. Long-Term Average Salinity at CCWD and SBA Diversion Locations in Portfolio D

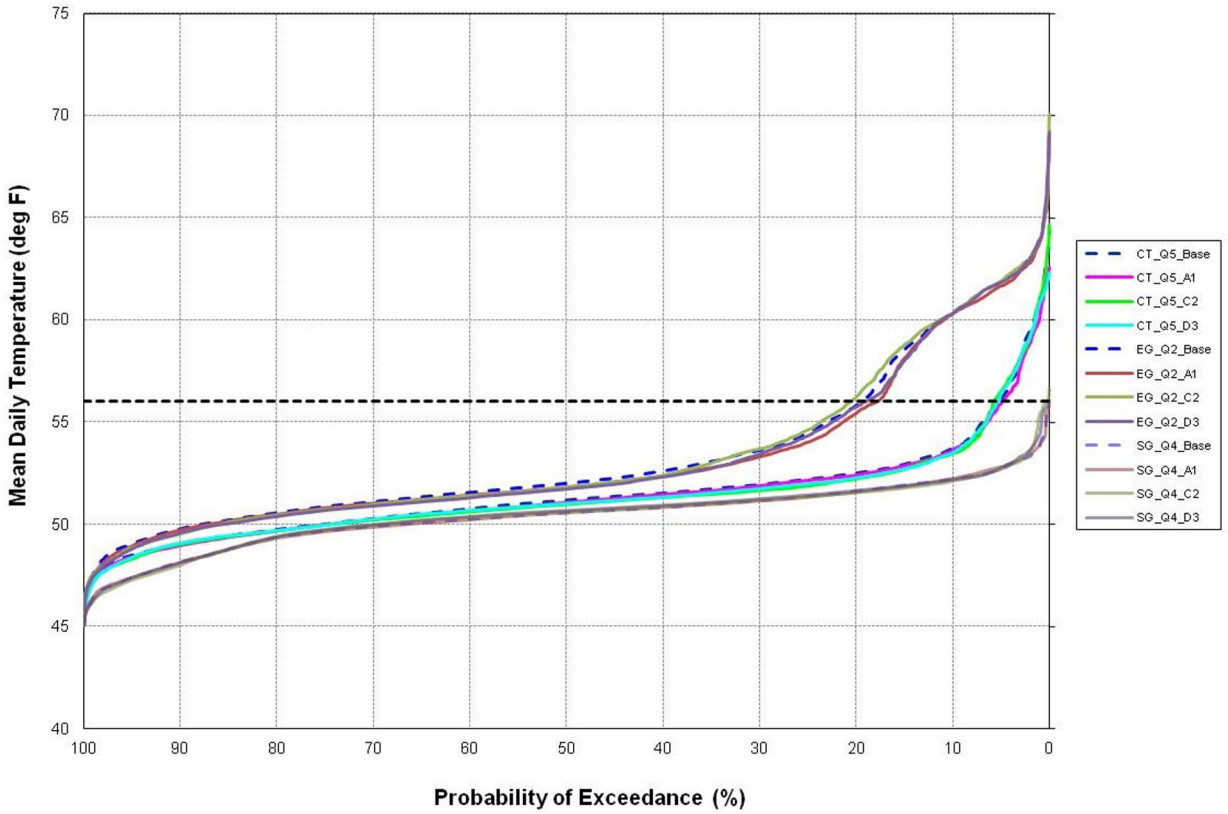

Figure 7-224. Exceedance of Mean Daily Temperature on Sacramento River at Keswick from July to September in Portfolio D

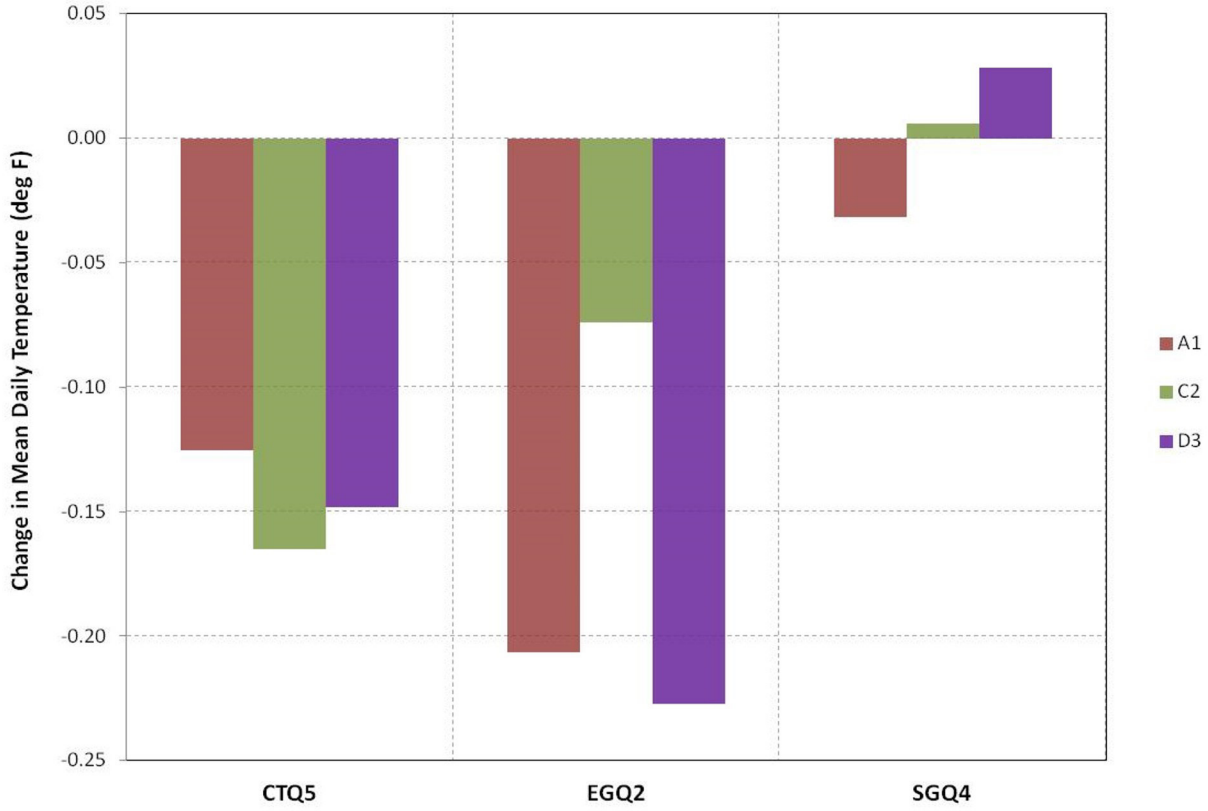

Figure 7-225. Change in Mean Daily Temperature on Sacramento River at Keswick from July to September in Portfolio D

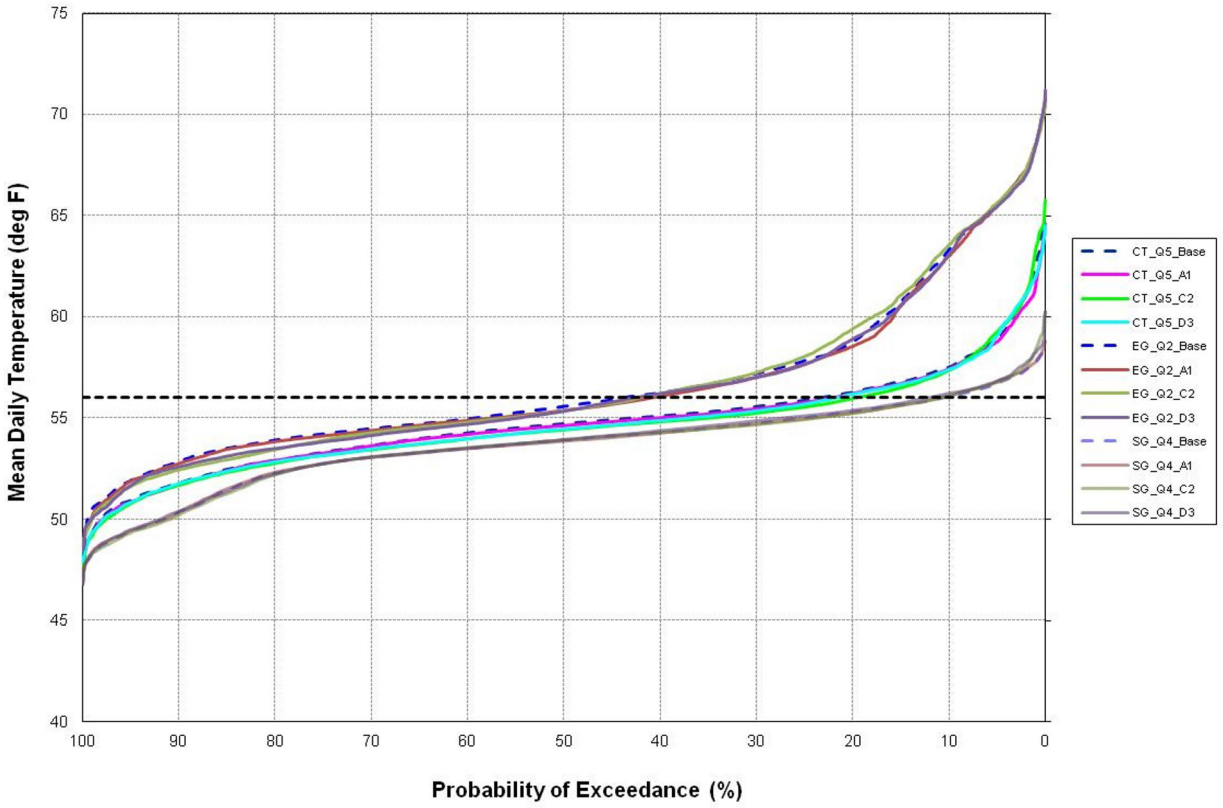

Figure 7-226. Exceedance of Mean Daily Temperature on Sacramento River at Jelly's Ferry from July to September in Portfolio D

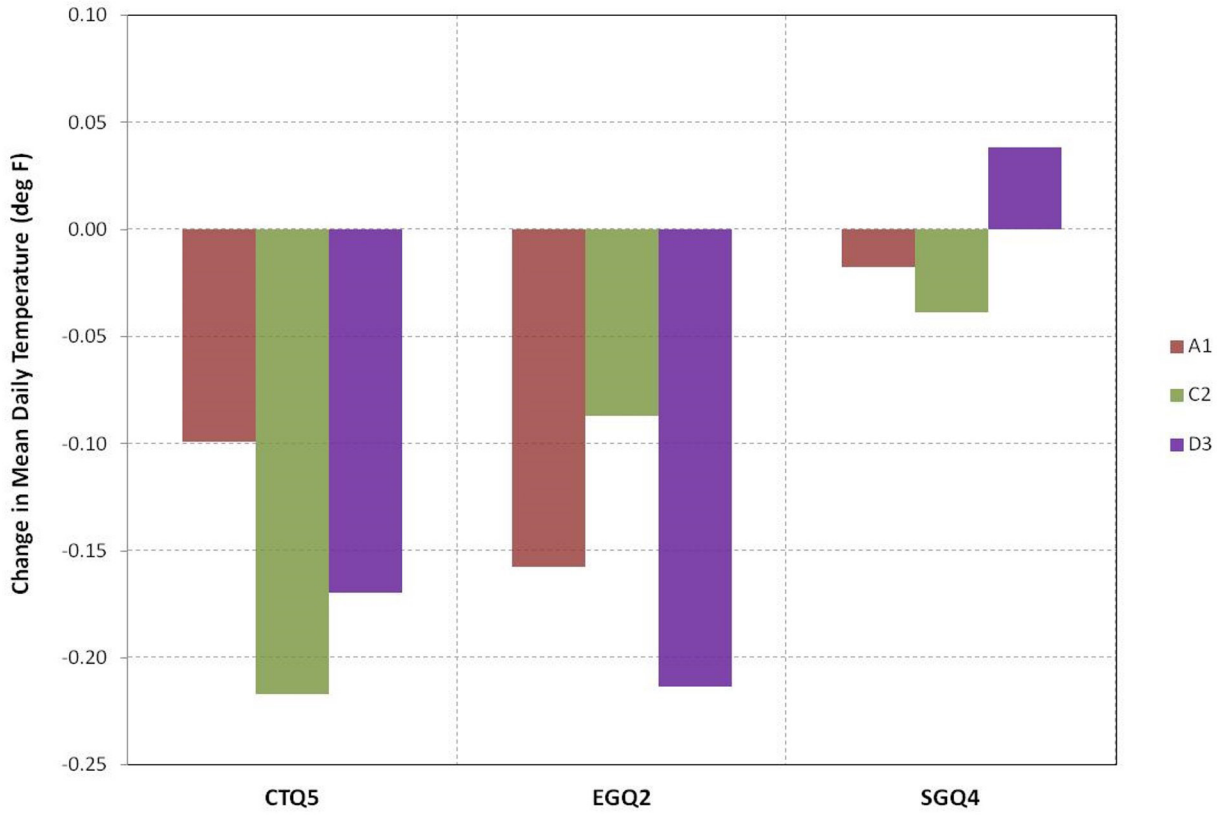

Figure 7-227. Change in Mean Daily Temperature on Sacramento River at Jelly's Ferry from July to September in Portfolio D

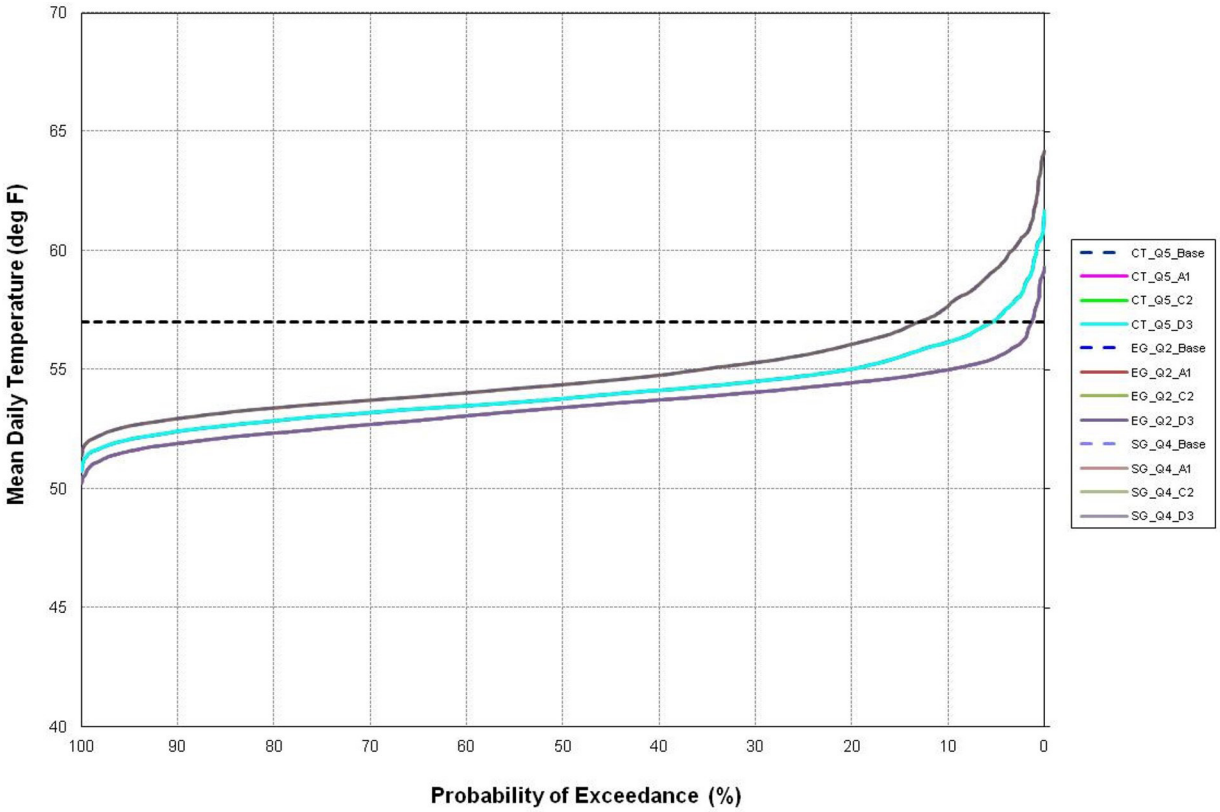

Figure 7-228. Exceedance of Mean Daily Temperature on San Joaquin River at Lost Lake from August to November in Portfolio D

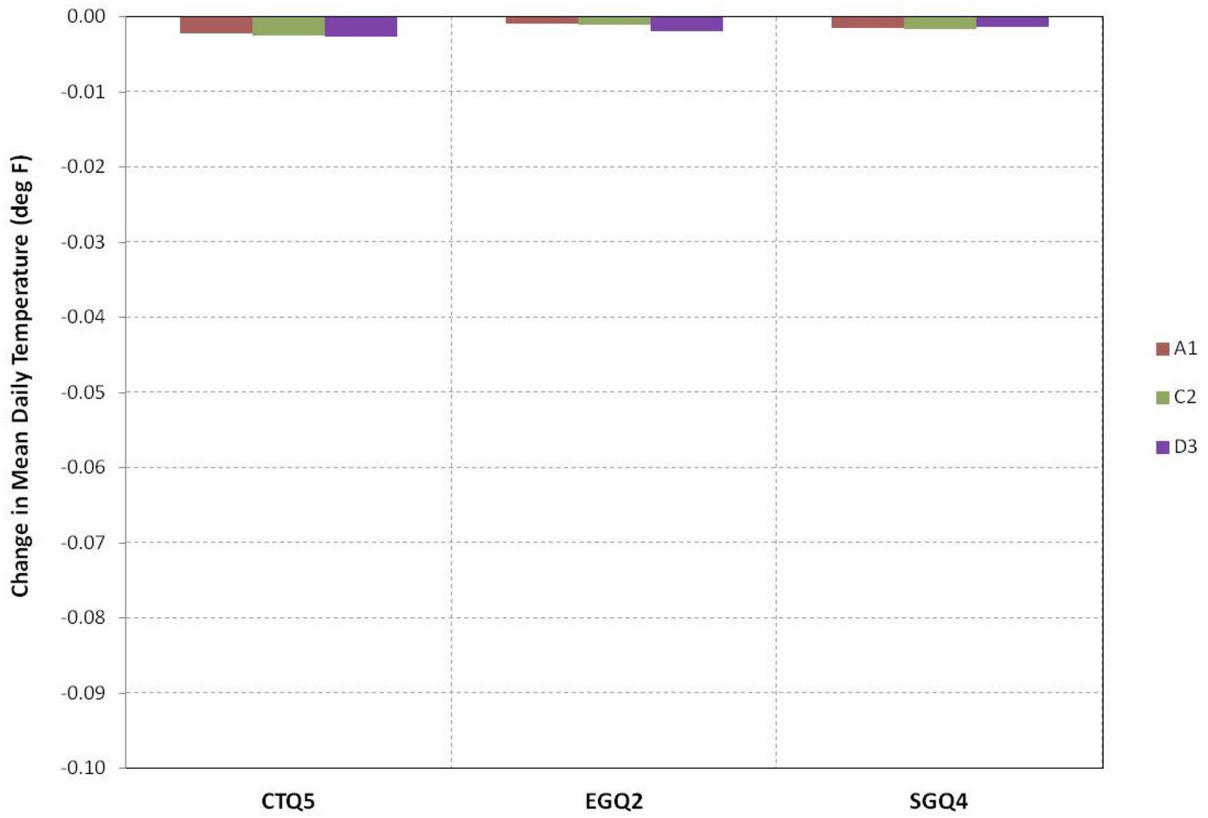

Figure 7-229. Change in Mean Daily Temperature on San Joaquin River at Lost Lake from August to November in Portfolio D

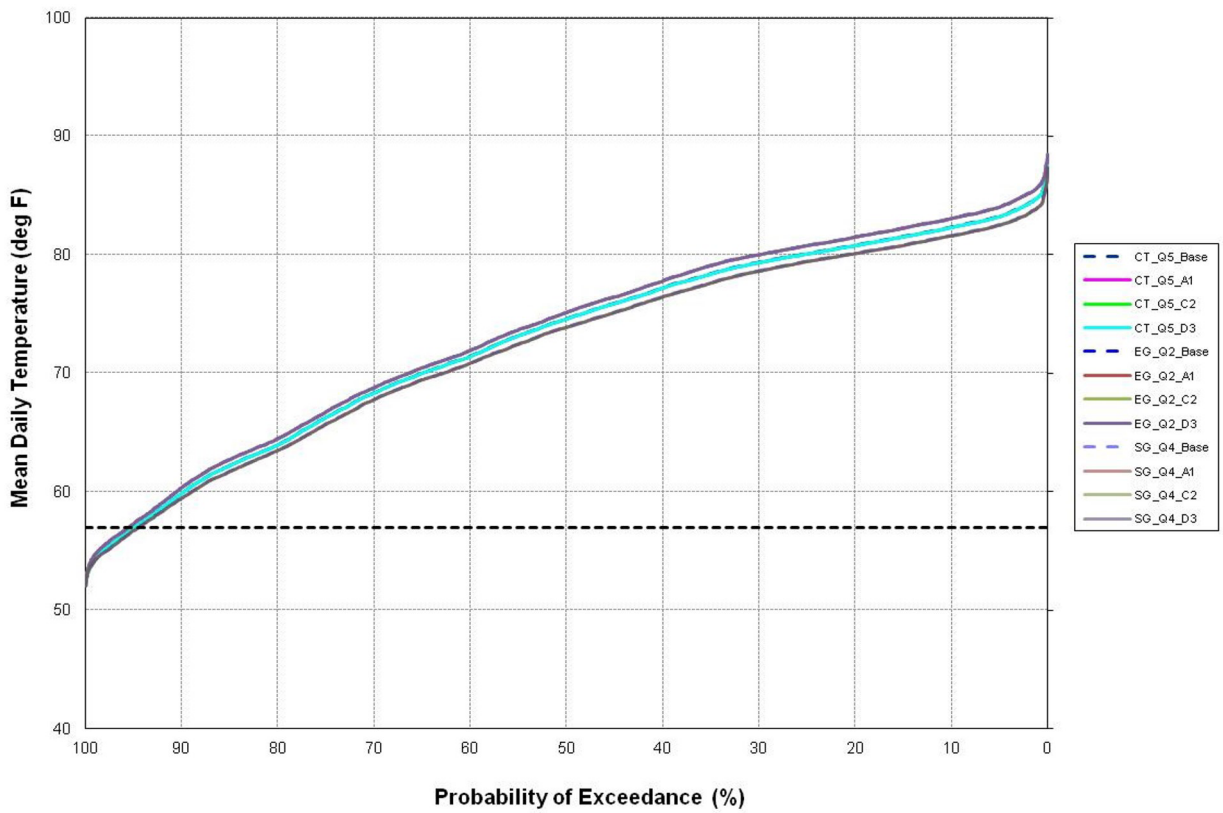

Figure 7-230. Exceedance of Mean Daily Temperature on San Joaquin River at Gravelly Ford from August to November in Portfolio D

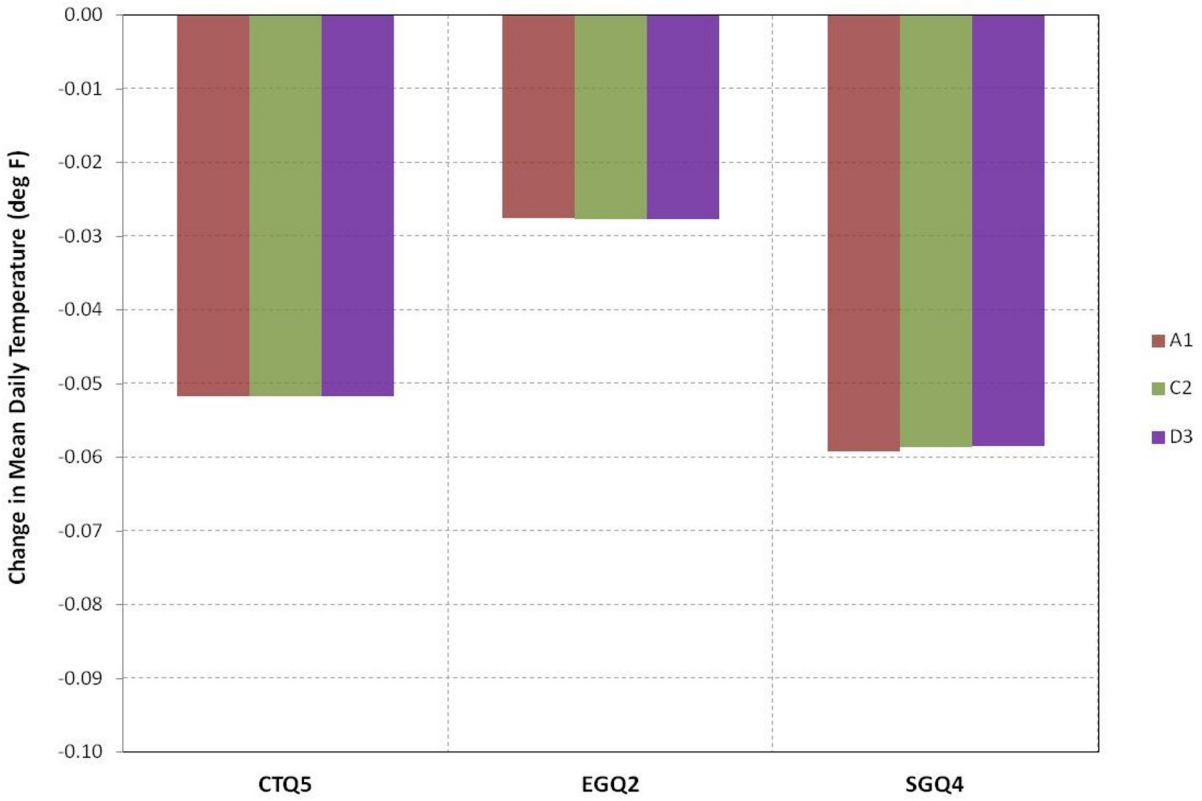

Figure 7-231. Change in Mean Daily Temperature on San Joaquin River at Gravelly Ford from August to November in Portfolio D

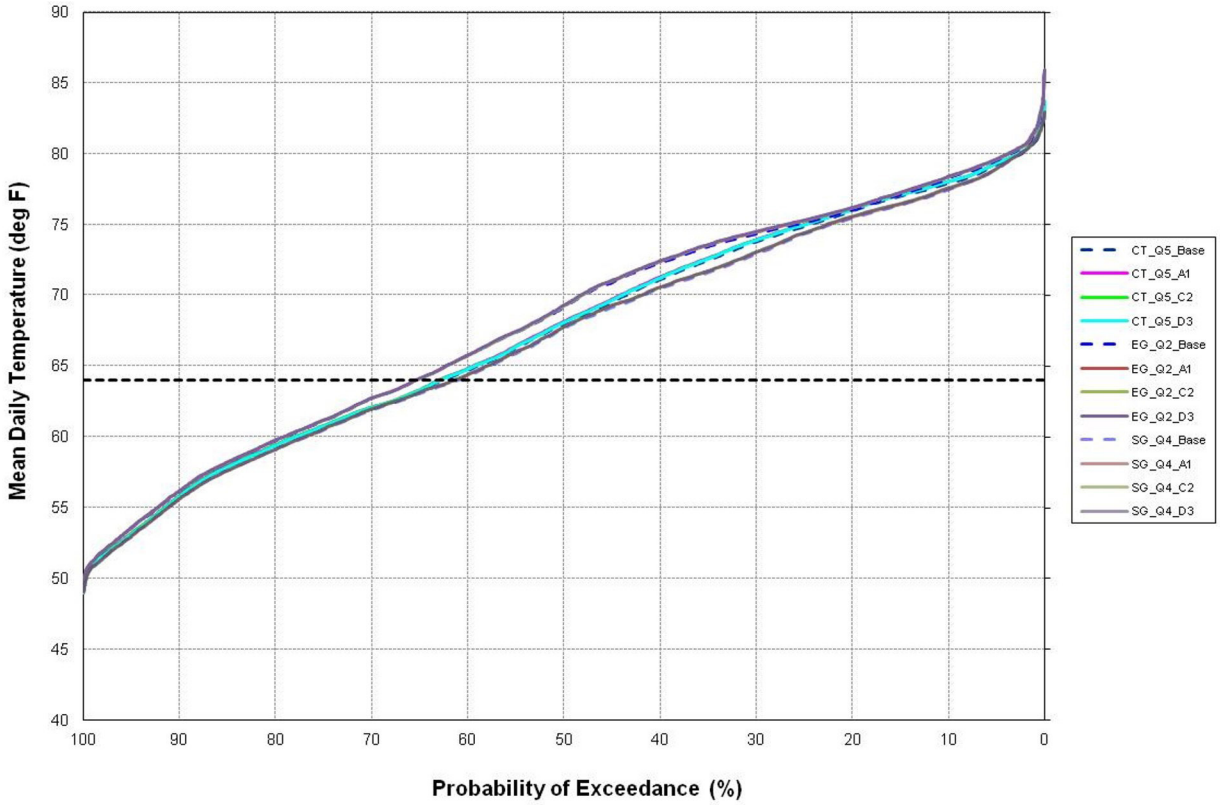

Figure 7-232. Exceedance of Mean Daily Temperature on San Joaquin River at Vernalis from August to November in Portfolio D

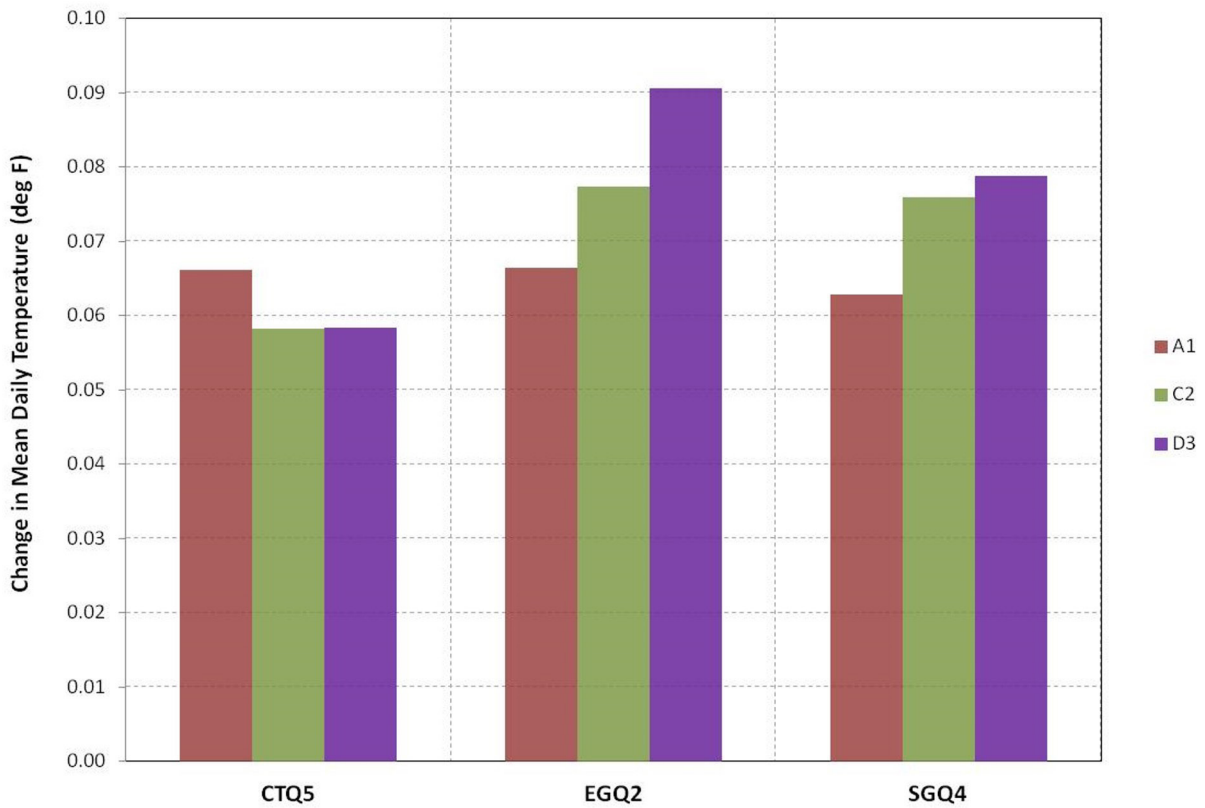

Figure 7-233. Change in Mean Daily Temperature on San Joaquin River at Vernalis from August to November in Portfolio D

and Vernalis for the same three scenarios. Under all scenarios with the C2 and D3 actions, there were only minimal changes in water temperatures at all three San Joaquin River locations relative to A1. Therefore, the Delta Conveyance and South-of-Delta Storage actions had negligible impacts on water temperatures in the San Joaquin River.

7.4.3.3 Hydropower and Greenhouse Gas Emissions

Figures 7-234 and 7-235 show the changes in net hydropower generation and GHG emissions (that is, increase in GHG emissions in the SWP system or reduction in potential GHG offsets in the CVP system) in the CVP and SWP systems with the Portfolio D actions relative to the Baseline. In the SWP system, as in Portfolio C, there were substantial reductions in net hydropower generation and increases in GHG emissions in the D3 suite of actions due to the large increases in Banks pumping. In D3, net generation was about 1,000–1,100 GWh/year less than in the Baseline, and GHG emissions were 129,000–149,000 mTCO2e higher than in the Baseline. In the CVP system, there were smaller but still substantial reductions in net generation of about 130–200 GWh/year and reductions in potential GHG offsets of about 40,000–61,000 mTCO2e in the D3 actions relative to the Baseline.

7.5 Portfolio E: Aggressive Local Actions, Enhanced Environmental Flows, and North-of-Delta Storage

The Aggressive Local Actions, Enhanced Environmental Flows, and North-of-Delta Storage Portfolio E was designed to investigate the integrated effects of more aggressive agricultural and urban water conservation, increased North-of-Delta storage, and EEF actions. The details of the implementation of each of the Portfolio E actions are described in Section 6.3. Simulation Suite A3 was the first action of this portfolio with three additional simulation suites added in the steps listed below:

1. Aggressive agricultural and urban conservation (same as A3)
2. Enhanced Environmental Flows

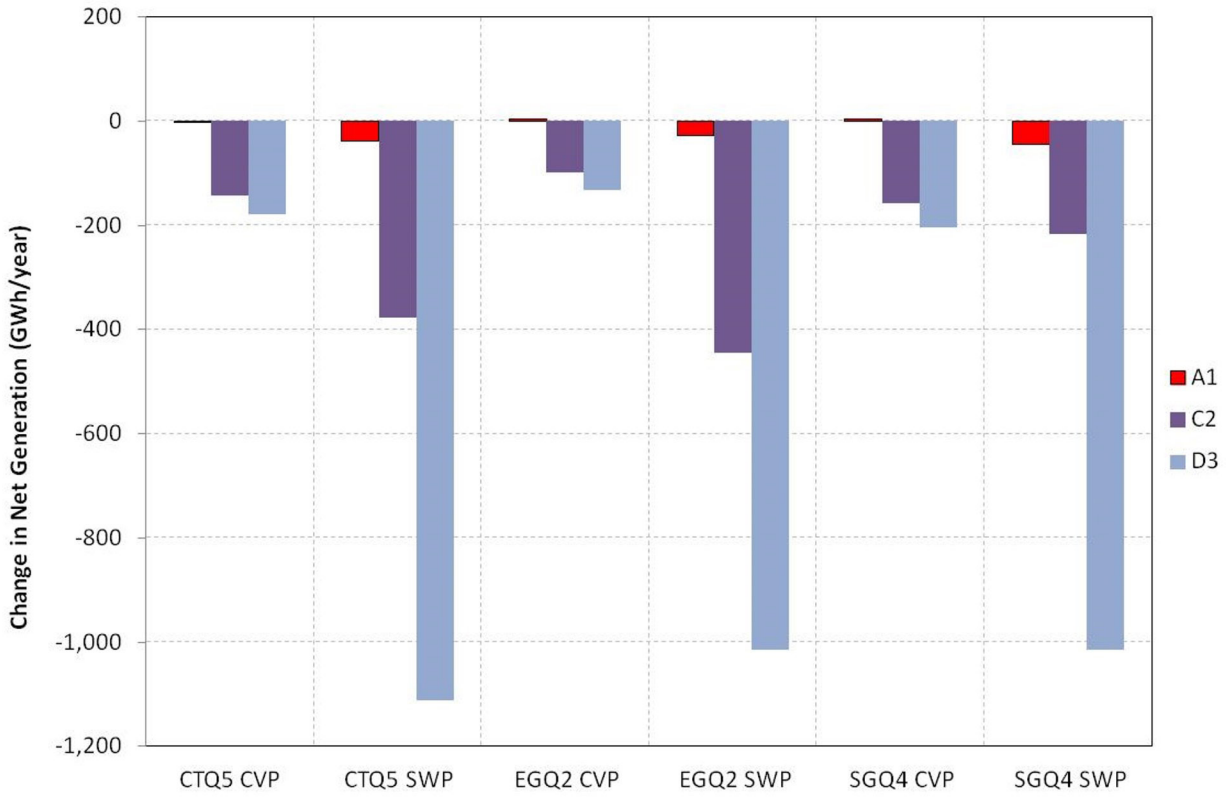

Figure 7-234. Change in Average Annual Net Energy Generation for the CVP and SWP Systems in Portfolio D

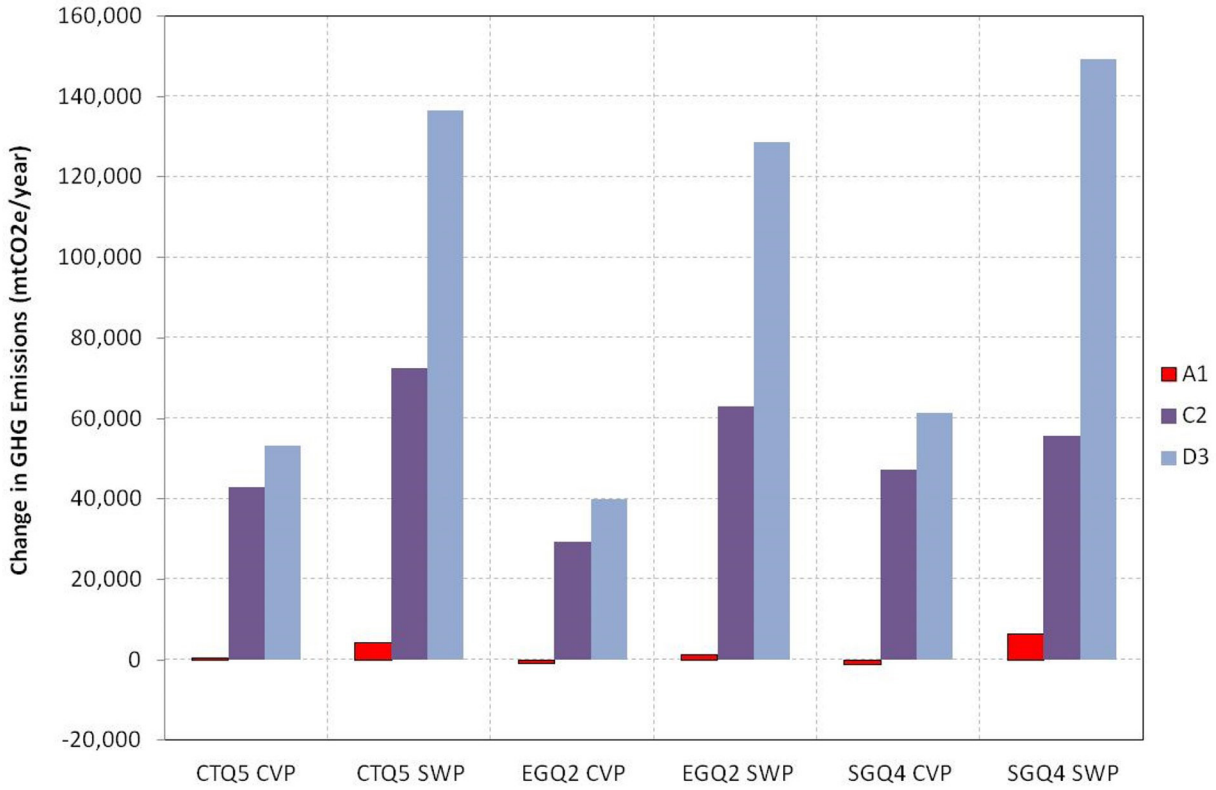

Figure 7-235. Change in Average Annual Greenhouse Gas Emissions for the CVP and SWP Systems in Portfolio D

3. Enlarged Shasta
4. Sites Reservoir

Table 7-5 shows the actions that are included in each simulation suite.

7.5.1 Supplies and Demands in CVP Divisions

Figure 7-236 shows the average reduction in unmet demand in the CVP Service Area in each Portfolio E suite in each scenario. Figures 7-237 through 7-245 show the same information for each of the CVP Divisions. As discussed in Portfolio A above, the reduction in unmet demand in the CVP Service Area ranged from 574 to 1,737 TAF/year (16–29 percent of Baseline unmet demands) with A3 aggressive demand-reduction actions across the range of simulated scenarios. Consistent with the reductions in Delta exports in E2, the reductions in unmet demand decreased to 408 to 1,360 TAF/year (11–24 percent of Baseline unmet demands) with the addi-tion of EEF in E2. However, there were additional reductions in unmet demands relative to E2 with the addition of the Enlarged Shasta action in E3 and of NODOS in E4. The range of reductions in unmet demand was 427 to 1,394 TAF/year (11–24 percent of Baseline unmet demands) in E3 and 453 to 1,471 TAF/year (12–25 percent of Baseline unmet demands) in E4 across the range of simulated scenarios.

Figures 7-246 through 7-248 show the annual time series of groundwater, surface water, and local project supplies, and the unmet demands for the CVP Service Area under CT-Q5, EG-Q2, and SG-Q4 scenarios under Portfolio E Suite E2. Figures 7-249 through 7-251 show the same information for Suite E3, and Figures 7-252 through 7-254 show the same information for Suite E4. This information was previously shown for Suite A3 in the discussion on Portfolio A above. Unmet demands in A3 ranged from 700 to 10,700 TAF/year in CT-Q5, from 800 to 14,100 TAF/year in EG-Q2, and from 600 to 6,800 TAF/year in SG Q4. Suite E2 showed significant increases in unmet demand relative to A3 due to the reductions in surface water deliveries that resulted from the EEF requirements. Unmet demands in E2 ranged from 800 to 11,000 TAF/year in CT Q5, from 1,000 to 14,400 TAF/year in EG-Q2, and from 700 to 7,200 TAF/year in SG-Q4. However, these increases in unmet demand were reduced in E3 and E4 with the addition of North-of-Delta storage actions. Unmet demands in E3 ranged from 800 to 11,000 TAF/year in CT-Q5, from 900 to 14,400 TAF/year in EG-Q2, and from 700 to 7,200 TAF/year in SG-Q4. Unmet demands in E4 ranged from 800 to 10,900 TAF/year in CT-Q5, from 900 to 14,400 TAF/year in EG-Q2, and from 600 to 7,200 TAF/year in SG-Q4.

7.5.2 CVP and SWP System Operations

The following sections describe the results of each simulation suite.

7.5.2.1 CVP and SWP Project Storage

Figures 7-255 through 7-270 show the exceedance plots of storage in the Baseline and for each Portfolio E simulation suite at the end of May and the end of September in Shasta, Sites Reservoir,

Table 7-5. Simulation Suites and Assumptions Included in Portfolio E

	Simulation Suite A1	Simulation Suite E2	Simulation Suite E3	Simulation Suite E4
Baseline Assumptions	x	x	x	x
Local Actions				
Modest Ag and M&I Conservation	x	x	x	x
Municipal Recycling and Desalination	x	x	x	x
Aggressive Ag and M&I Conservation	x	x	x	x
Systemwide Actions				
Delta Conveyance				
Shasta Lake Enlargement			x	x
North-of-Delta Offstream Storage				x
South-of-Delta SW or GW Storage				
Enhanced Environmental Flows		x	x	x

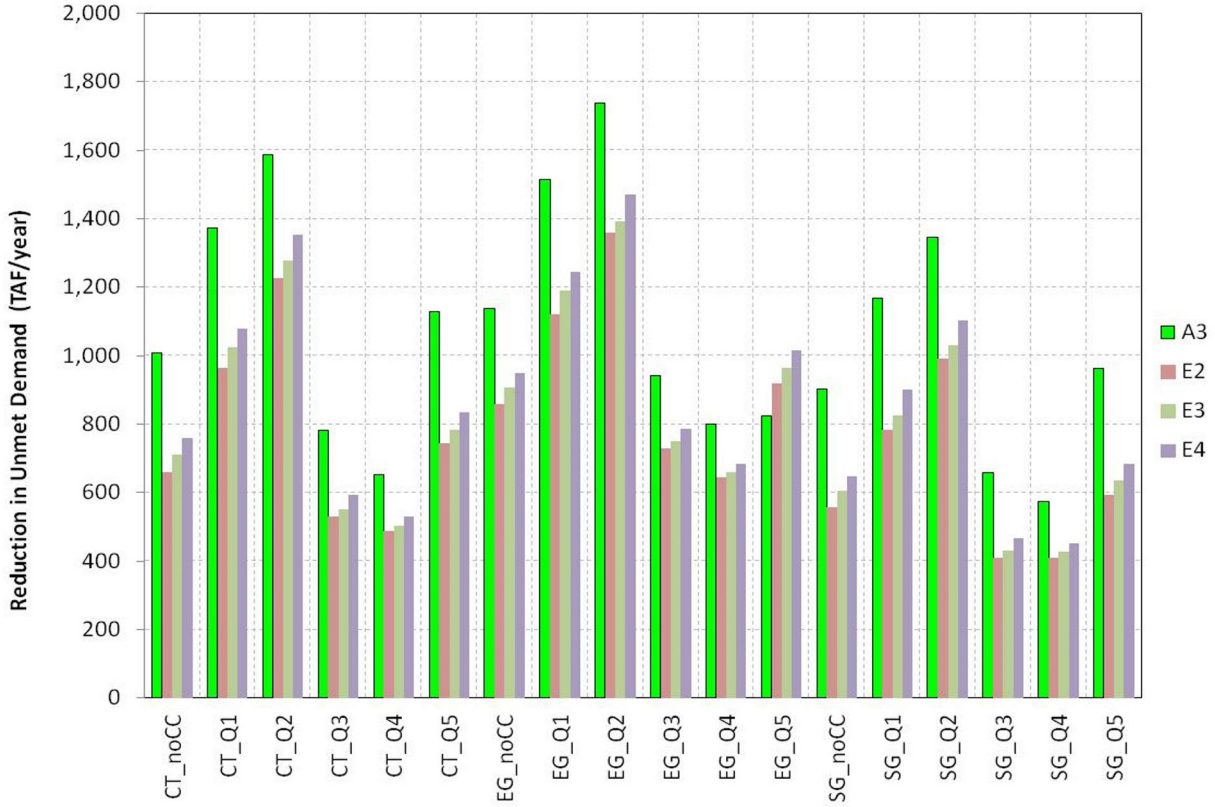

Figure 7-236. Average Annual Reduction in Unmet Demand in the CVP Service Area for Portfolio E in Each Scenario

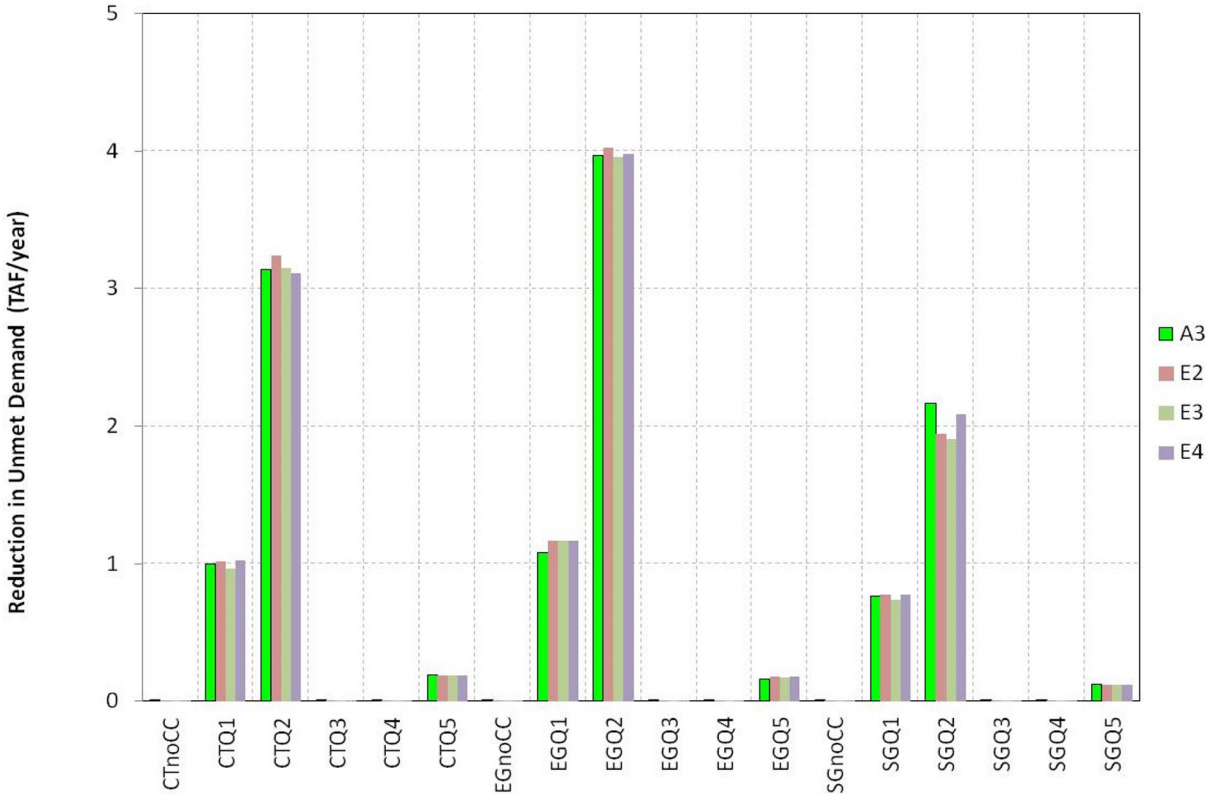

Figure 7-237. Average Annual Reduction in Unmet Demand in the American River Division for Portfolio E in Each Scenario

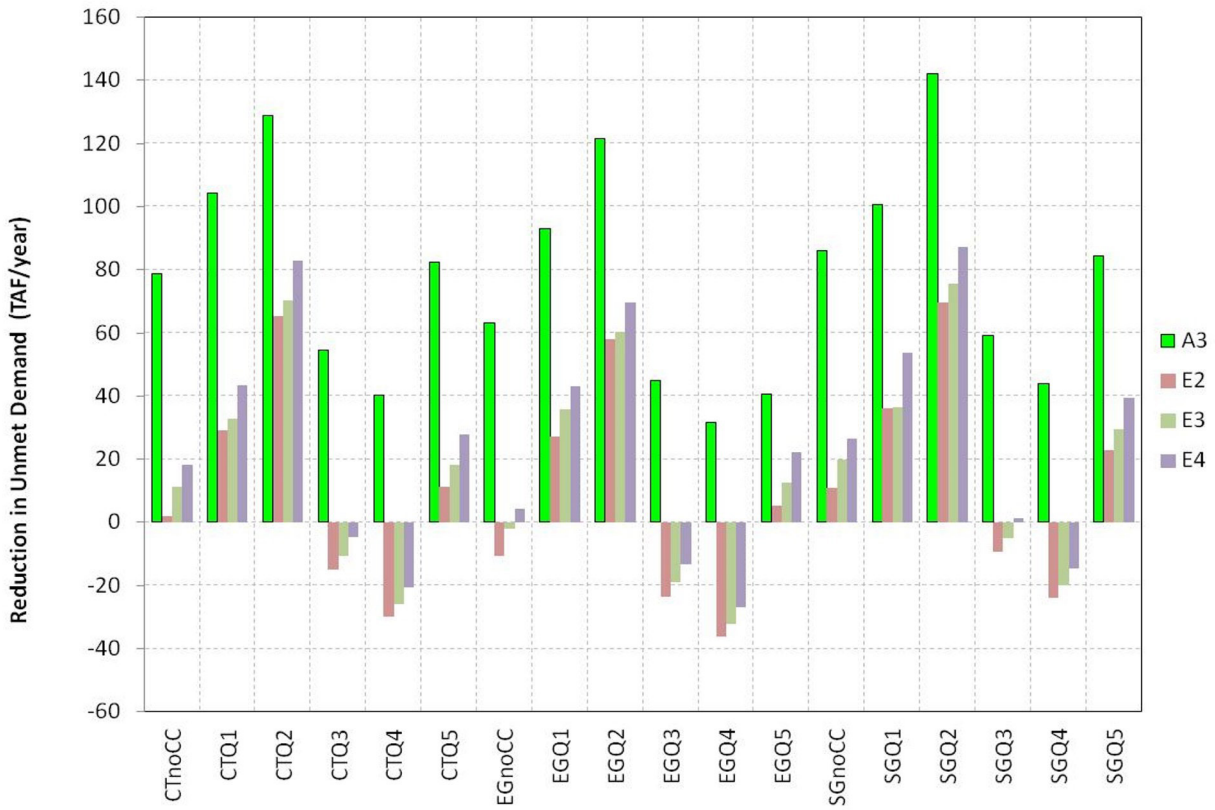

Figure 7-238. Average Annual Reduction in Unmet Demand in the Delta Division for Portfolio E in Each Scenario

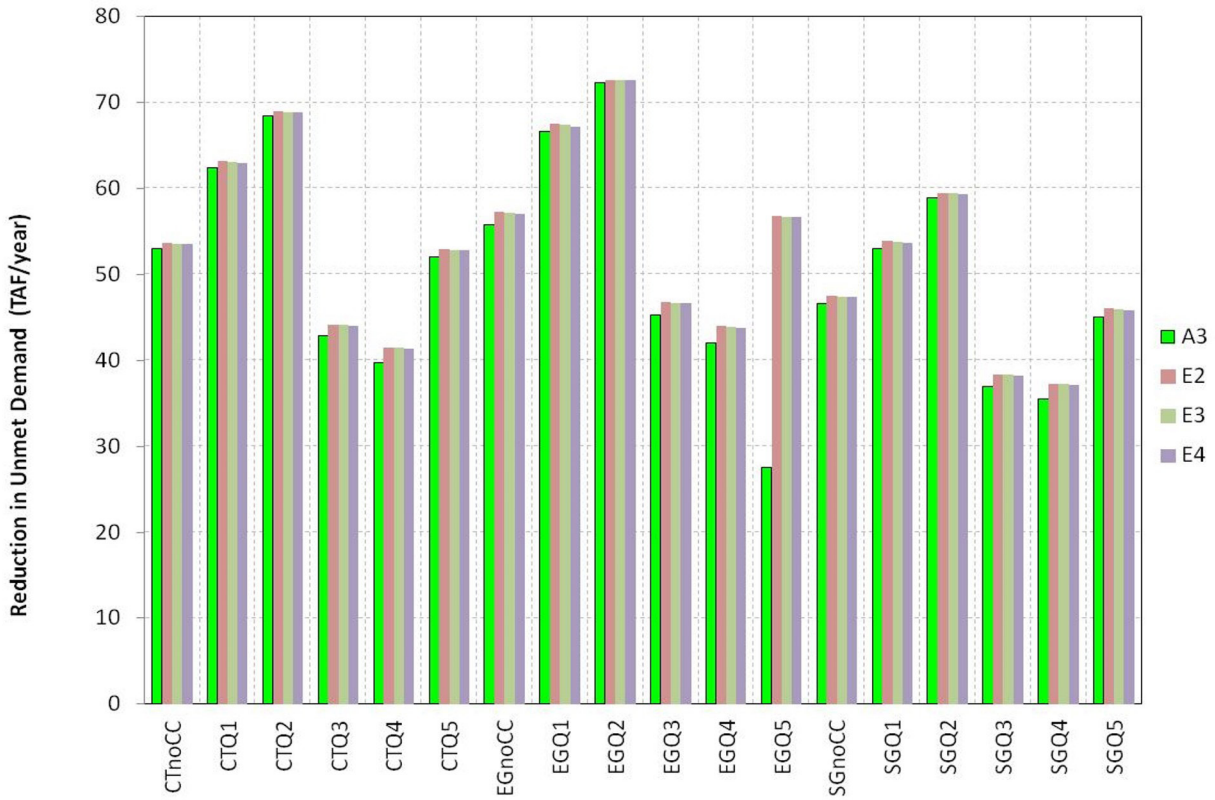

Figure 7-239. Average Annual Reduction in Unmet Demand in the East Side Division for Portfolio E in Each Scenario

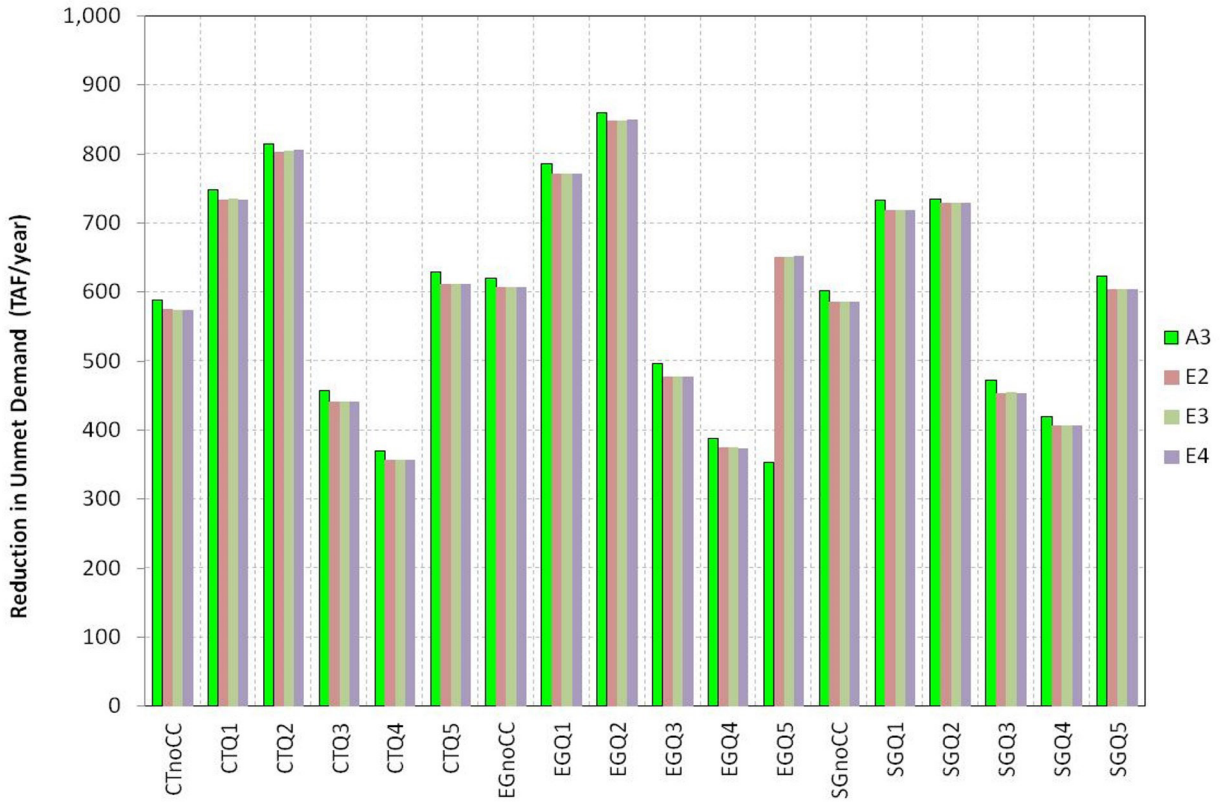

Figure 7-240. Average Annual Reduction in Unmet Demand in the Friant Division for Portfolio E in Each Scenario

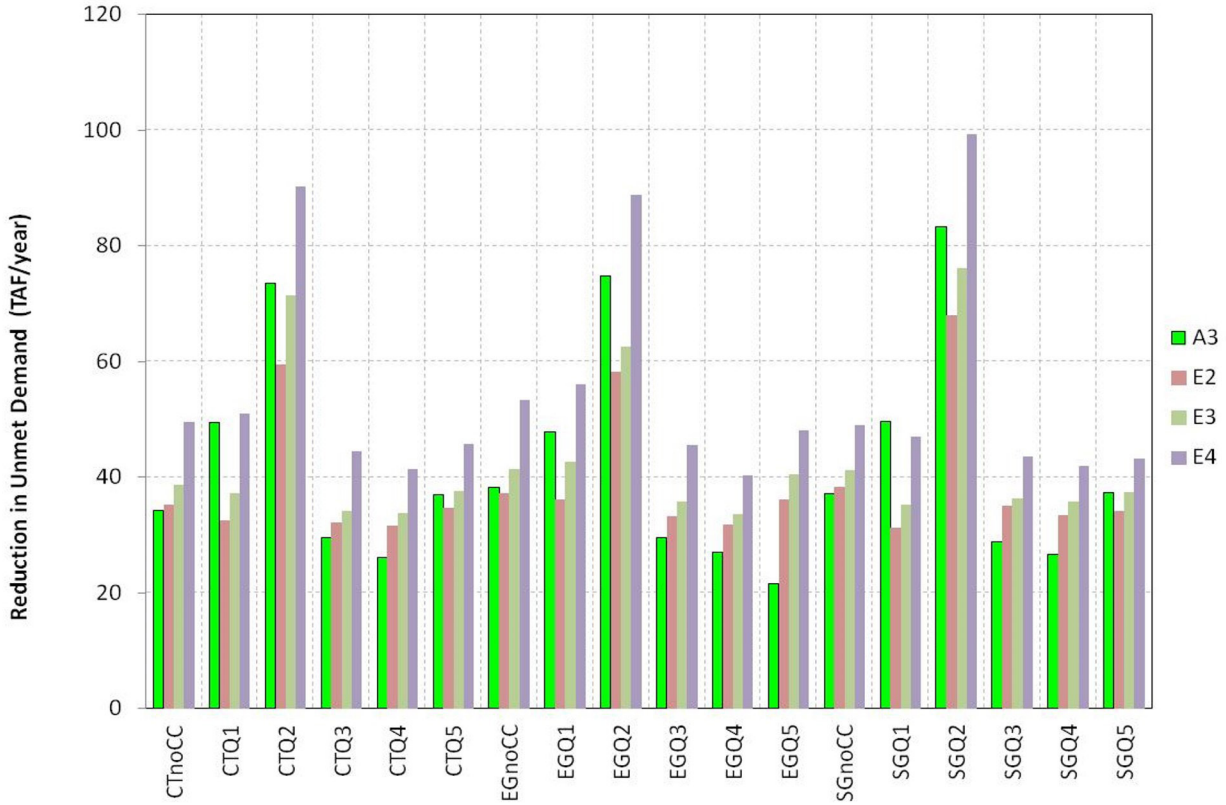

Figure 7-241. Average Annual Reduction in Unmet Demand in the Sacramento River Division for Portfolio E in Each Scenario

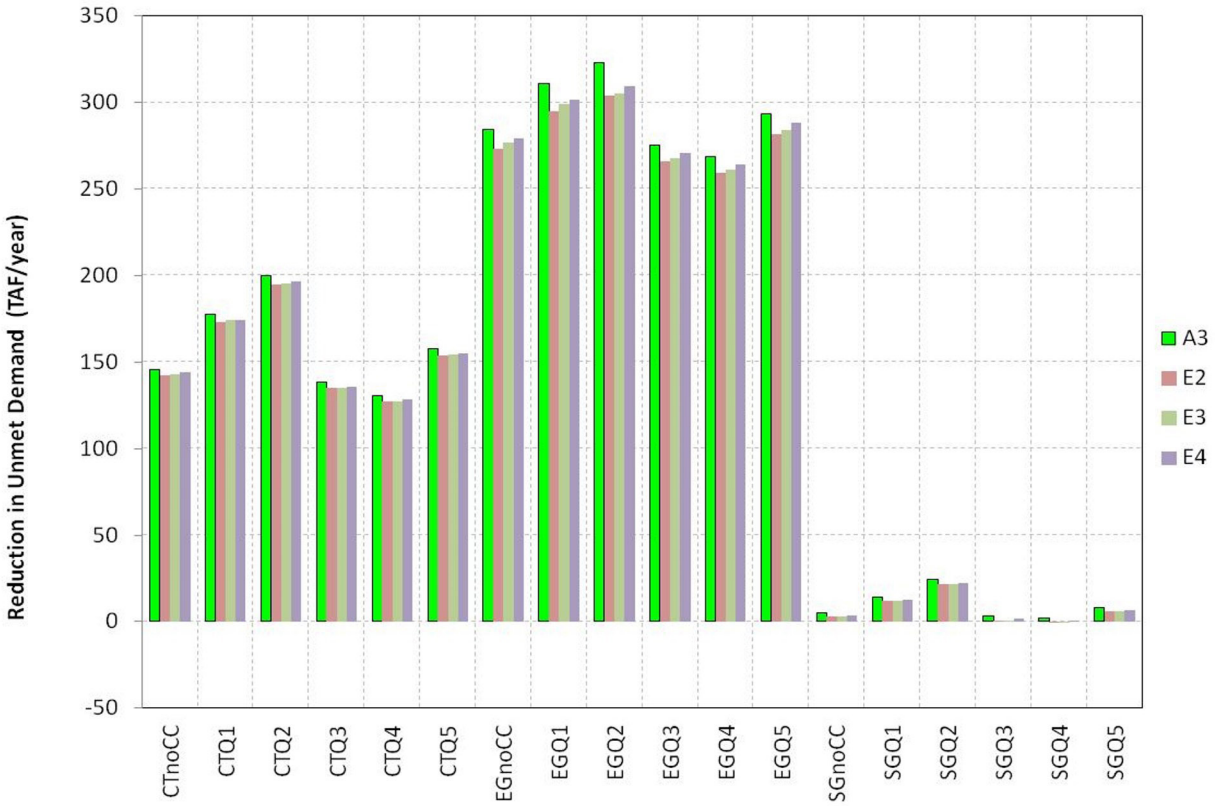

Figure 7-242. Average Annual Reduction in Unmet Demand in the San Felipe Division for Portfolio E in Each Scenario

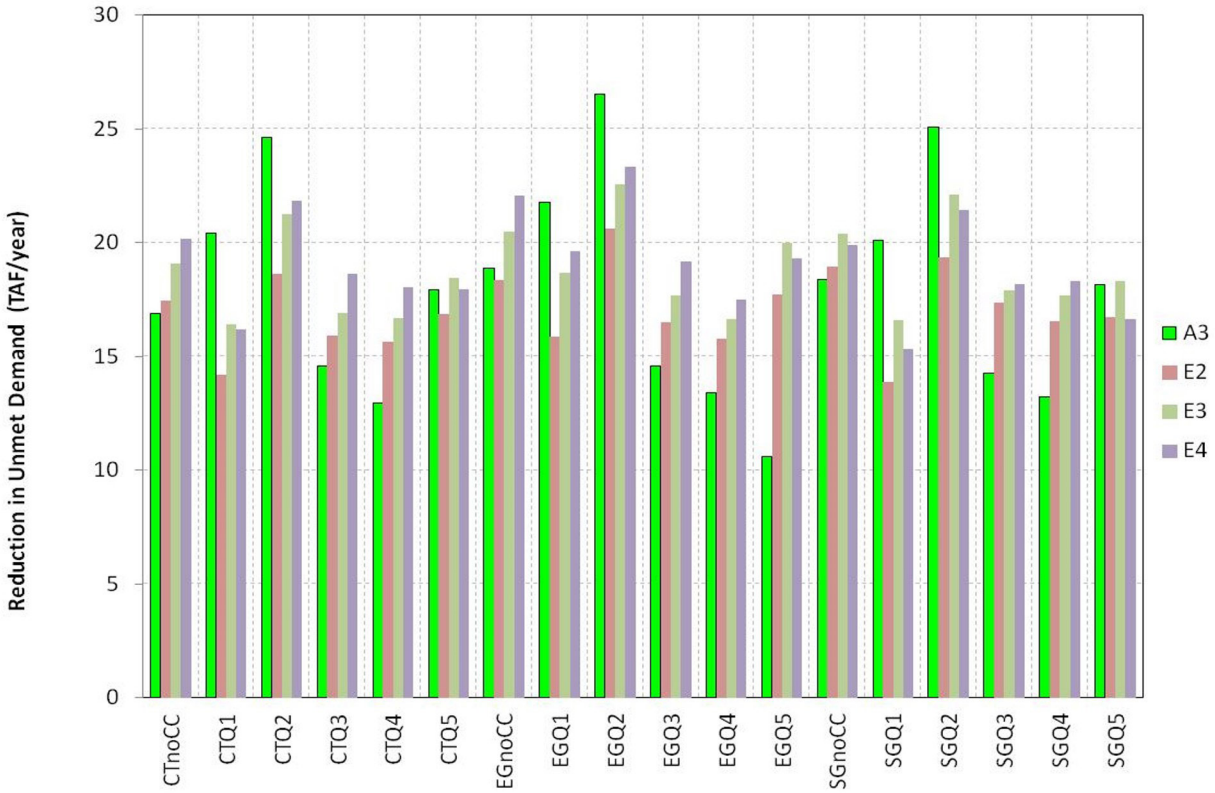

Figure 7-243. Average Annual Reduction in Unmet Demand in the Shasta Division for Portfolio E in Each Scenario

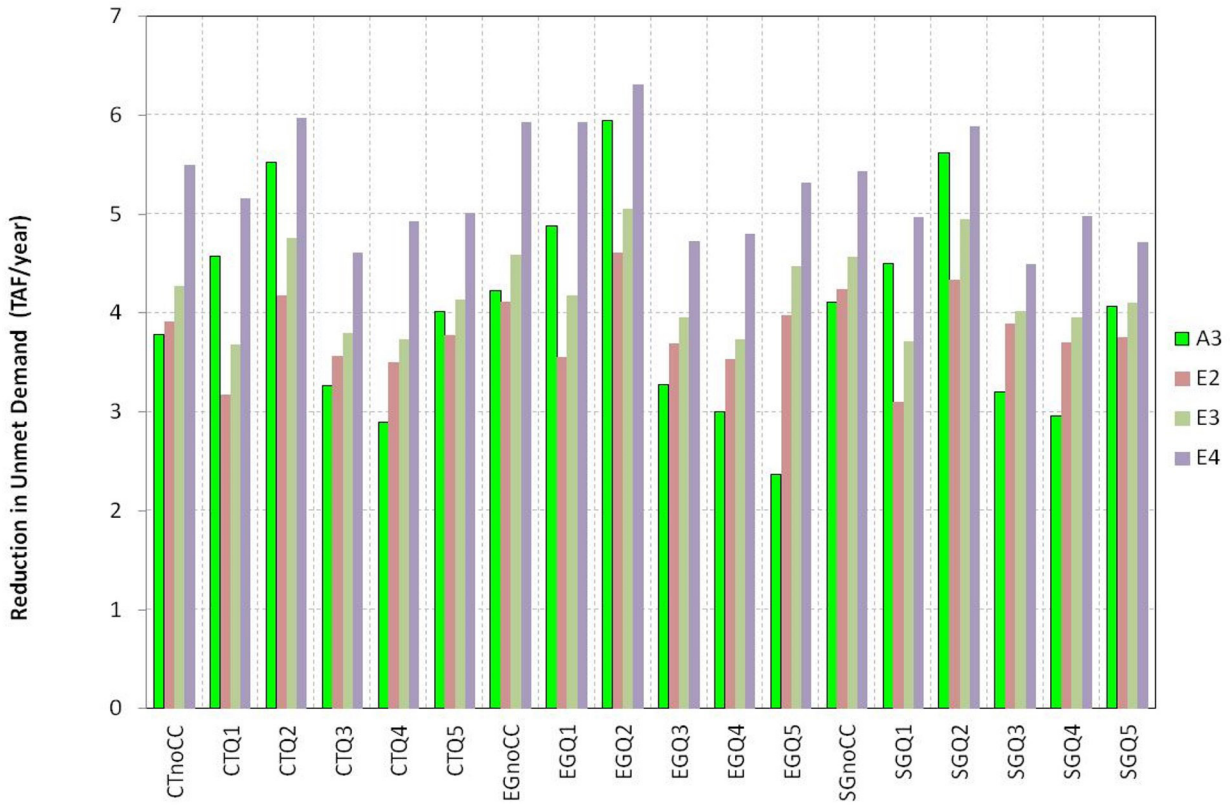

Figure 7-244. Average Annual Reduction in Unmet Demand in the Trinity Division for Portfolio E in Each Scenario

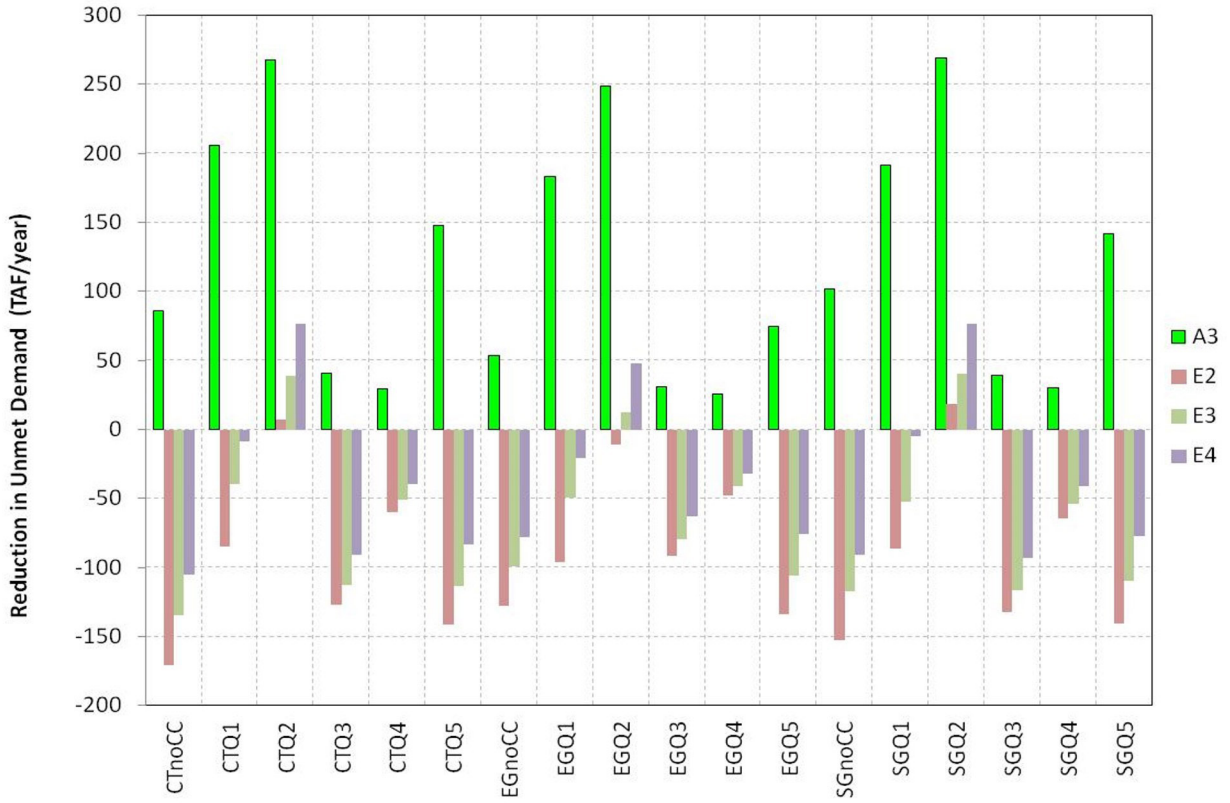

Figure 7-245. Average Annual Reduction in Unmet Demand in the West San Joaquin Division for Portfolio E in Each Scenario

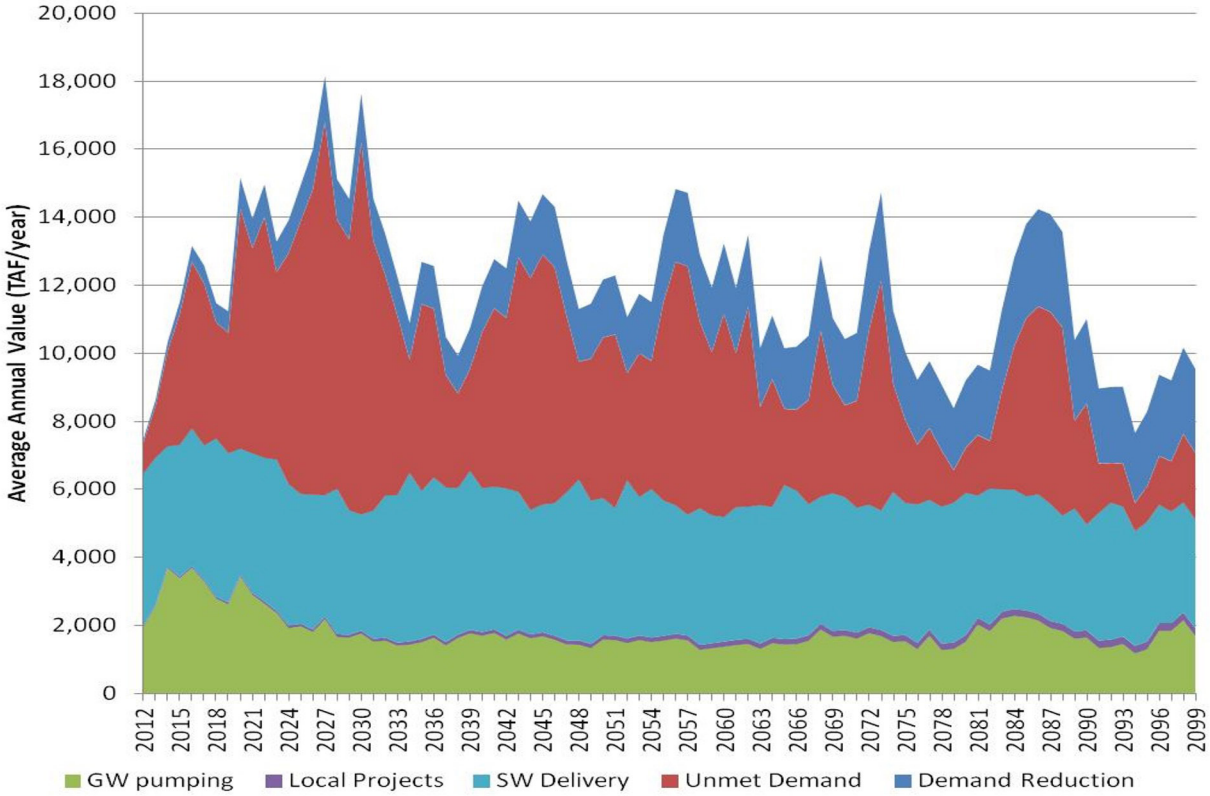

Figure 7-246. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite E2 in the CT-Q5 Scenario

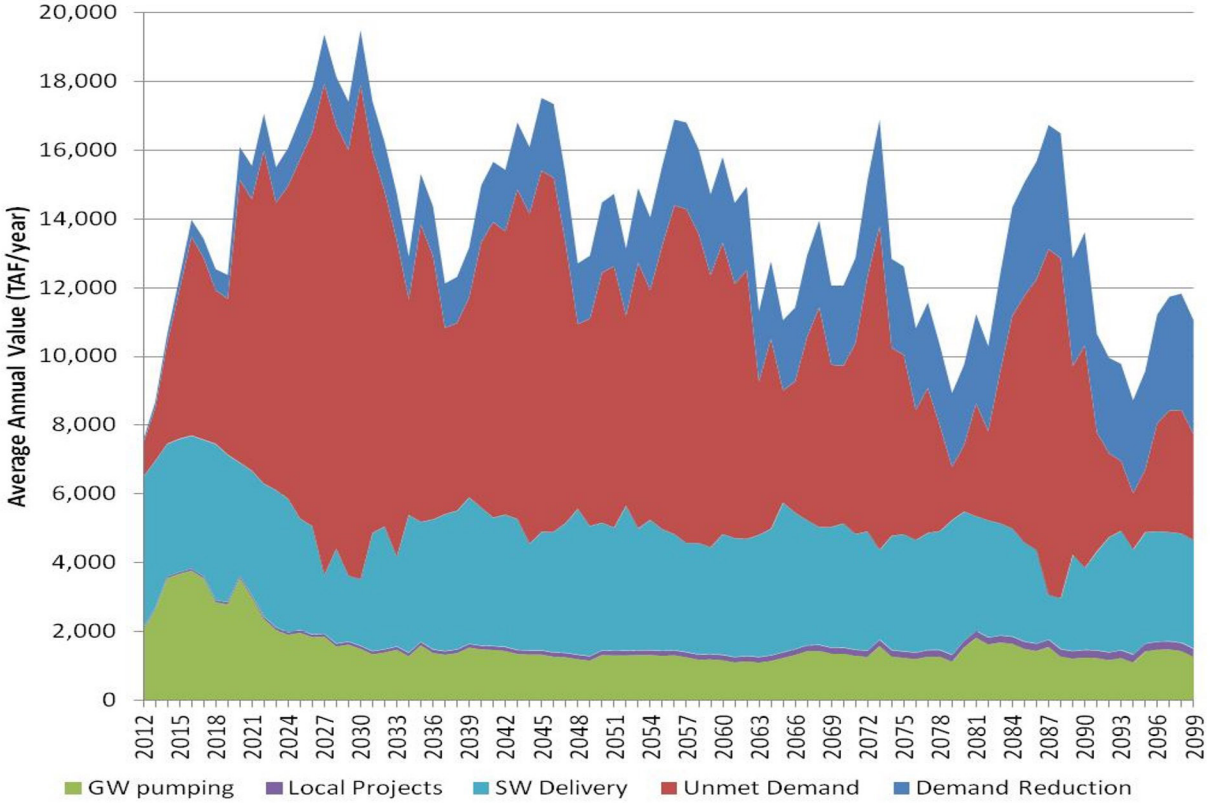

Figure 7-247. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite E2 in the EG-Q2 Scenario

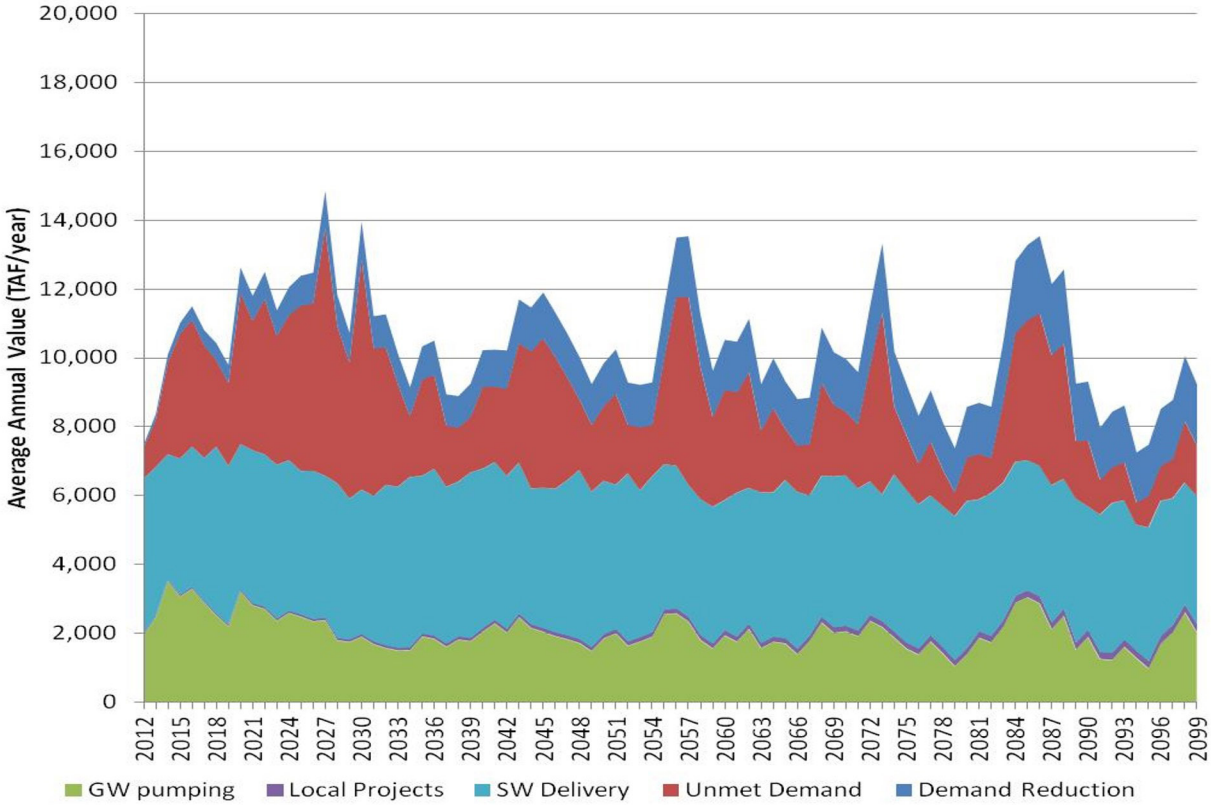

Figure 7-248. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite E2 in the SG-Q4 Scenario

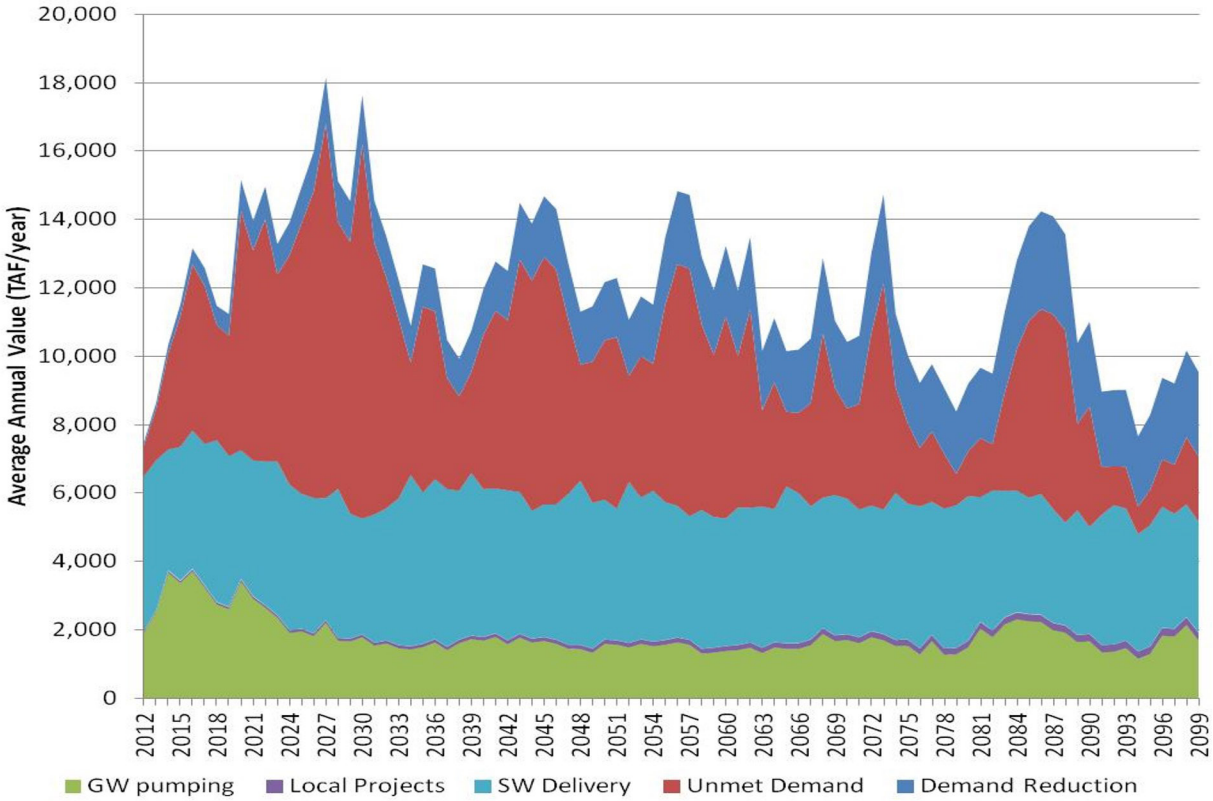

Figure 7-249. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite E3 in the CT-Q5 Scenario

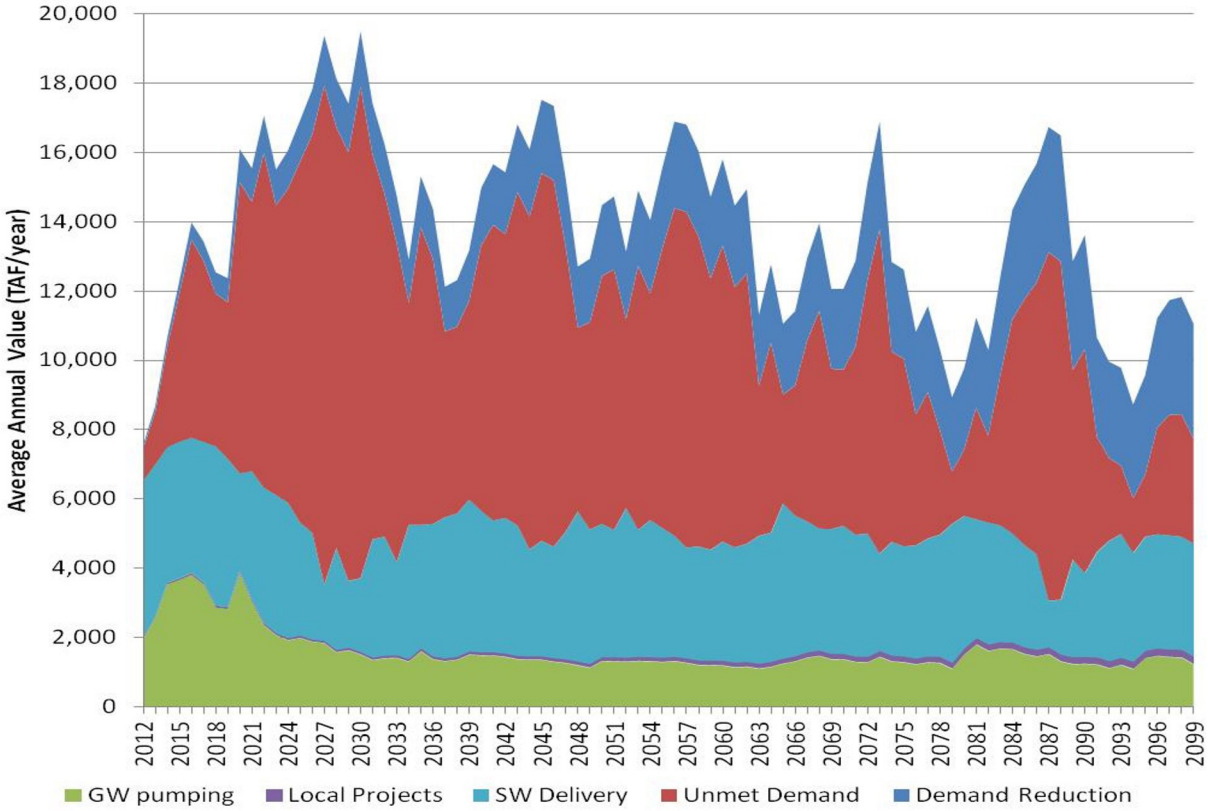

Figure 7-250. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite E3 in the EG-Q2 Scenario

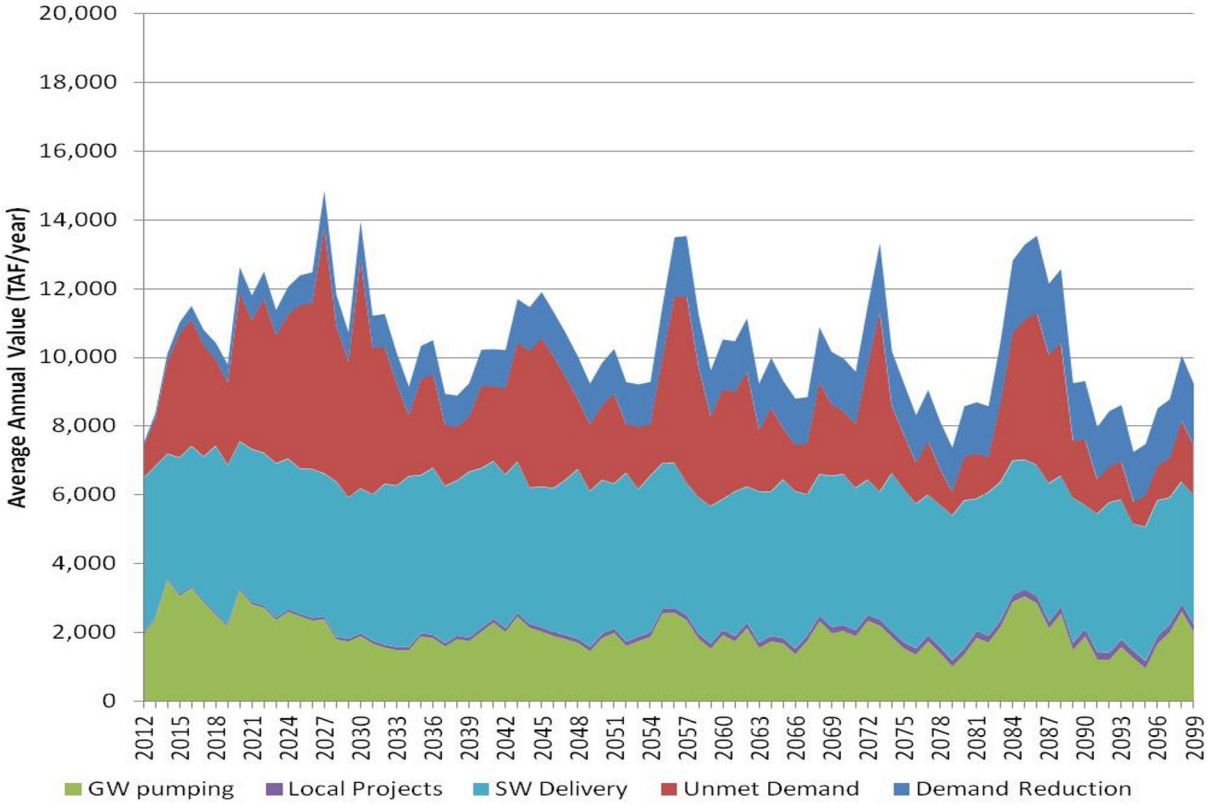

Figure 7-251. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite E3 in the SG-Q4 Scenario

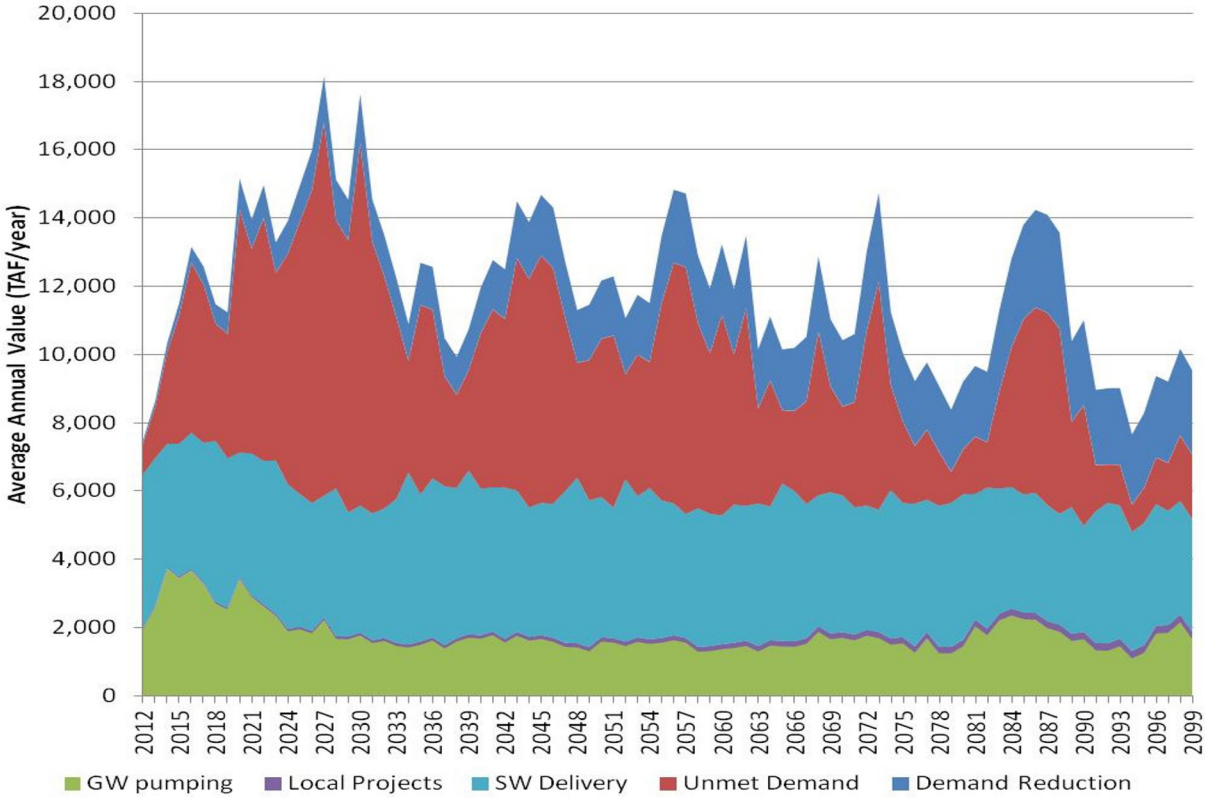

Figure 7-252. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite E4 in the CT-Q5 Scenario

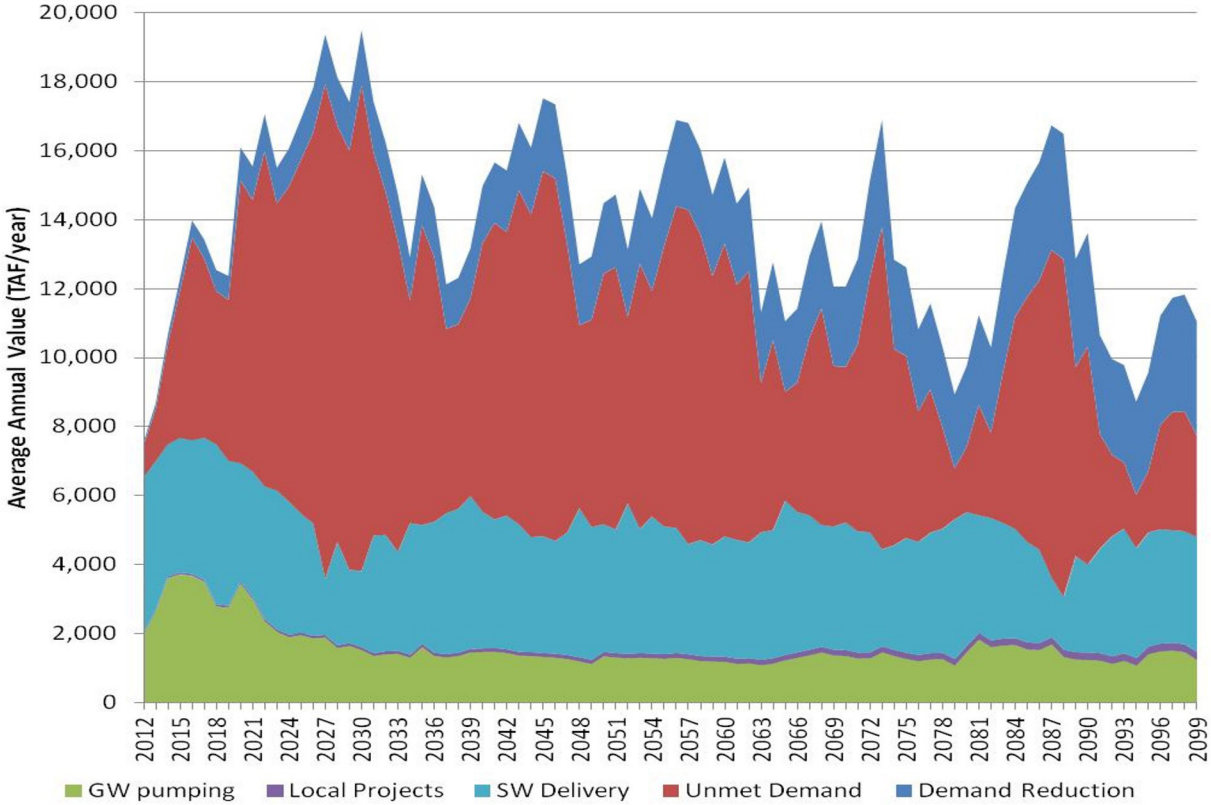

Figure 7-253. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite E4 in the EG-Q2 Scenario

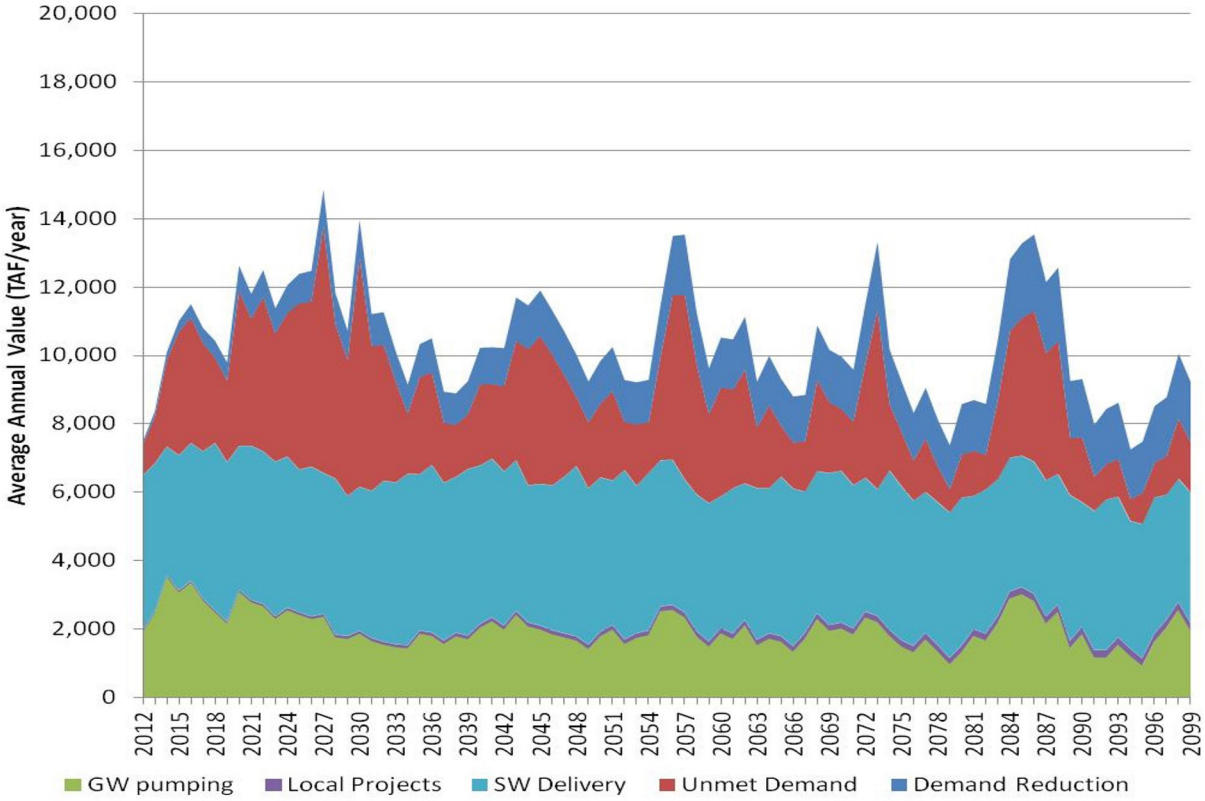

Figure 7-254. Annual Time Series of Supplies and Unmet Demand in the CVP Service Area for Suite E4 in the SG-Q4 Scenario

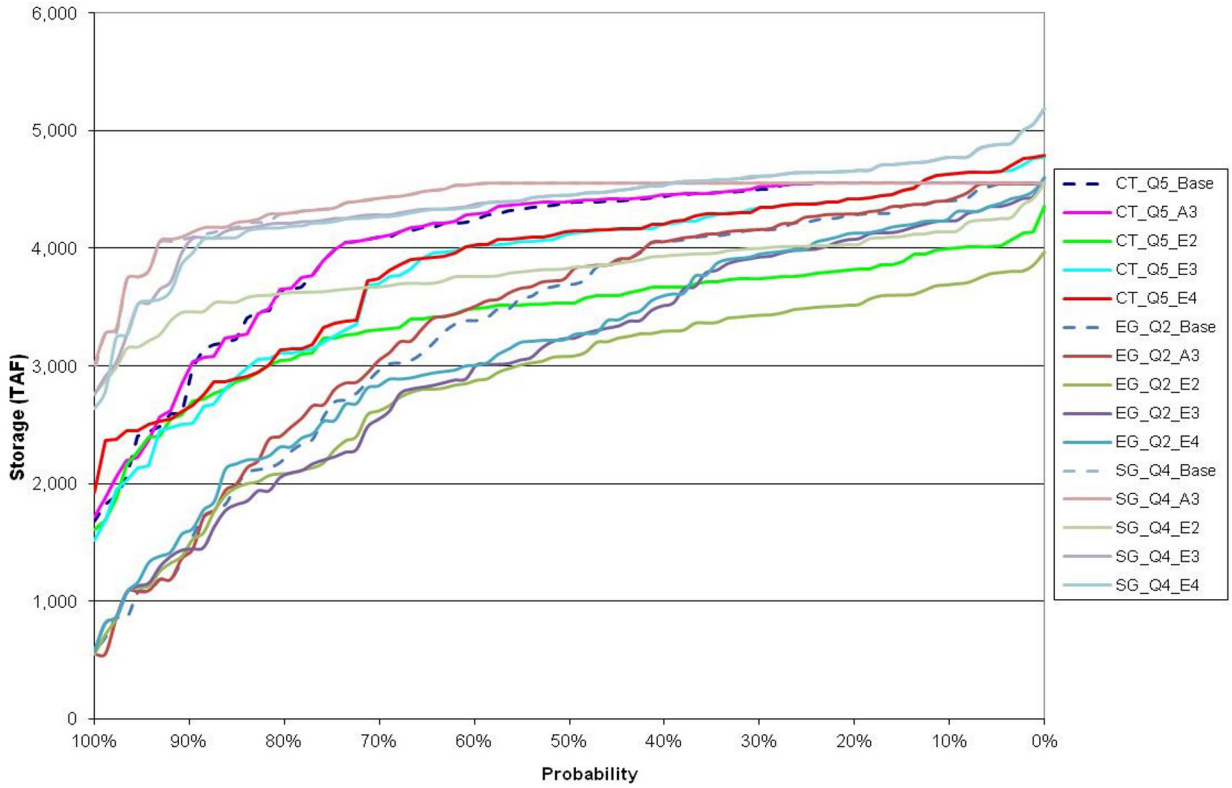

Figure 7-255. Exceedance of Lake Shasta End-of-May Storage in Portfolio E

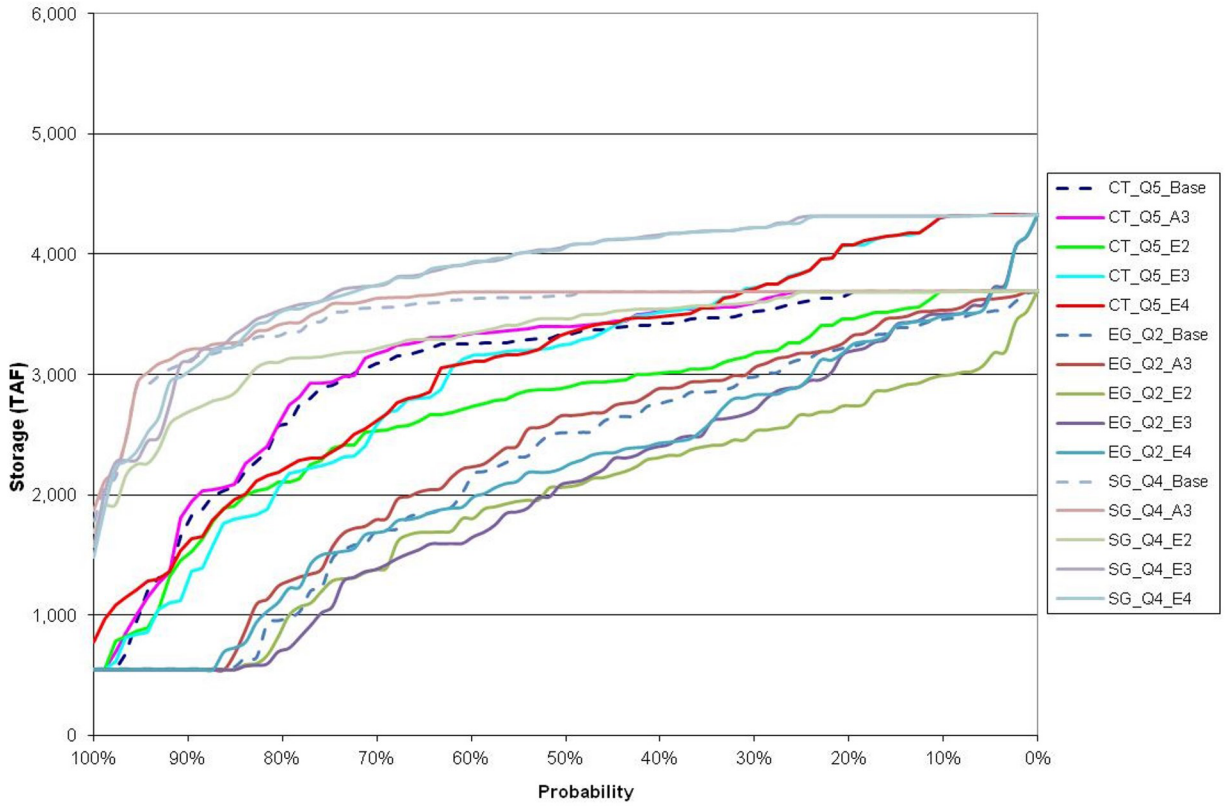

Figure 7-256. Exceedance of Lake Shasta End-of-May Storage in Portfolio E

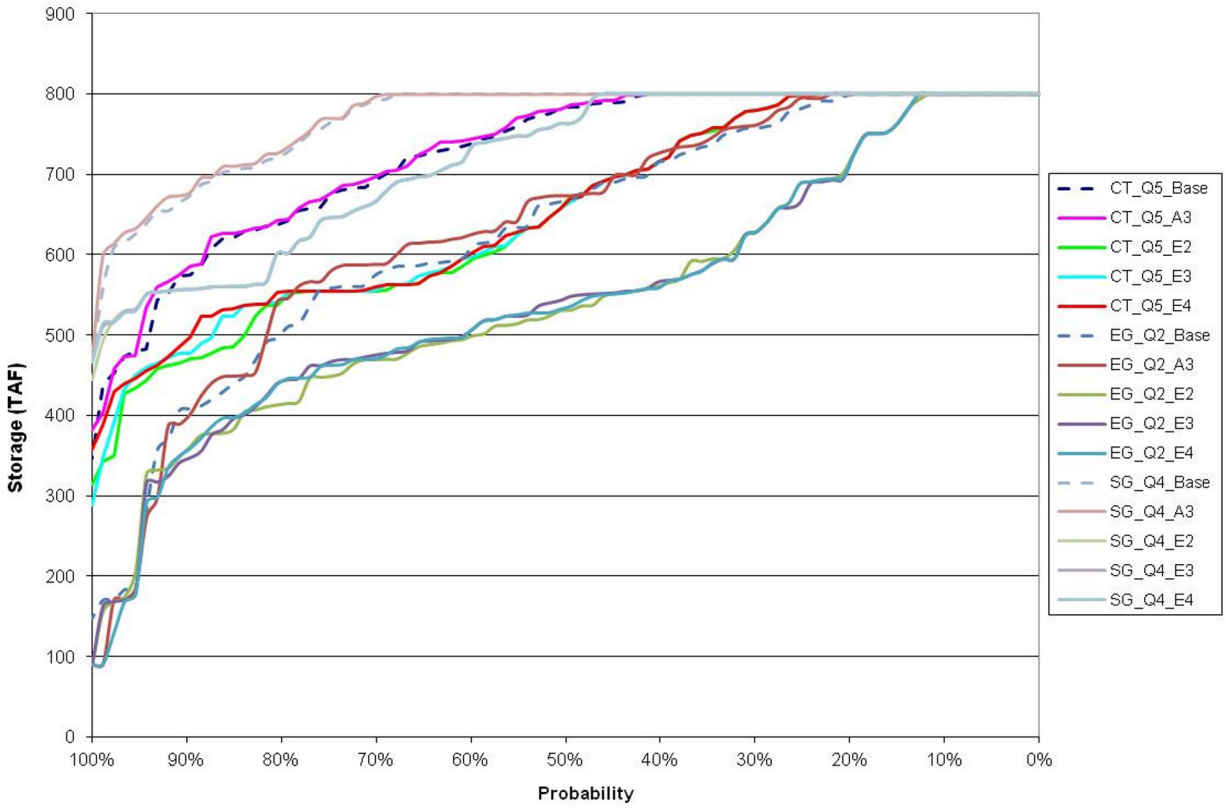

Figure 7-257. Exceedance of Lake Shasta End-of-May Storage in Portfolio E

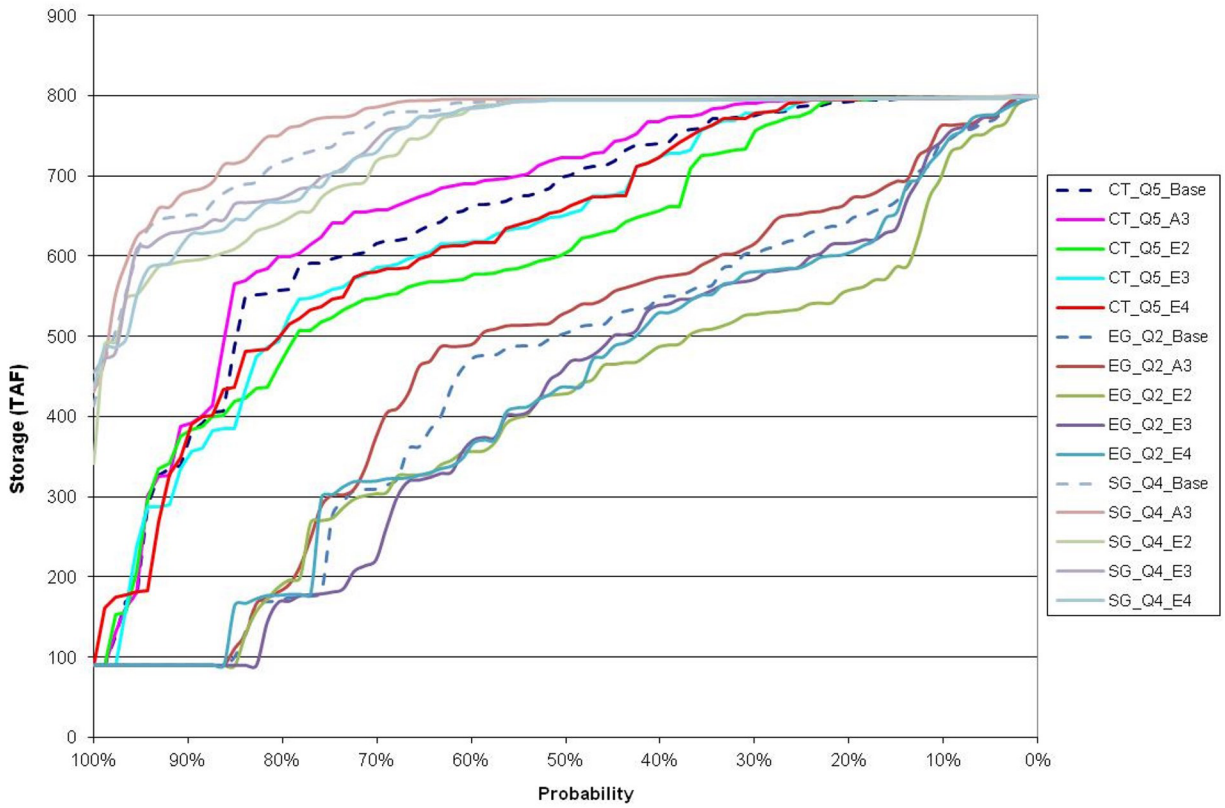

Figure 7-258. Exceedance of Folsom Lake End-of-September Storage in Portfolio E

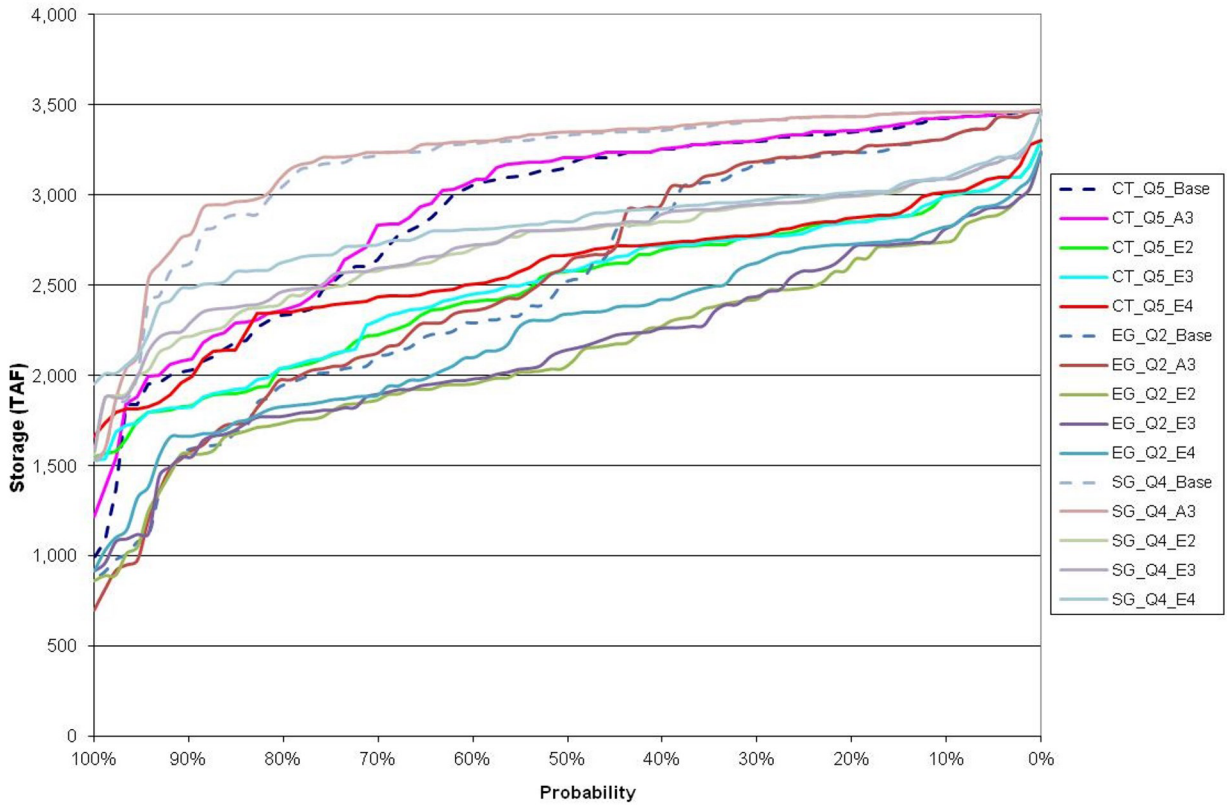

Figure 7-259. Exceedance of Lake Oroville End-of-May Storage in Portfolio E

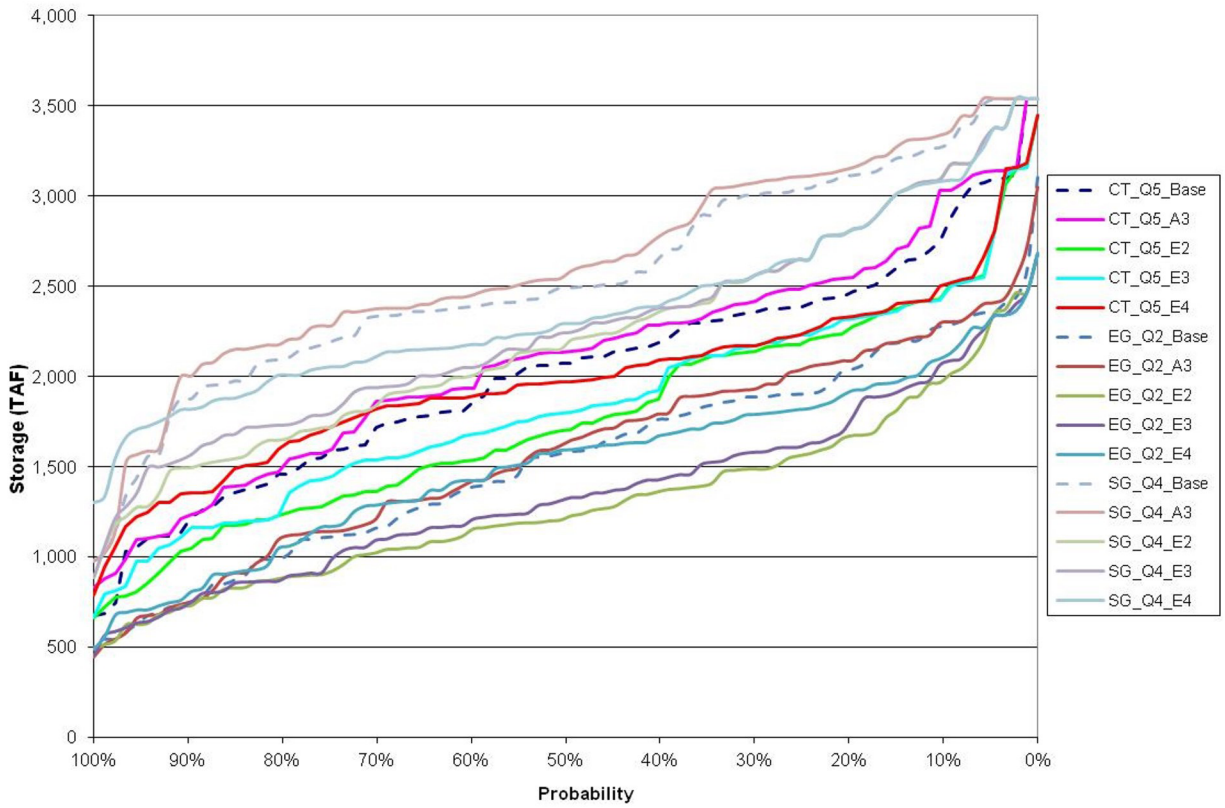

Figure 7-260. Exceedance of Lake Oroville End-of-September Storage in Portfolio E

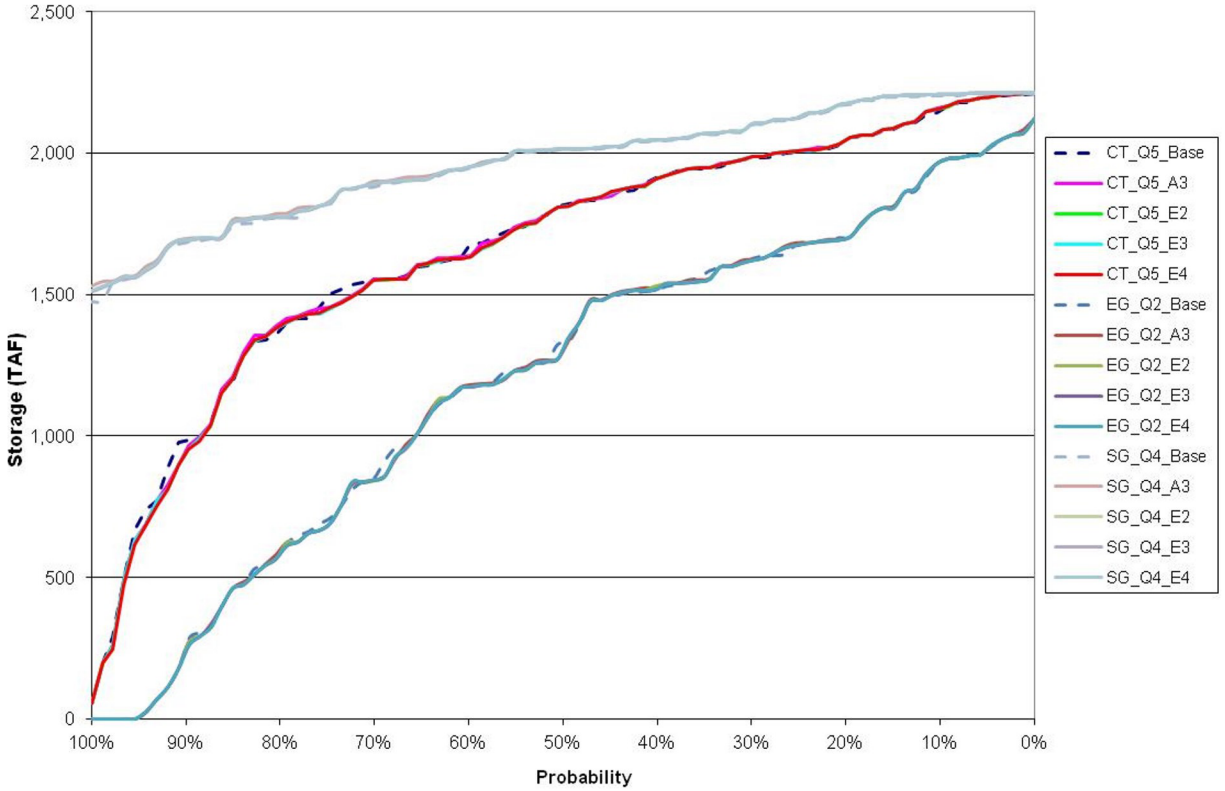

Figure 7-261. Exceedance of New Melones Reservoir End-of-May Storage in Portfolio E

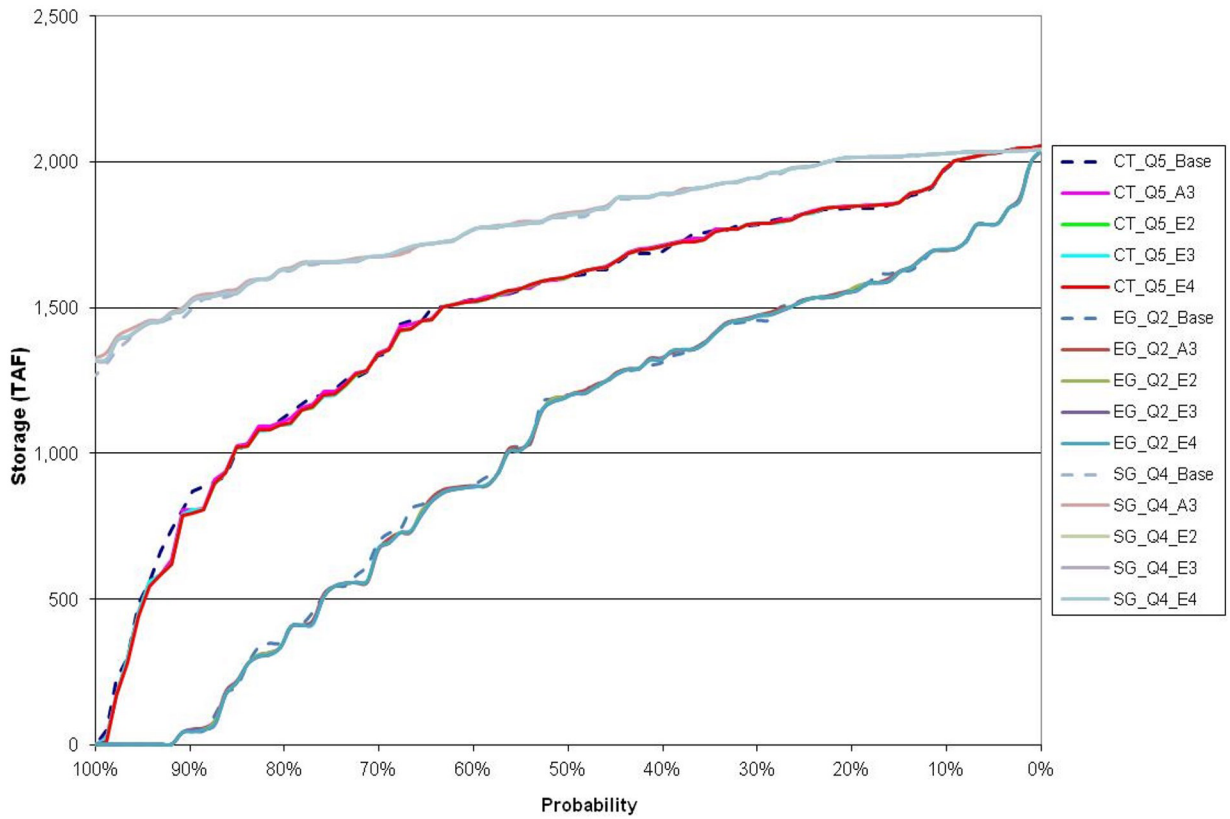

Figure 7-262. Exceedance of New Melones Reservoir End-of-September Storage in Portfolio E

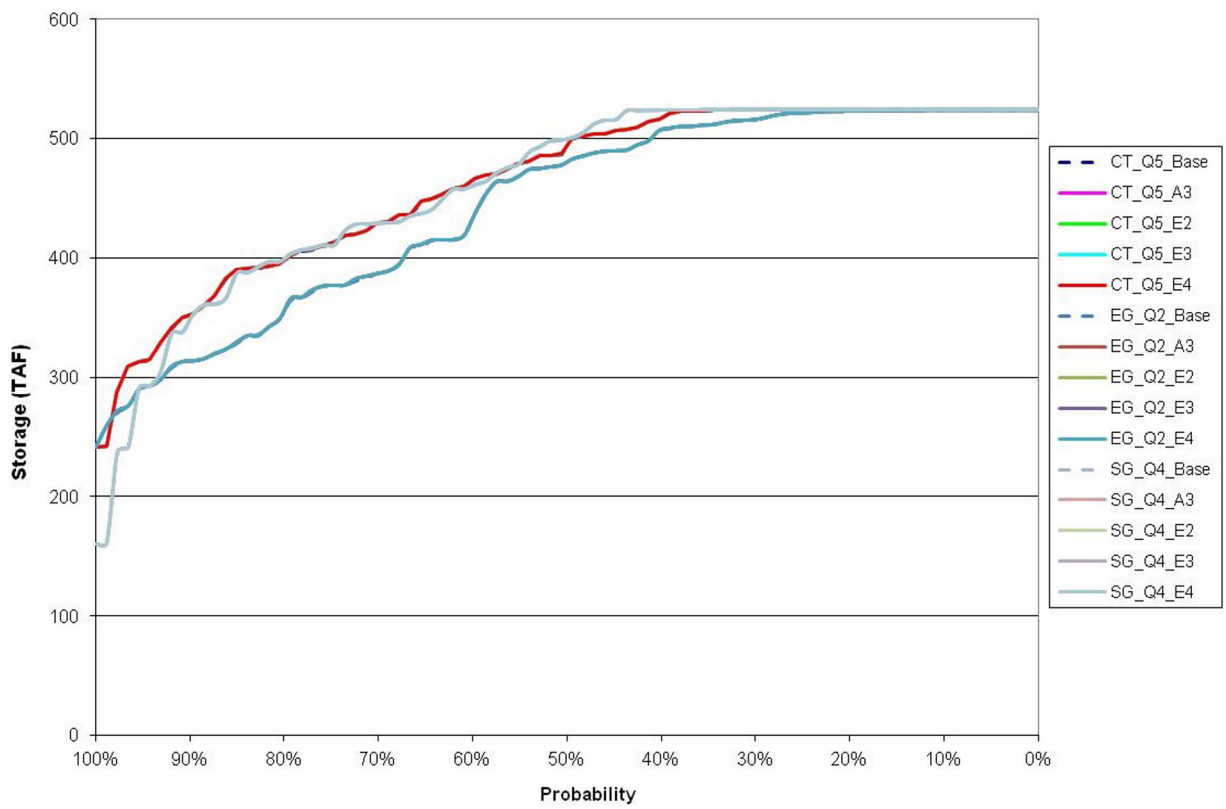

Figure 7-263. Exceedance of Millerton Lake End-of-May Storage in Portfolio E

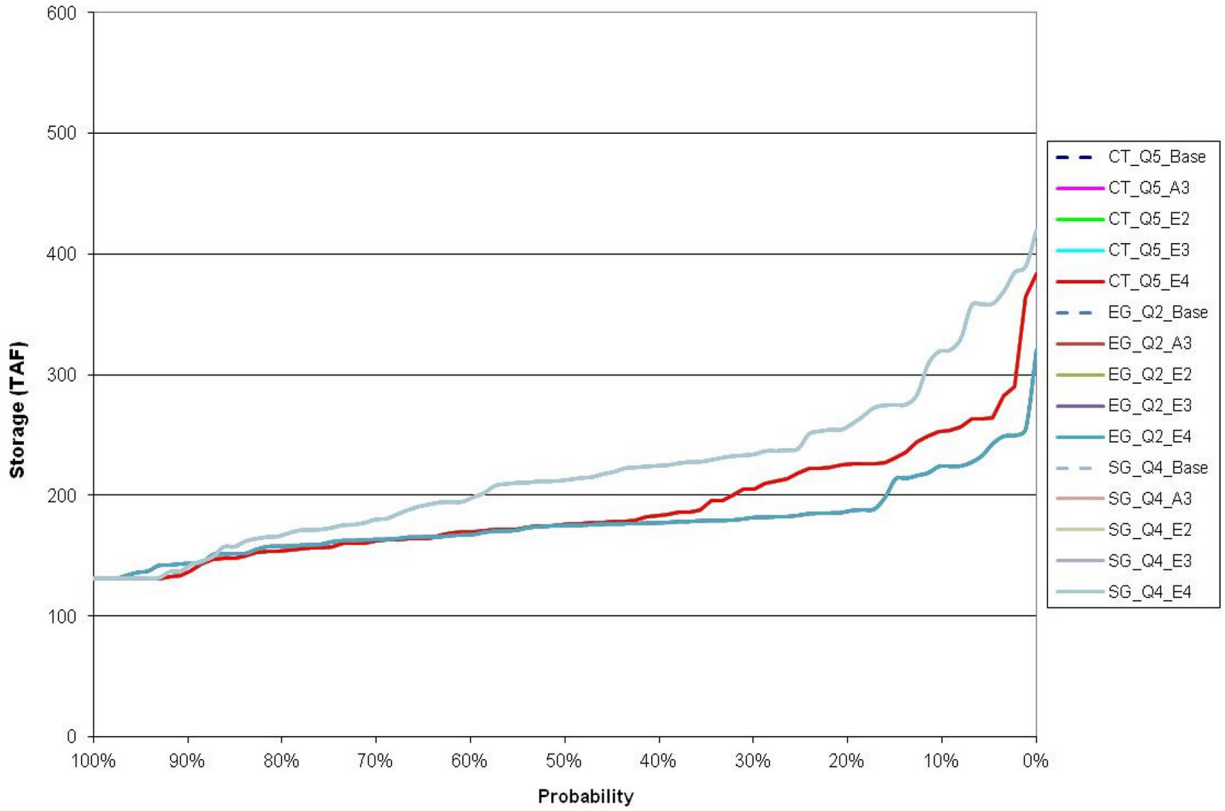

Figure 7-264. Exceedance of Millerton Lake End-of-September Storage in Portfolio E

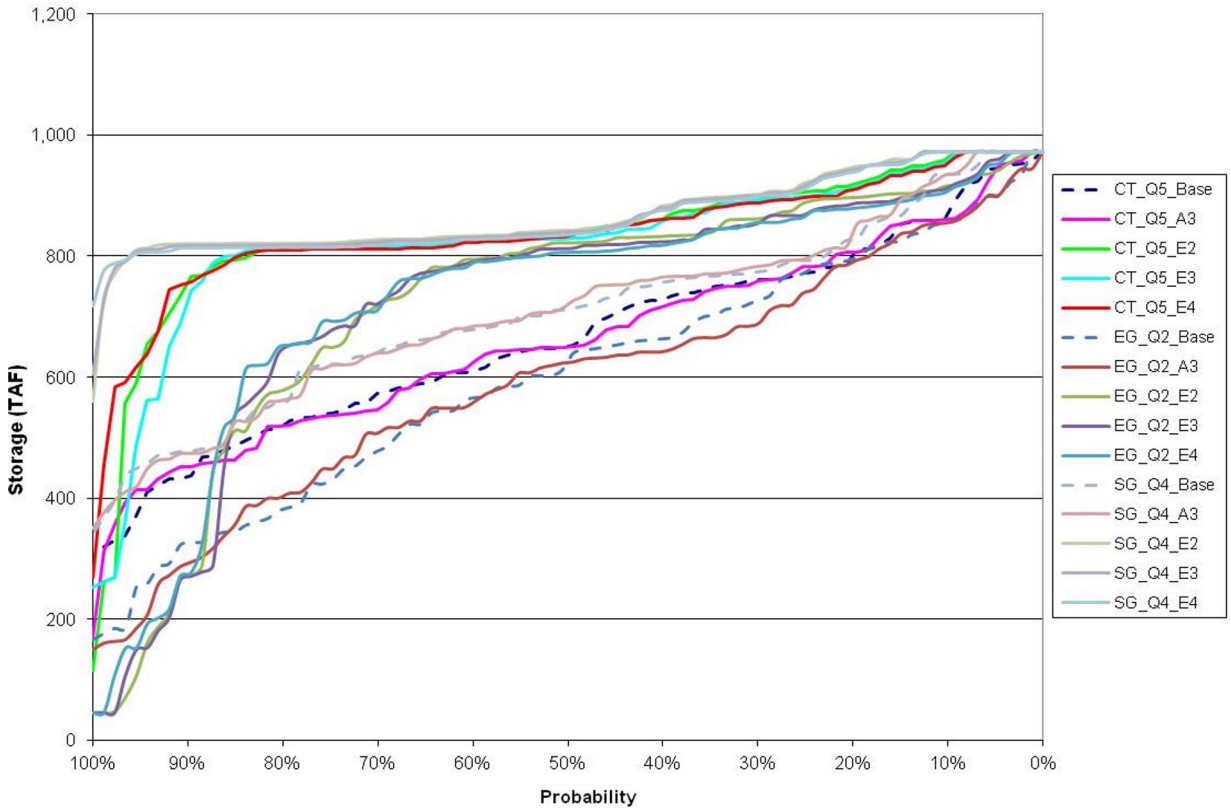

Figure 7-265. Exceedance of CVP San Luis End-of-May Storage in Portfolio E

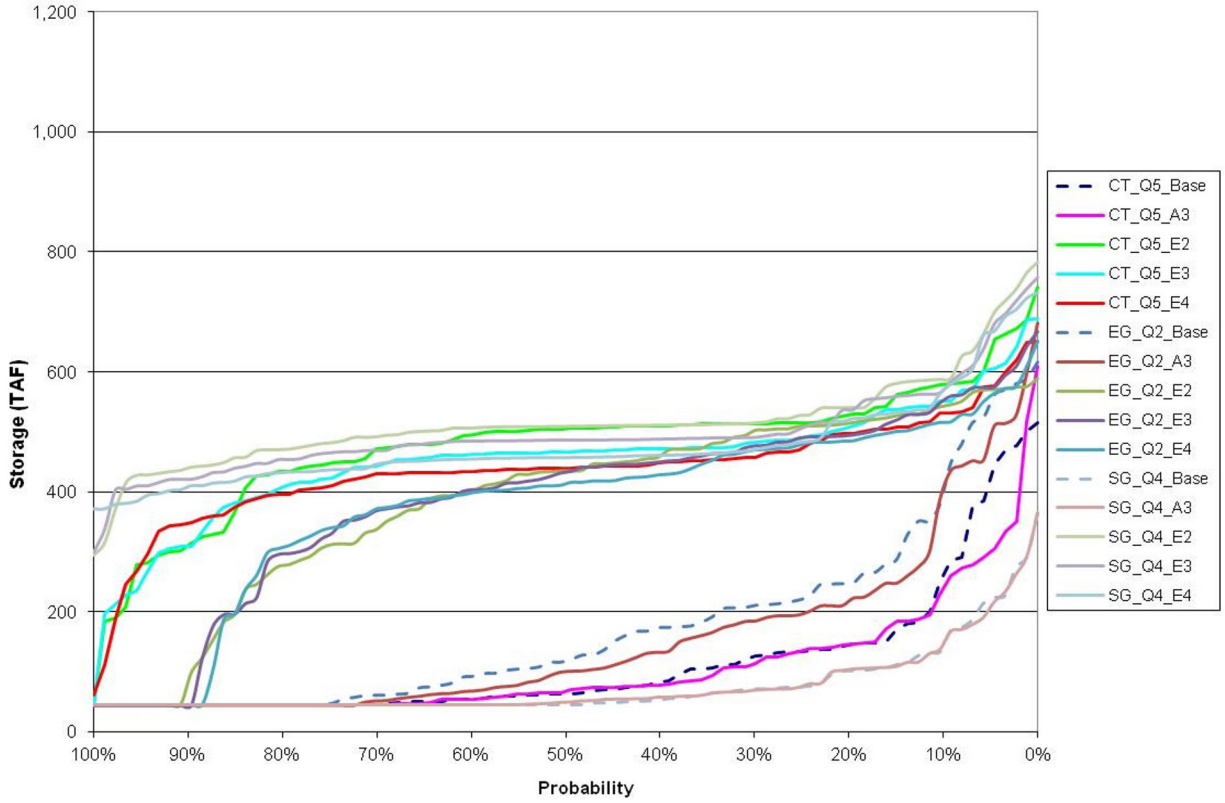

Figure 7-266. Exceedance of CVP San Luis End-of-September Storage in Portfolio E

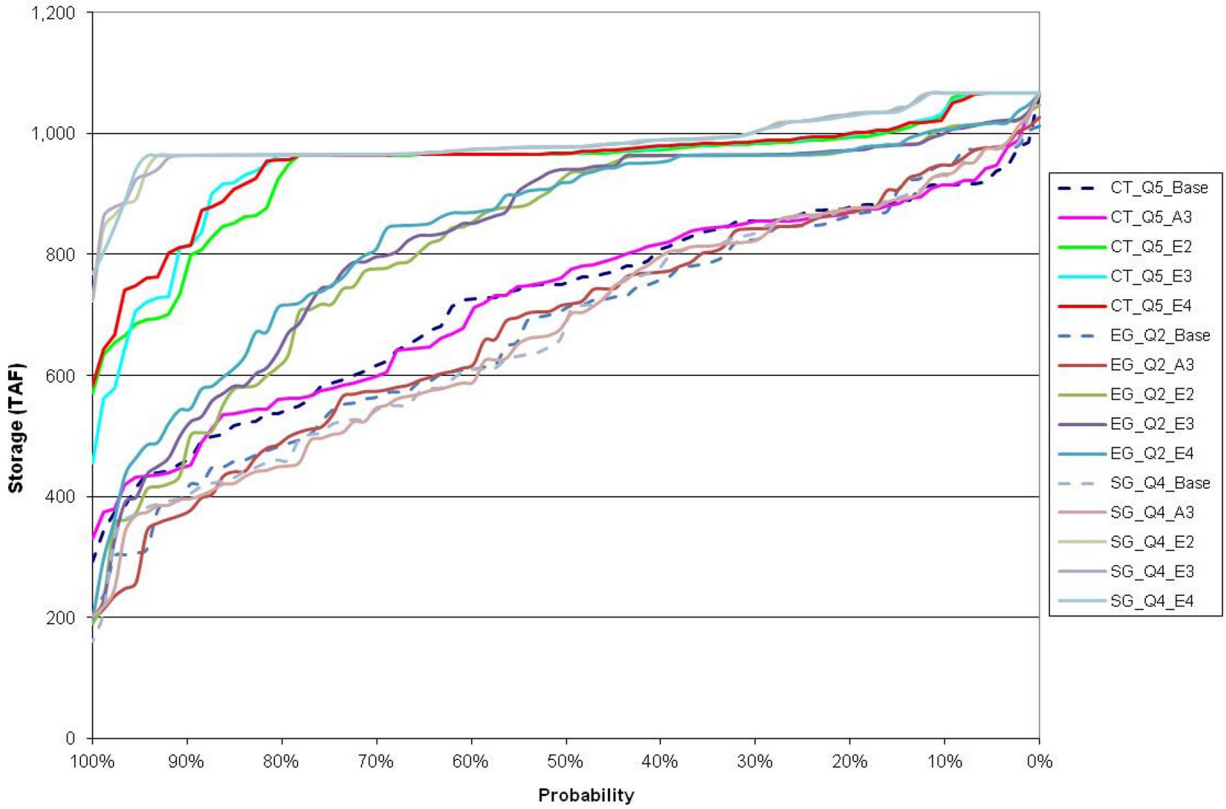

Figure 7-267. Exceedance of SWP San Luis End-of-May Storage in Portfolio E

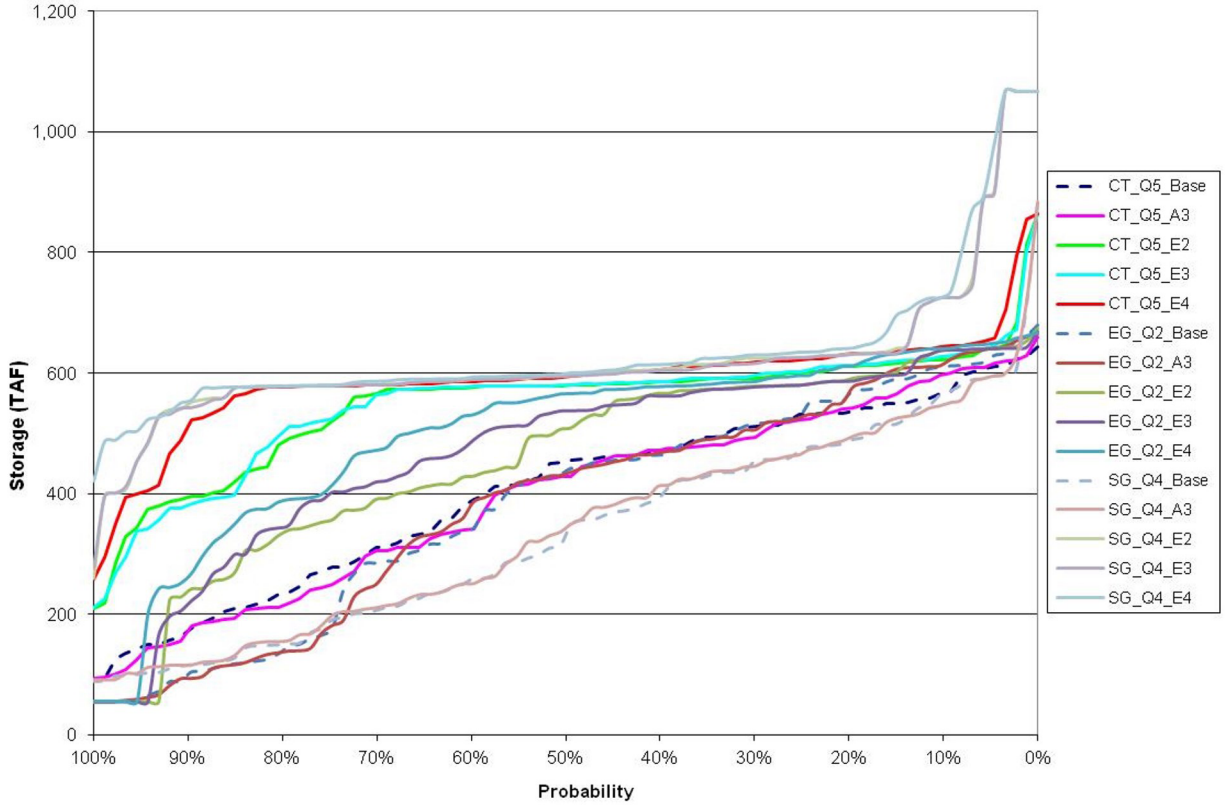

Figure 7-268. Exceedance of SWP San Luis End-of-September Storage in Portfolio E

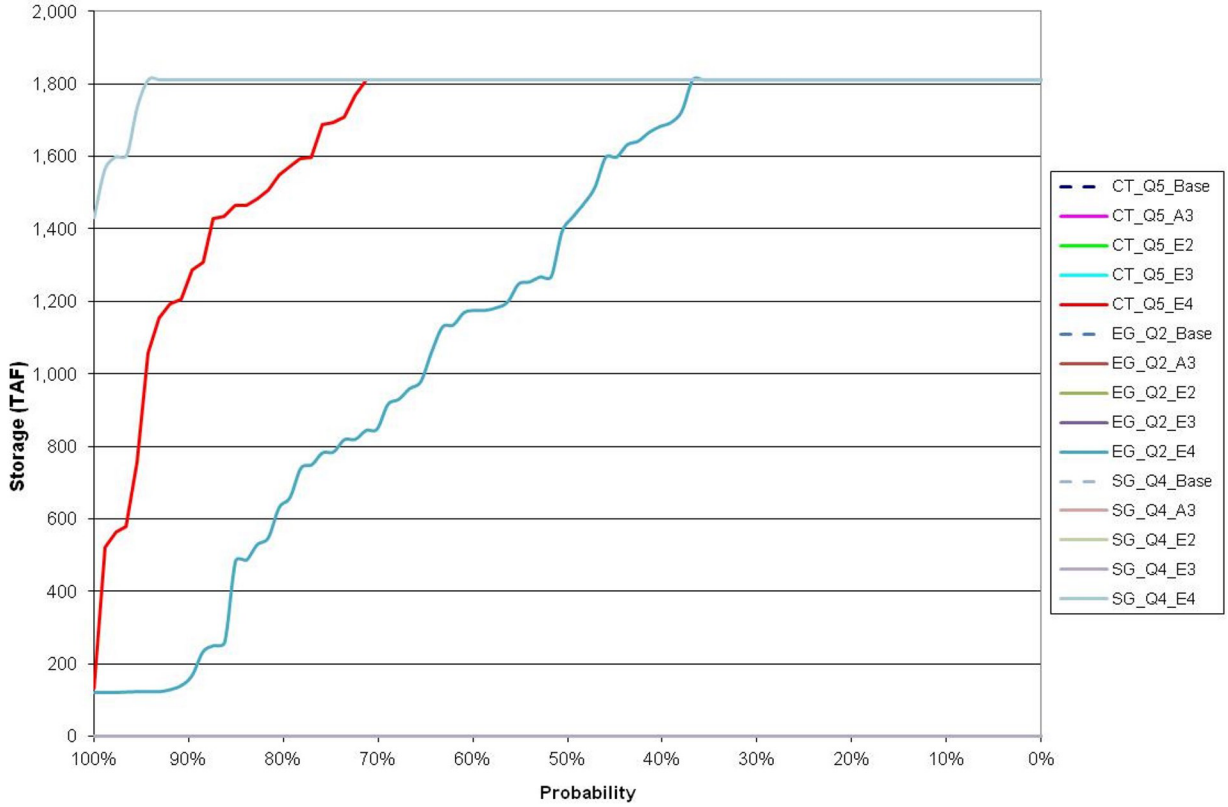

Figure 7-269. Exceedance of NODOS End-of-May Storage in Portfolio E

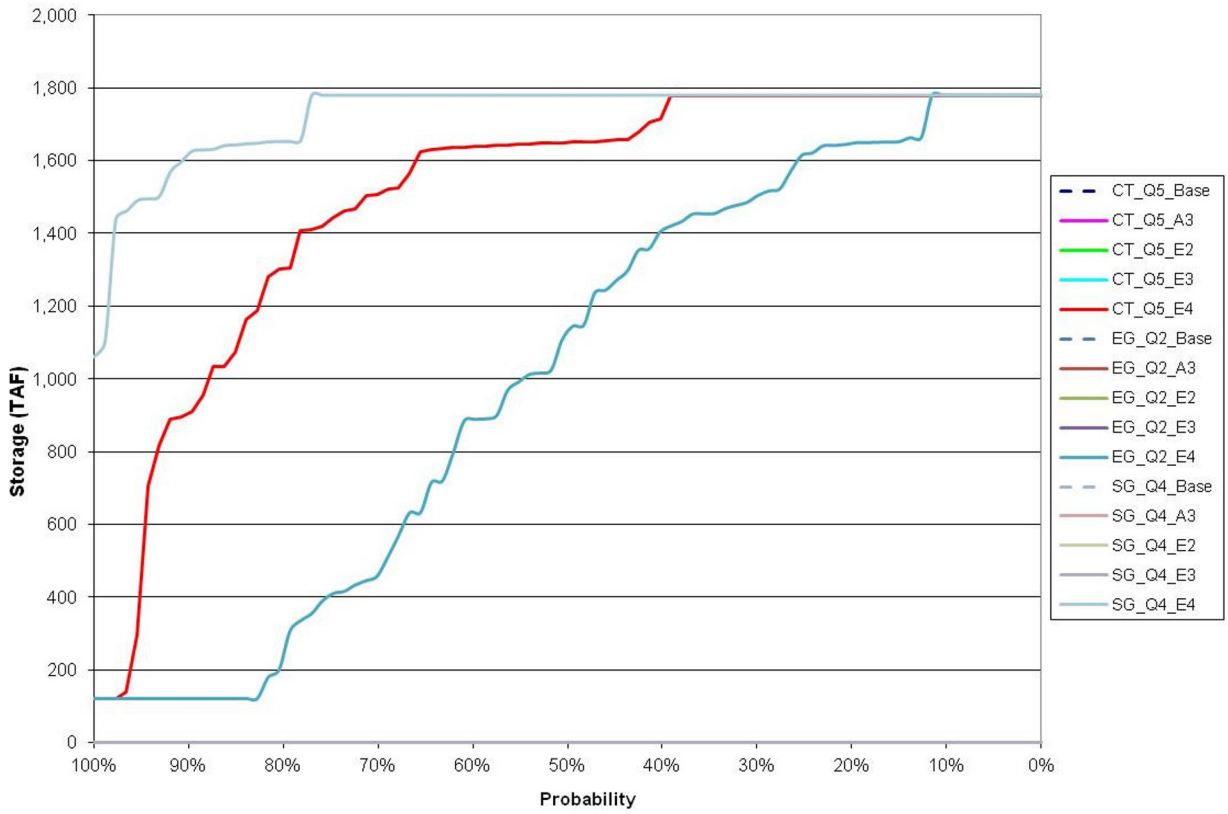

Figure 7-270. Exceedance of NODOS End-of-September Storage in Portfolio E

Folsom, Oroville, New Melones, Millerton, CVP San Luis, and SWP San Luis Reservoirs under scenarios CT-Q5, EG-Q2, and SG-Q4. The addition of the EEF in E2, E3, and E4 resulted in a moderate reduction in storage at Oroville and Folsom as compared to the Baseline and A1, reflecting the effects of required releases from these reservoirs to meet the EEF requirements. However, the storage levels at CVP San Luis and SWP San Luis were significantly increased relative to the Baseline because of reductions in CVP and SWP allocations. Similarly, Lake Shasta storage with only the EEF action in E2 was also reduced relative to the Baseline and A1, but the Enlarged Shasta action resulted in increased Shasta Lake storage with E3 and E4 actions. Storage levels in New Melones and Millerton were almost unchanged relative to the Baseline. Finally, the combined North-of-Delta storage in E4 was also lower than when NODOS was operated on its own in B2, reflecting the additional EEF releases.

7.5.2.2 Delta Exports and Delta Outflow

Figures 7-271 through 7-276 show the annual exceedance plots of pumping at Banks PP and Jones PP, and of total Delta exports under scenarios CT-Q5, EG Q2, and SG-Q4 as well as changes in annual average flows relative to the Baseline at these locations for all 18 socioeconomic-climate scenarios. Figures 7-277 and 7-278 show the same information for Delta outflow. Across the range of scenarios, total average annual Delta exports decreased significantly with EEF requirements relative to the Baseline ranging from 529 to 1,009 TAF/year with the EEF-only action in E2 suite. These reductions were reduced with the addition of Enlarged Shasta in E3 and Sites Reservoir in E4. With both proposed storage project's actions, total exports in E4 were lower than the Baseline values by 389 to 945 TAF/year across the range of scenarios.

Delta outflows increased in E2, E3, and E4 by amounts consistent with the decreases in Delta exports. Whereas A1 had small increases in Delta outflow, Delta outflows were 876 to 1,348 TAF/year greater in E2 than in the Baseline across the range of scenarios. When both Enlarged Shasta and Sites Reservoir actions were included in E4, the increases in Delta outflows were reduced to between 646 and 1,226 TAF/year across the range of scenarios.

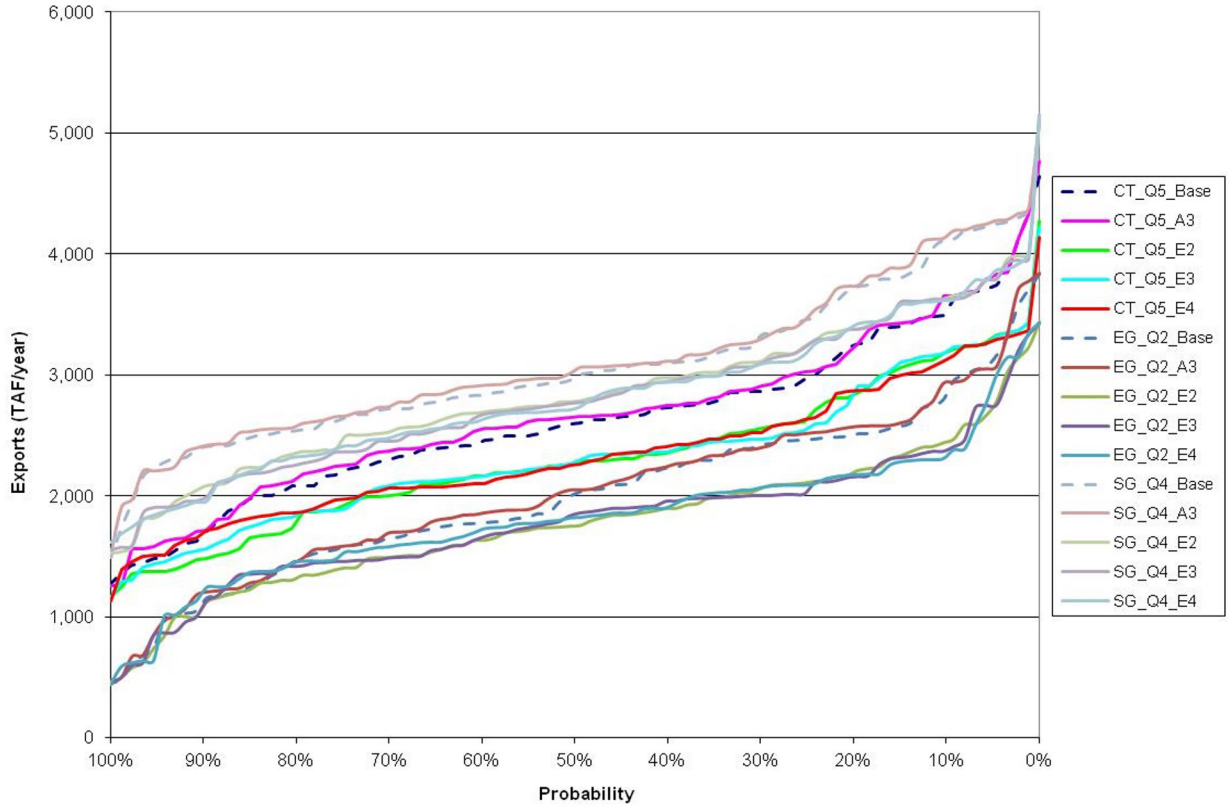

Figure 7-271. Annual Exceedance of Banks Pumping in Portfolio E

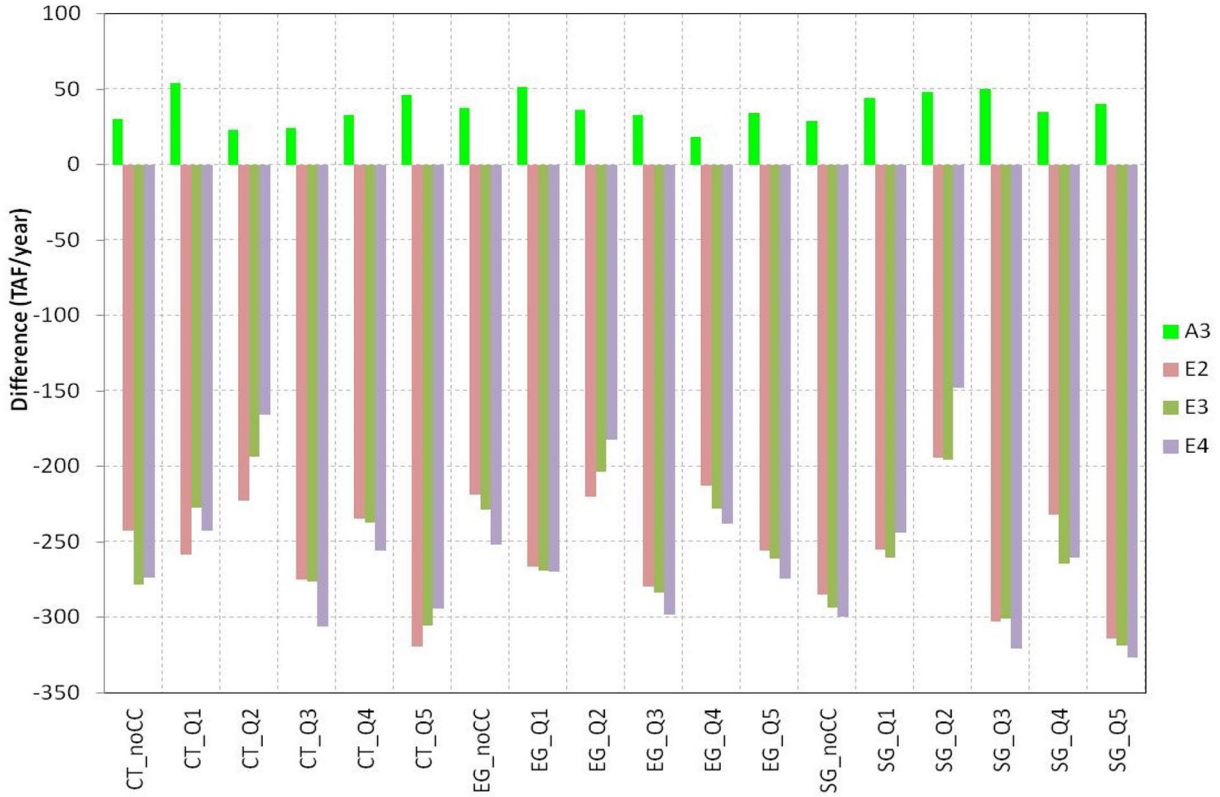

Figure 7-272. Average Annual Change in Banks Pumping for Portfolio E Relative to the Baseline in Each Scenario

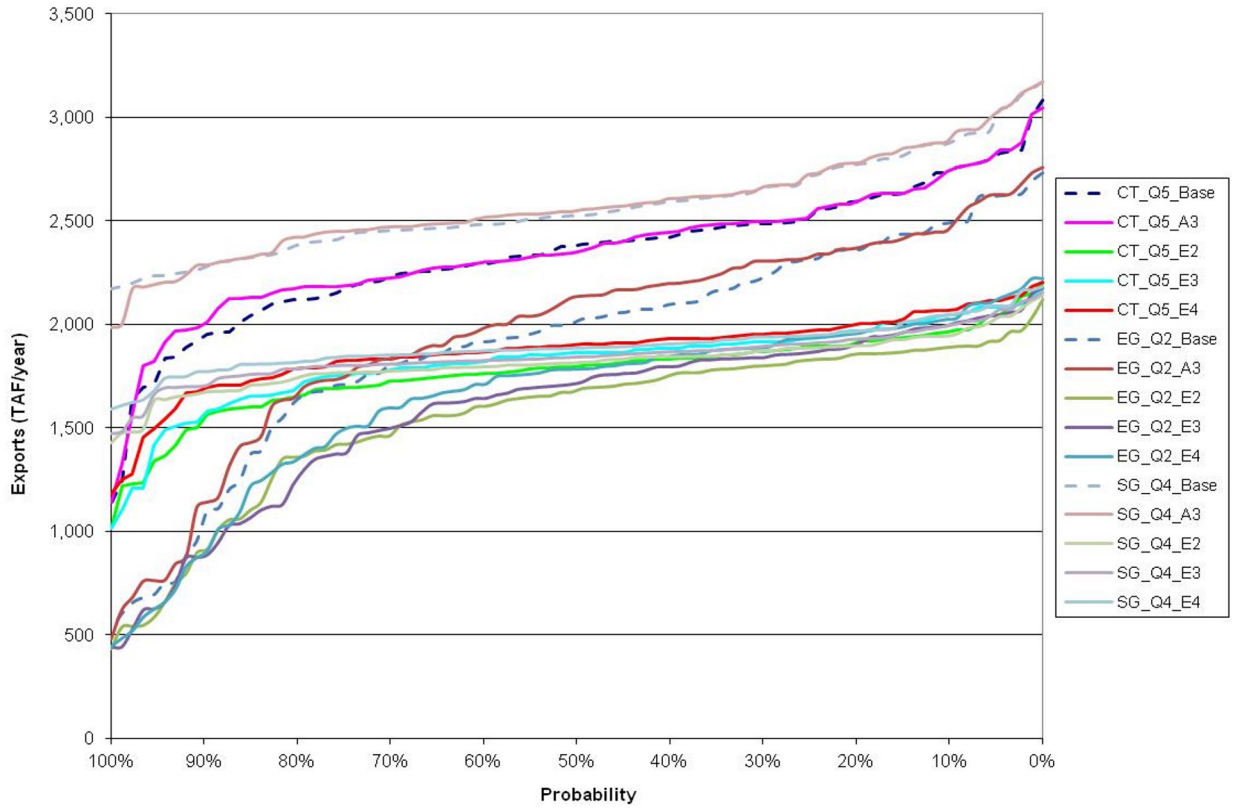

Figure 7-273. Annual Exceedance of Jones Pumping in Portfolio E

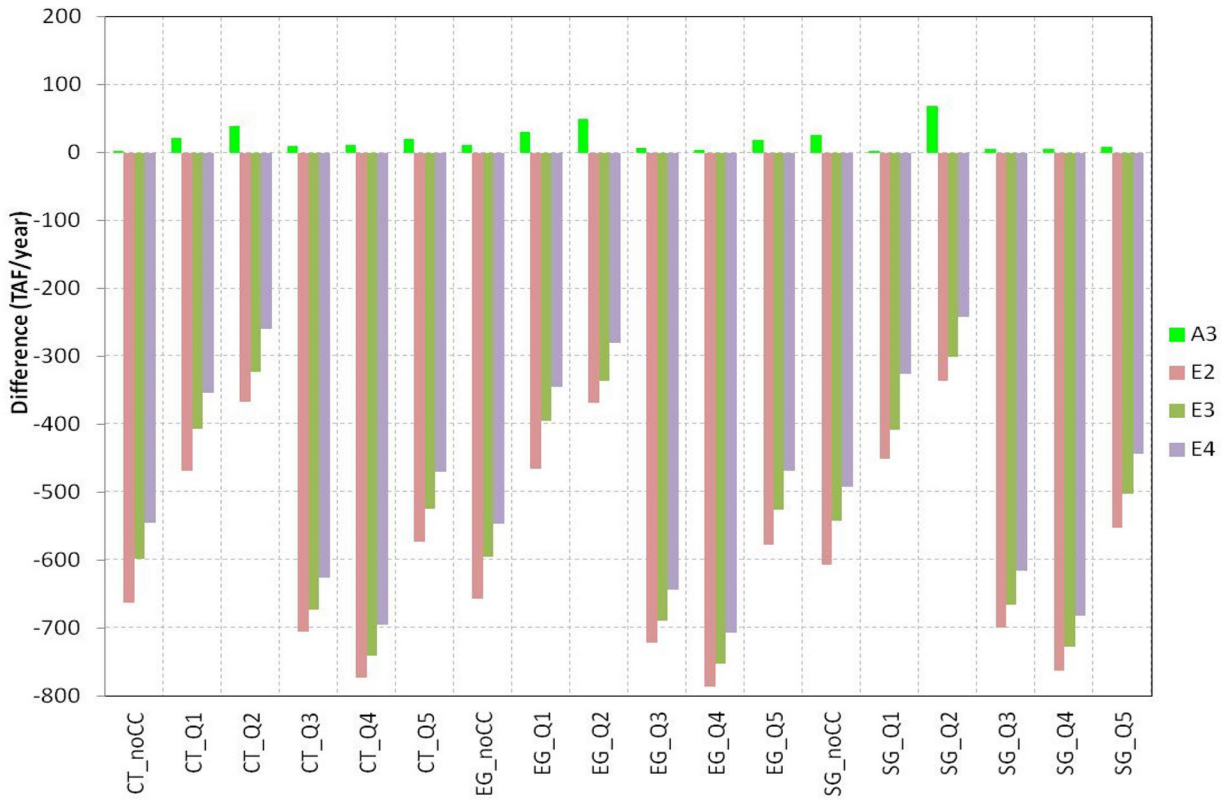

Figure 7-274. Average Annual Change in Jones Pumping for Portfolio E Relative to the Baseline in Each Scenario

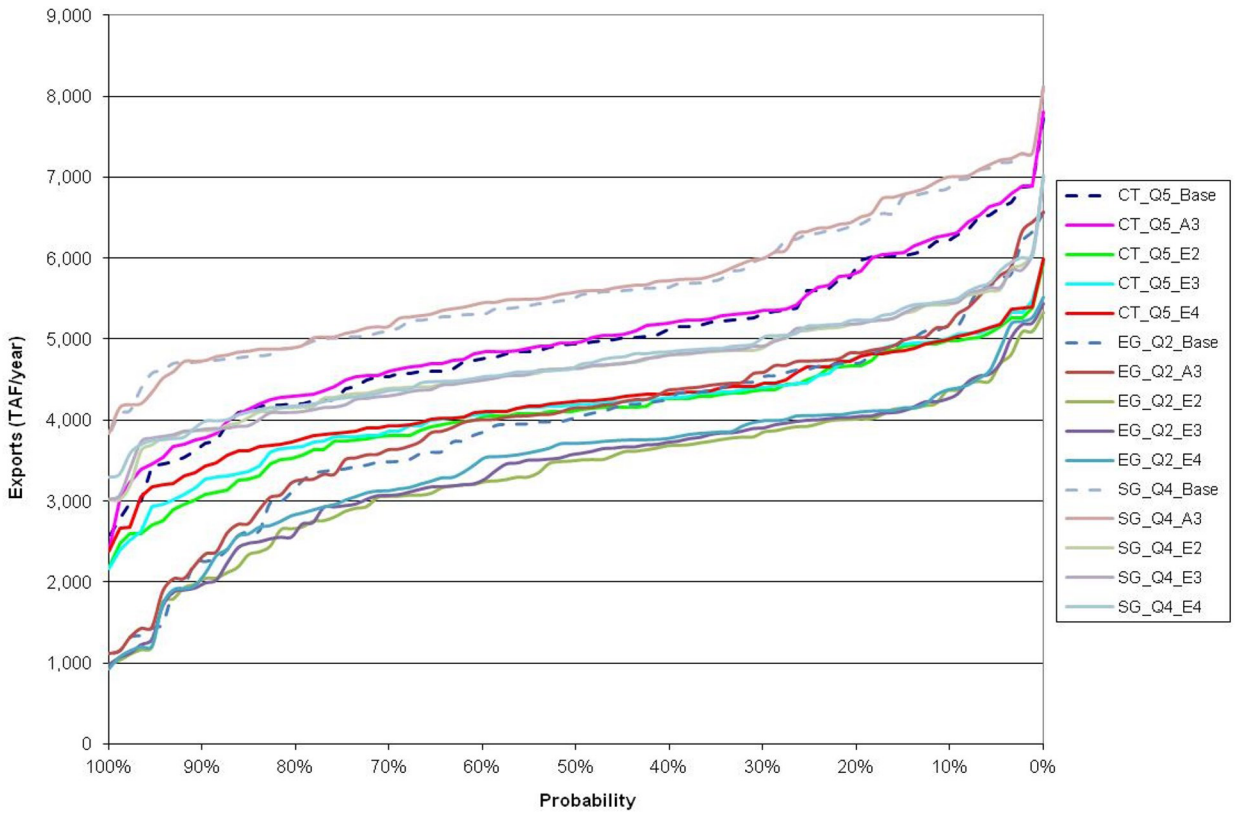

Figure 7-275. Annual Exceedance of Total Delta Exports in Portfolio E

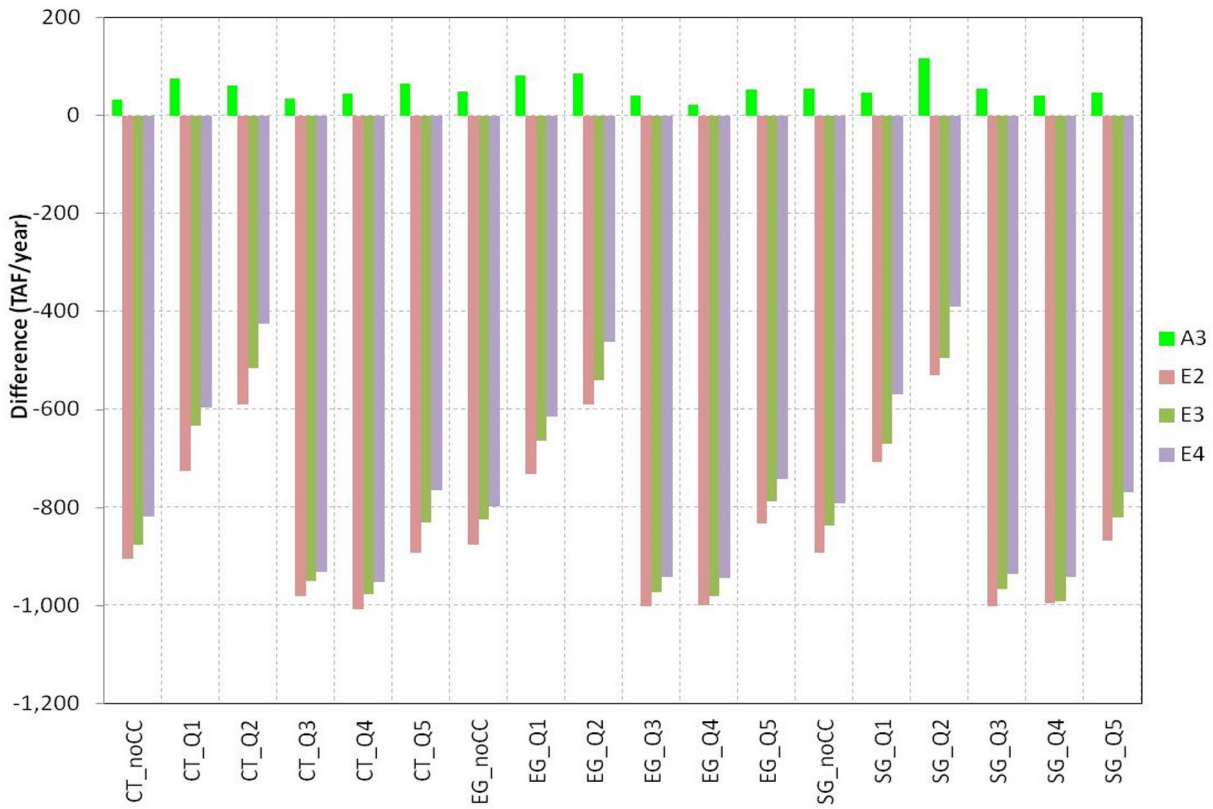

Figure 7-276. Average Annual Change in Total Delta Exports for Portfolio A Relative to the Baseline in Each Scenario

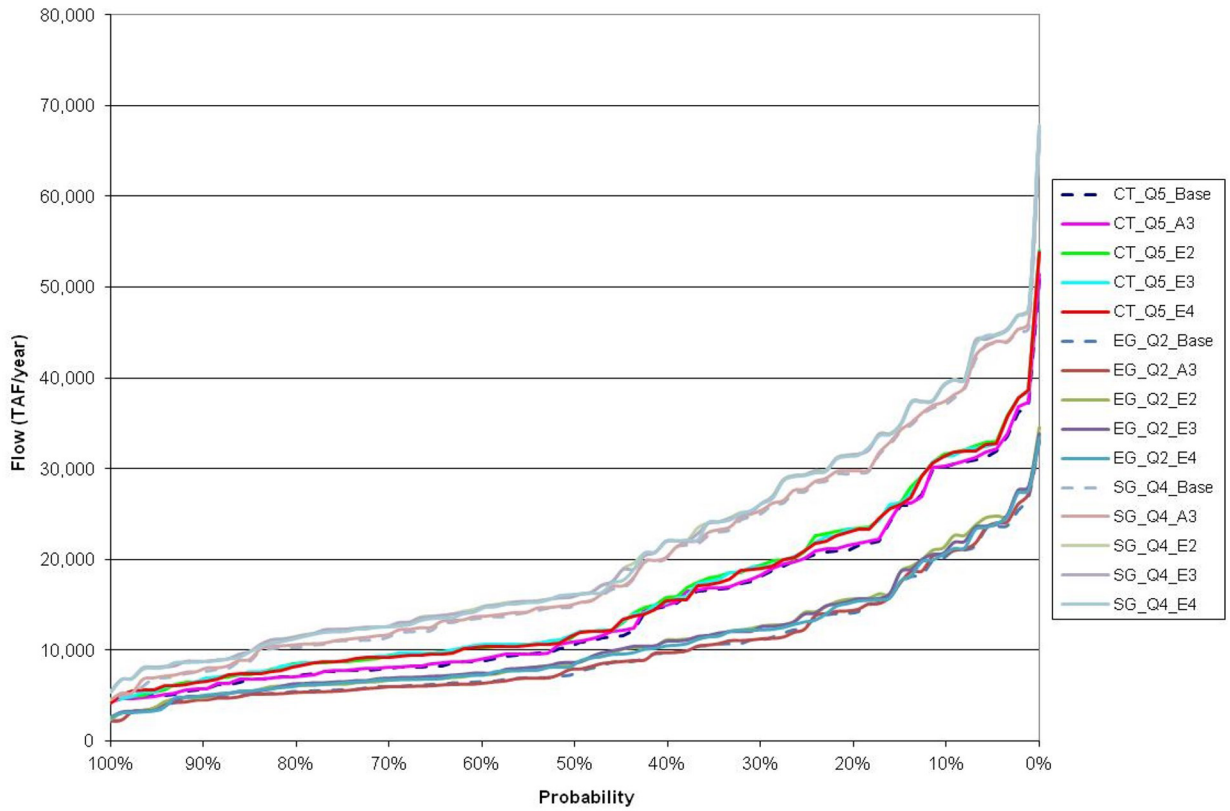

Figure 7-277. Annual Exceedance of Delta Outflow in Portfolio E

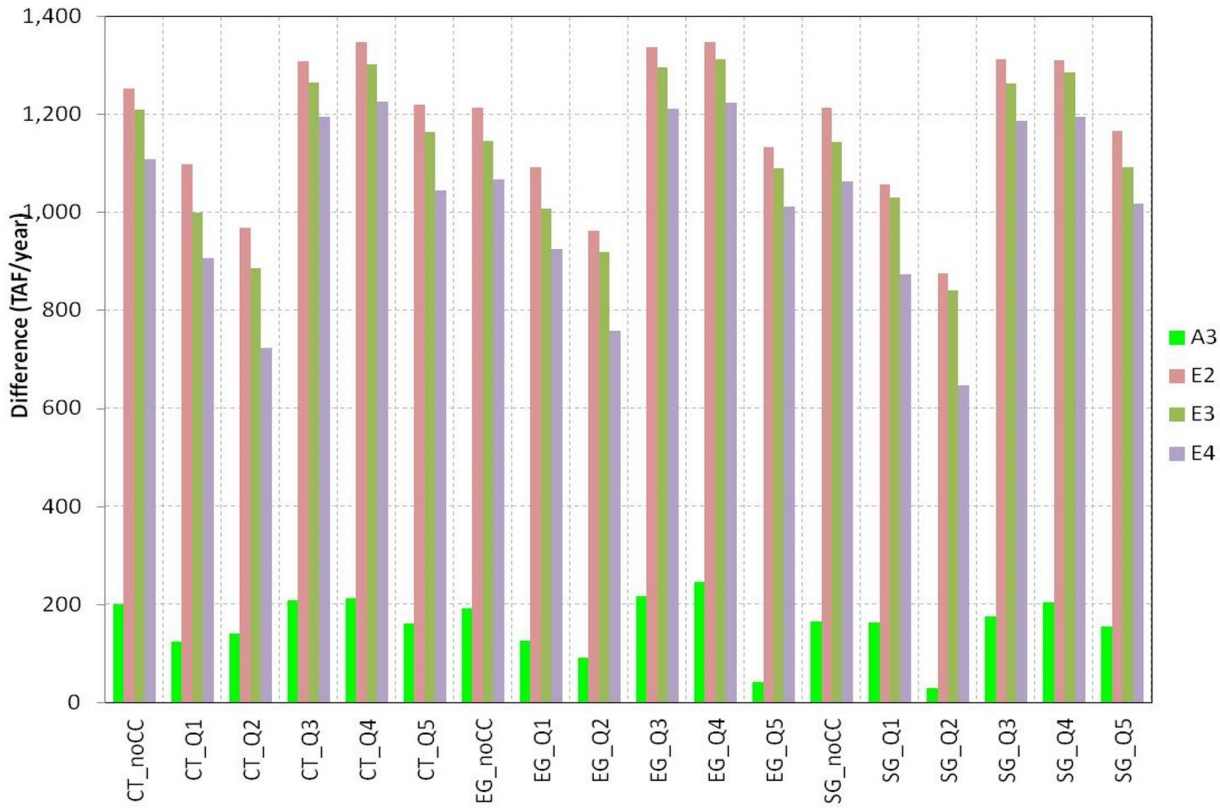

Figure 7-278. Average Annual Change in Delta Outflow for Portfolio E Relative to the Baseline in Each Scenario

7.5.2.3 Delta Salinity

Figure 7-279 shows the average X2 position from February through June for each of the simulated socioeconomic-climate scenarios with the Portfolio E actions. Figure 7-280 shows the exceedance plot of the average X2 position from February through June under scenarios CT-Q5, EG-Q2, and SG-Q4. The average X2 position decreased by about 2 to 3 km in E2, E3, and E4 relative to the Baseline across the range of scenarios, reflecting improved Delta salinity conditions that occur with greater EEF Delta outflows.

7.5.3 Other Performance Assessments

7.5.3.1 Economics

Figures 7-281 through 7-284 show the changes in net water supply system costs from the urban economic models LCPSIM and OMWEM, the changes in avoided costs from the water quality economic model SBWQM, and changes in net agricultural revenues from SWAP for each Portfolio E suite in the CT-Q5, EG Q2, and SG-Q4 scenarios at the 2025, 2055, and 2085 LODs.

In contract to Portfolios C and D, the SBA urban economic model results from LCPSIM showed substantial economic costs in the CT-Q5 and EG-Q2 scenarios with the EEF-only Suite E2 actions ranging up to $169 million per year in CT-Q5 and up to $313 million per year in EG-Q2. These costs resulted from the increases in shortage costs due to the reduced deliveries to the SBA and were larger in EG-Q2 because the SBA has very high unmet demands and, therefore, high marginal shortage costs in the Baseline in EG-Q2 due to the increased population in the Expansive Growth scenario and reduced water supplies in the drier Q2 climate scenario. However, these costs were reduced with the addition of E3 and E4 actions because deliveries to the SBA increased with the addition of Enlarged Shasta and Sites Reservoirs. As with Portfolios C and D, there was very little change in the economic values for the SG-Q4 scenario, despite a reduction in SWP and CVP deliveries to the SBA, because the lower population increase combined with the higher deliveries in the SG-Q4 Baseline resulted in very little marginal value from additional water supplies.

Figure 7-285 shows the long-term average salinity at CCWD and SBA diversion locations with Portfolio E actions. The SBA water quality costs simulated by SBWQM were mixed for Portfolio E. As in simulations E2, E3, and E4, the export amounts decreased, but the salinity at the export locations increased relative to the Baseline. Because these effects counteract each other in the determination of salinity costs, each simulation had small increases or decreases in water quality costs relative to the Baseline. In Suite E4, there were small incremental water quality costs ranging from about $1.4–3.6 million across the simulated scenarios and LODs.

The changes in Central Valley net agricultural revenues from SWAP and urban water supply costs from OMWEM showed substantial reductions in net revenues as compared to the Baseline with only the E2 action (see Figure 7-284). Additions of the E3 and E4 actions partially offset these reductions. Across the different scenarios and LODs, the average annual reductions in net agricultural revenues with E4 actions ranged from $58–106 million per year and from about $8–87 million per year for urban supply costs. As with LCPSIM, the OMWEM results showed substantially less costs in SG-Q4 than in the other scenarios because the marginal incremental benefits relative to the Baseline are smaller.

7.5.3.2 Water Temperature

Figures 7-286 through 7-289 show exceedance plots and average changes of daily water temperatures from July through September in Portfolio E relative to the Baseline for CT-Q5, EG-Q2, and SG-Q4 scenarios in the Sacramento River at Keswick and Jelly's Ferry. With the addition of the EEF-only action in E2, there were increases in water temperature relative to A3 due to reductions in storage levels in Lake Shasta. With the addition of increased North-of-Delta surface storage in E3 and E4 actions, these increases in temperature were moderately reduced due to the increased storage relative to E2 and increased coldwater pool with the Enlarged Shasta action. In E2, the mean daily water temperatures in the Sacramento River at Keswick was about 0.7–0.9°F higher than in the Baseline, and the mean daily water temperatures at Jelly's Ferry were about 0.8–1.0°F higher than the Baseline across the range of simulated scenarios. In E4, the increases in mean daily water temperatures relative to the Baseline were reduced by about 0.2–0.3°F at Keswick and by about 0.2–0.4°F at Jelly's Ferry.

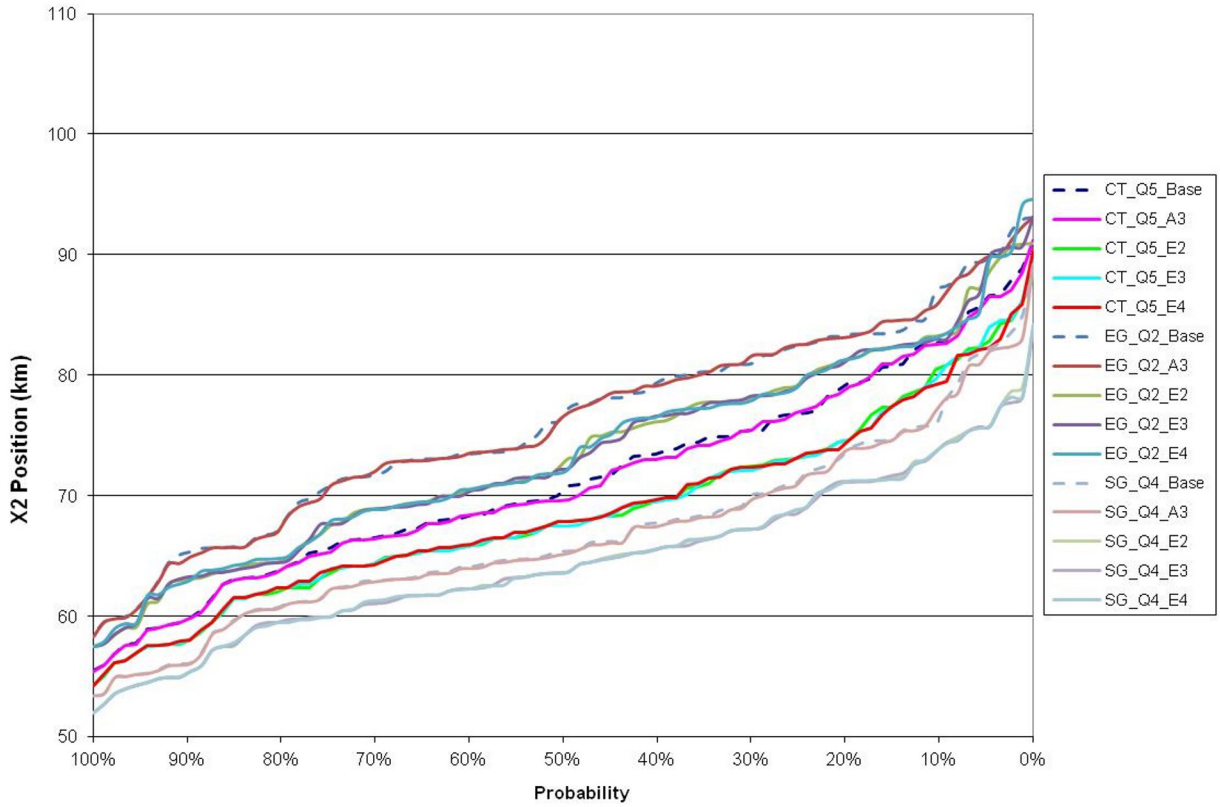

Figure 7-279. Exceedance of Average February-to-June X2 Position in Portfolio E

Figure 7-280. Change in Average February-to-June X2 Position for Portfolio E Relative to the Baseline in Each Scenario

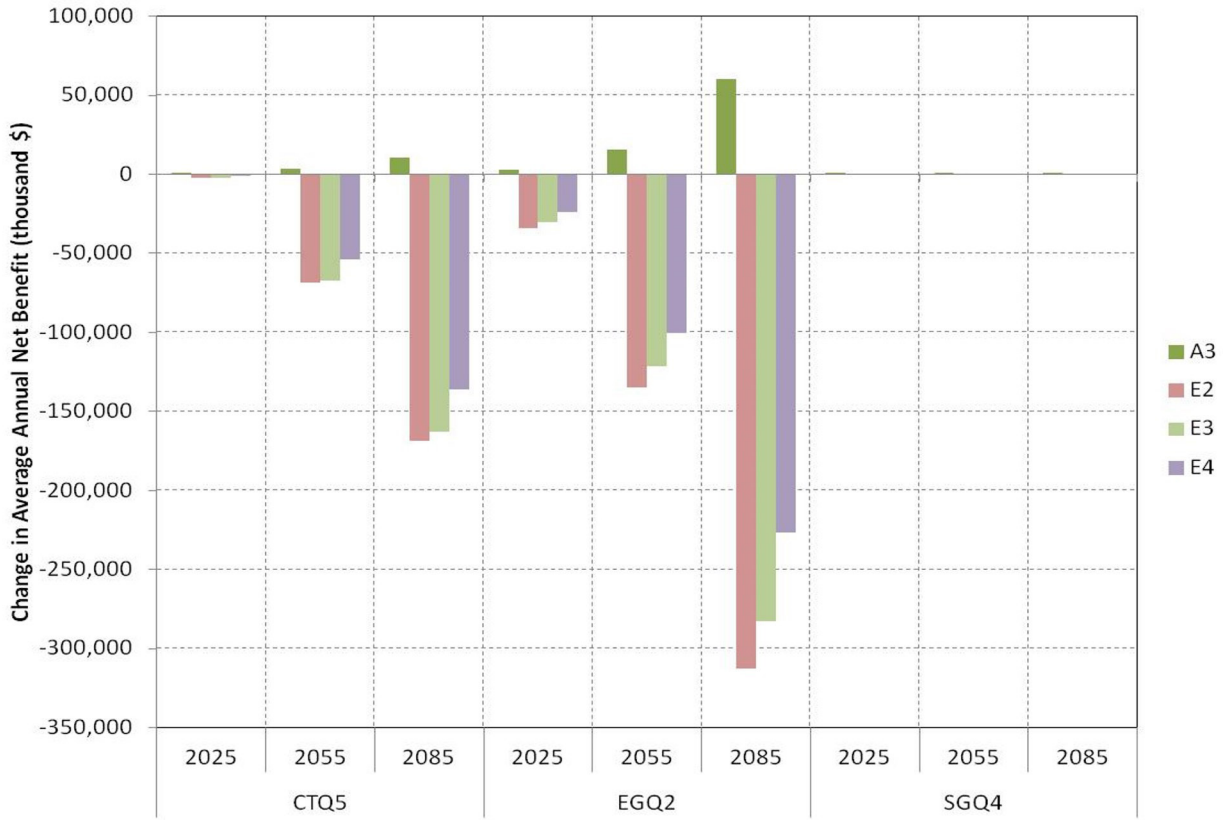

Figure 7-281. Improvement in Average Annual Urban Net Water Supply System Costs in South Bay Region from LCPSIM in Portfolio E

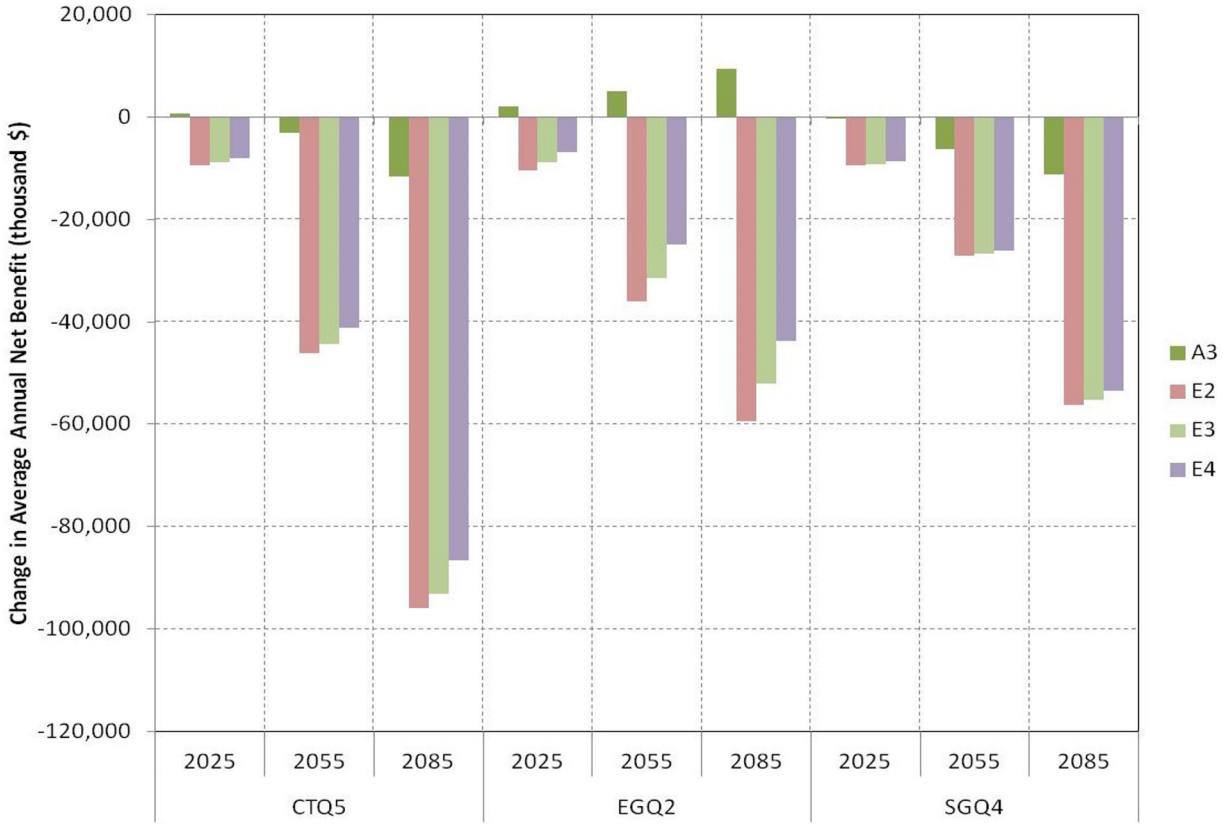

Figure 7-282. Improvement in Average Annual Urban Net Water Supply System Costs in Central Valley from OMWEM in Portfolio E

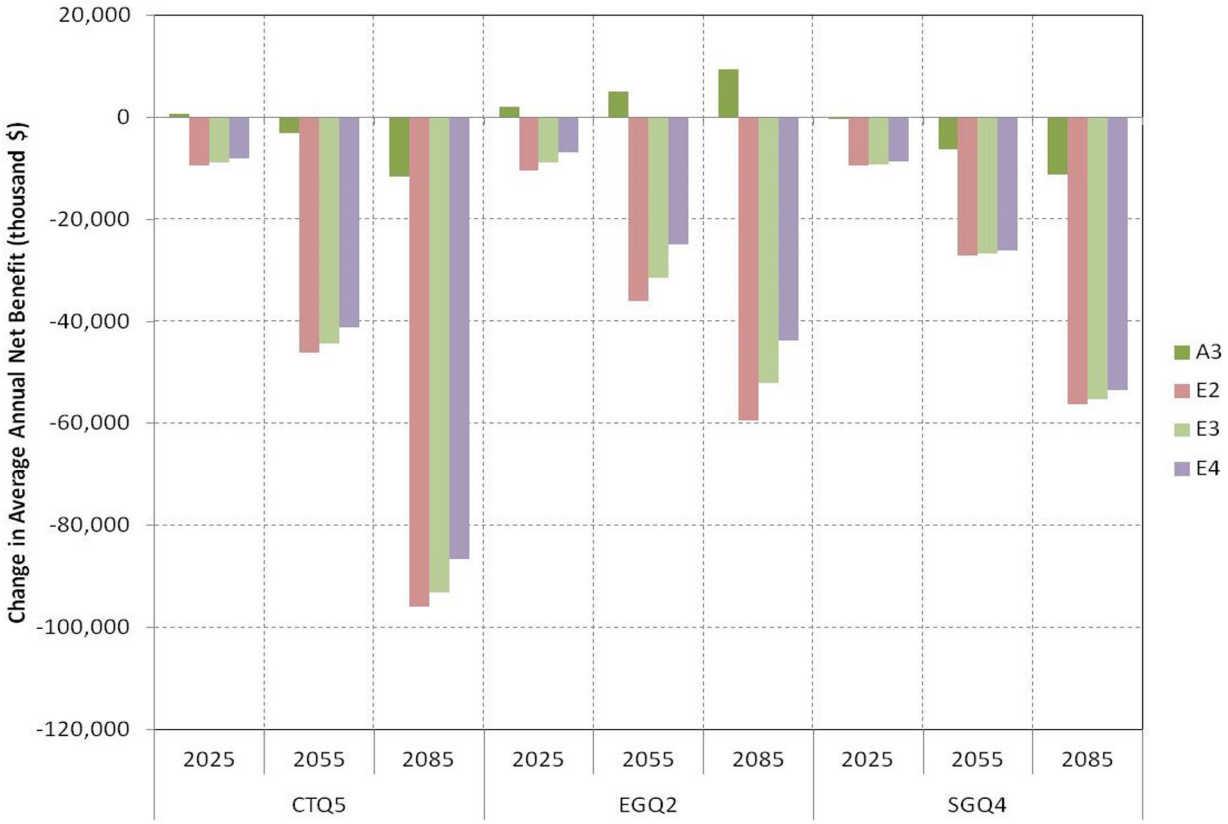

Figure 7-283. Improvement in Average Annual Avoided Water Quality Costs in South Bay Region from SBWQM in Portfolio E

Figure 7-284. Improvement in Average Annual Agricultural Net Revenue in Central Valley from SWAP in Portfolio E

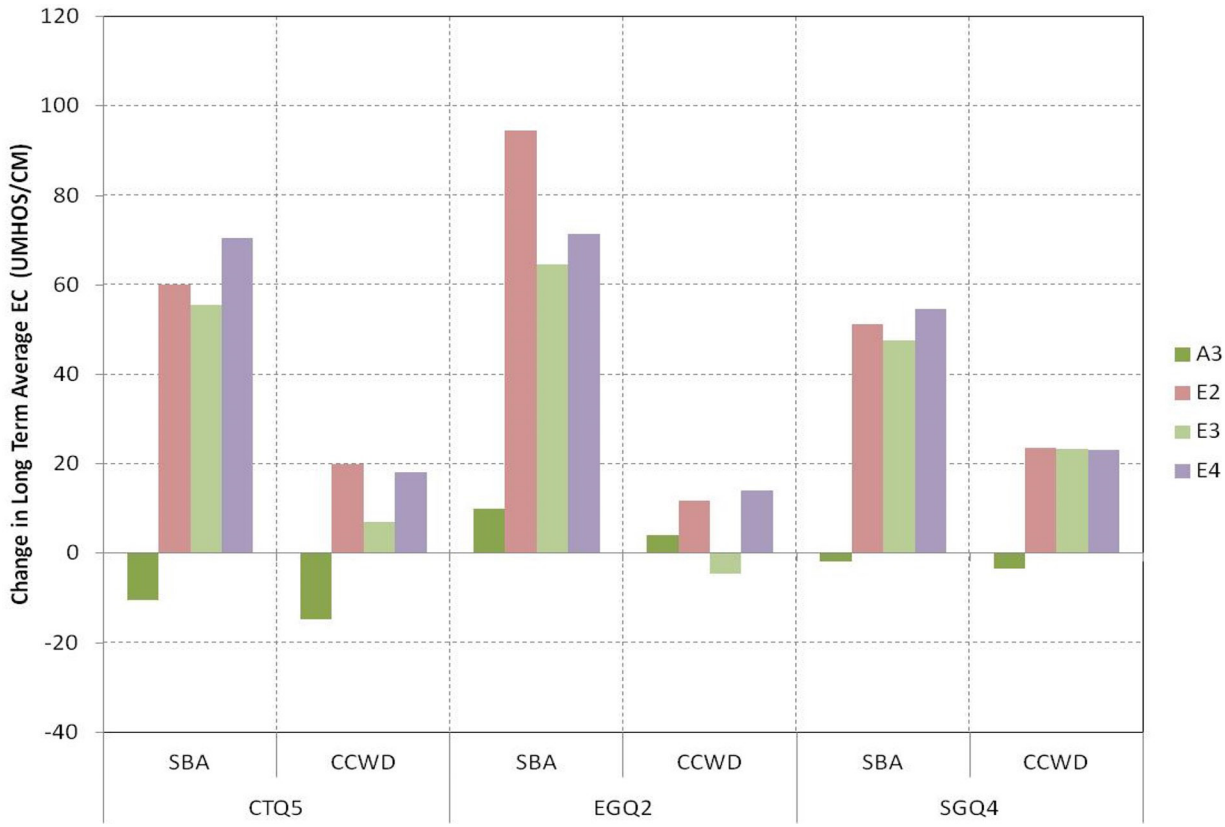

Figure 7-285. Long-Term Average Salinity at CCWD and SBA Diversion Locations in Portfolio E

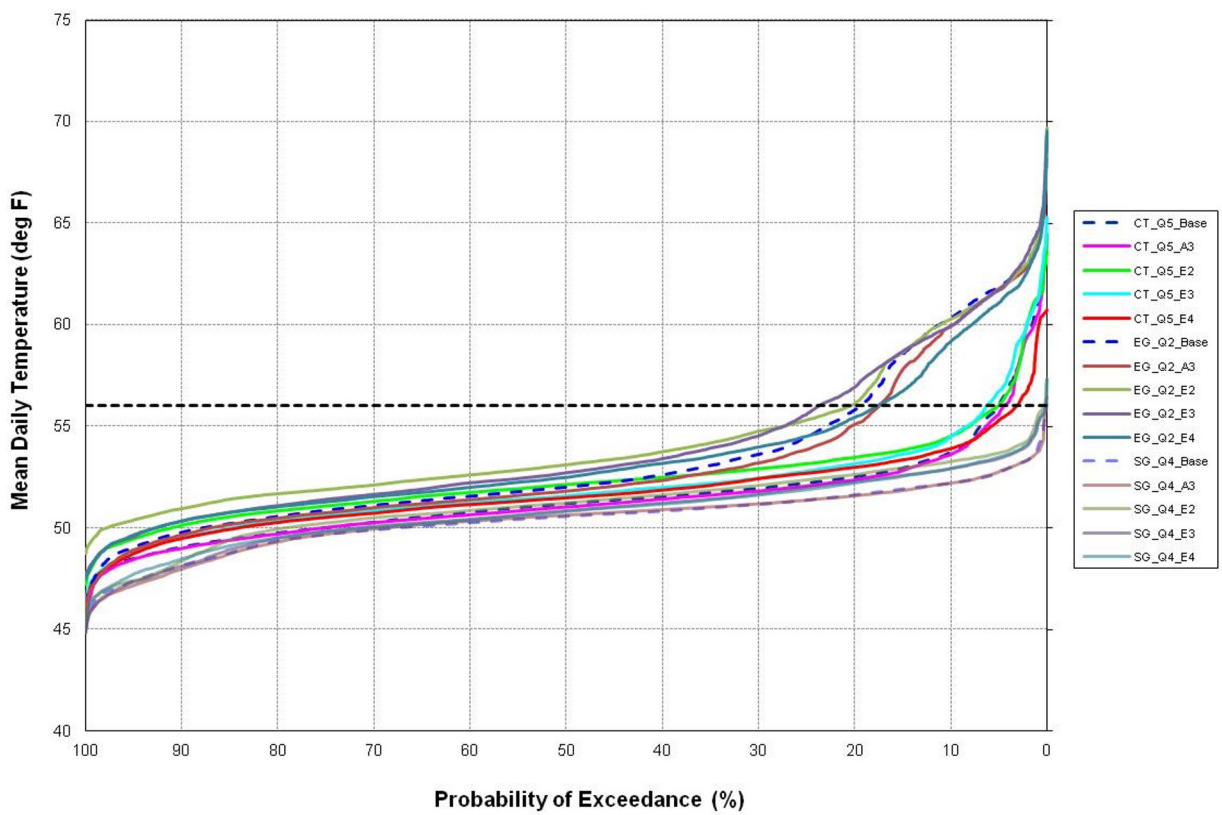

Figure 7-286. Exceedance of Mean Daily Temperature on Sacramento River at Keswick from July to September in Portfolio E

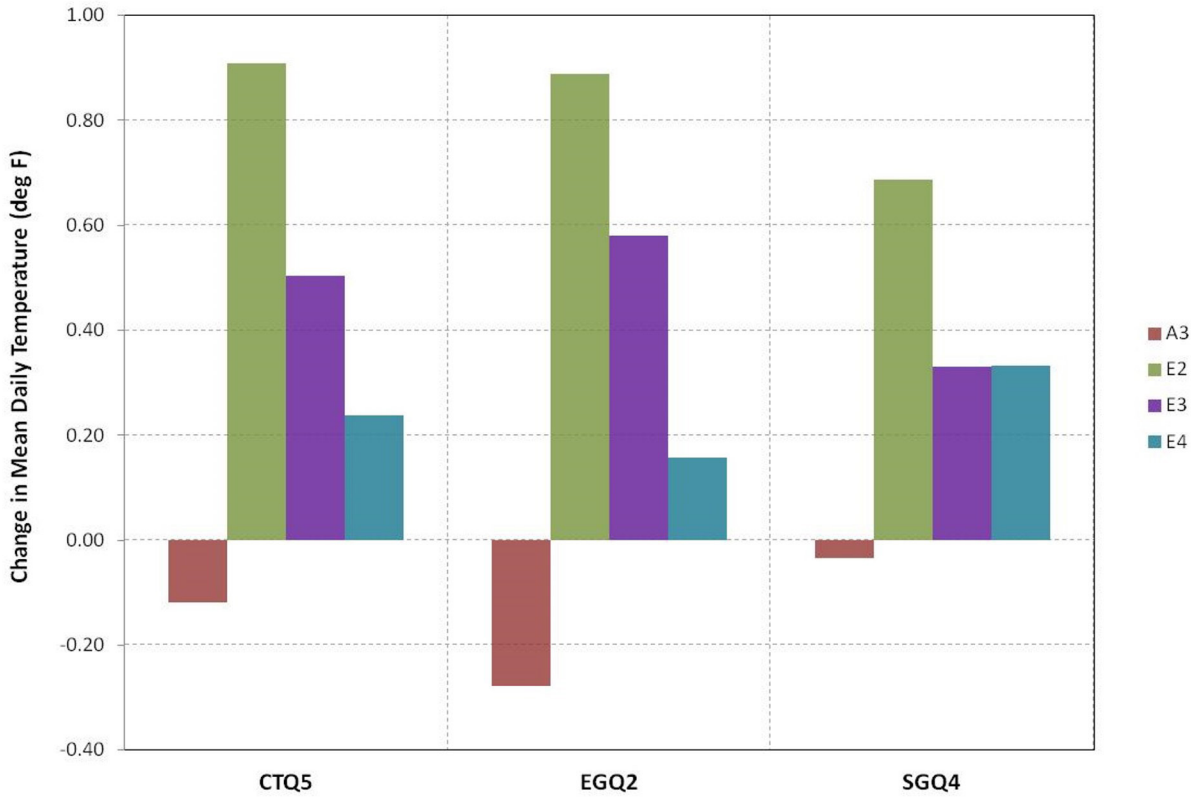

Figure 7-287. Change in Mean Daily Temperature on Sacramento River at Keswick from July to September in Portfolio E

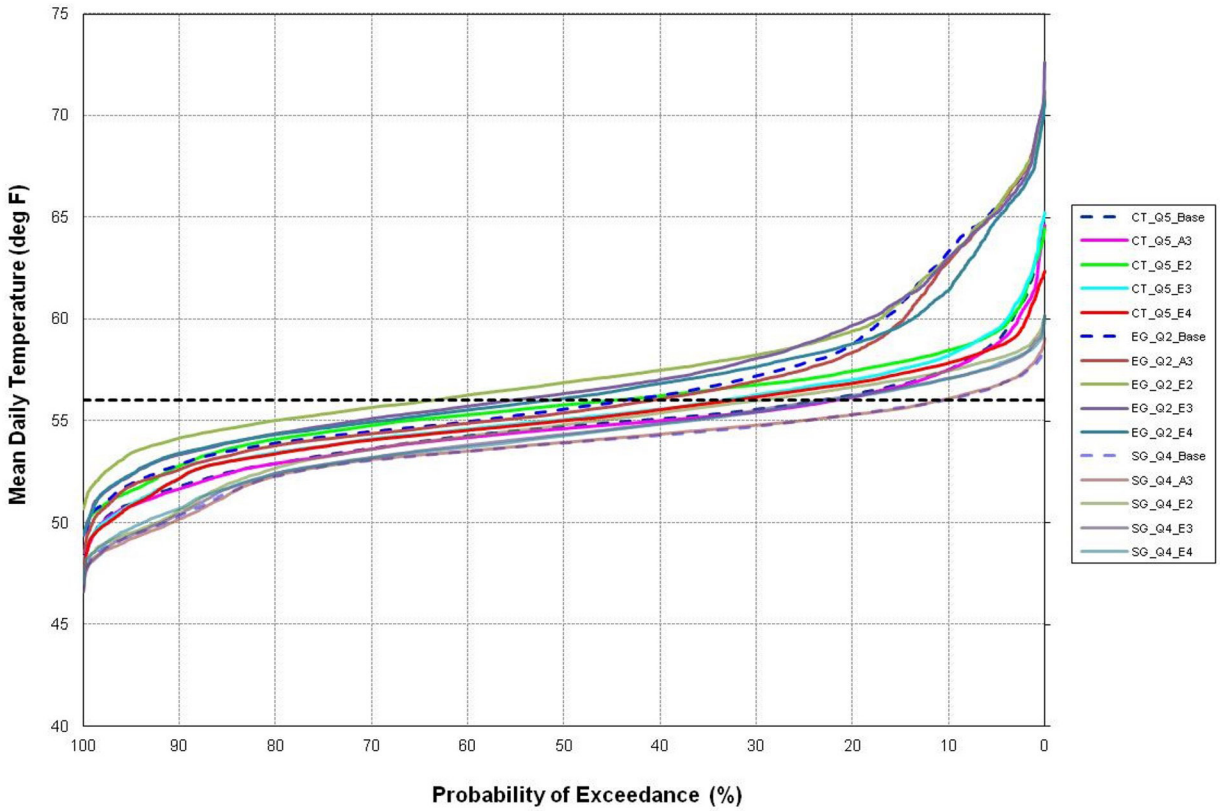

Figure 7-288. Exceedance of Mean Daily Temperature on Sacramento River at Jelly's Ferry from July to September in Portfolio E

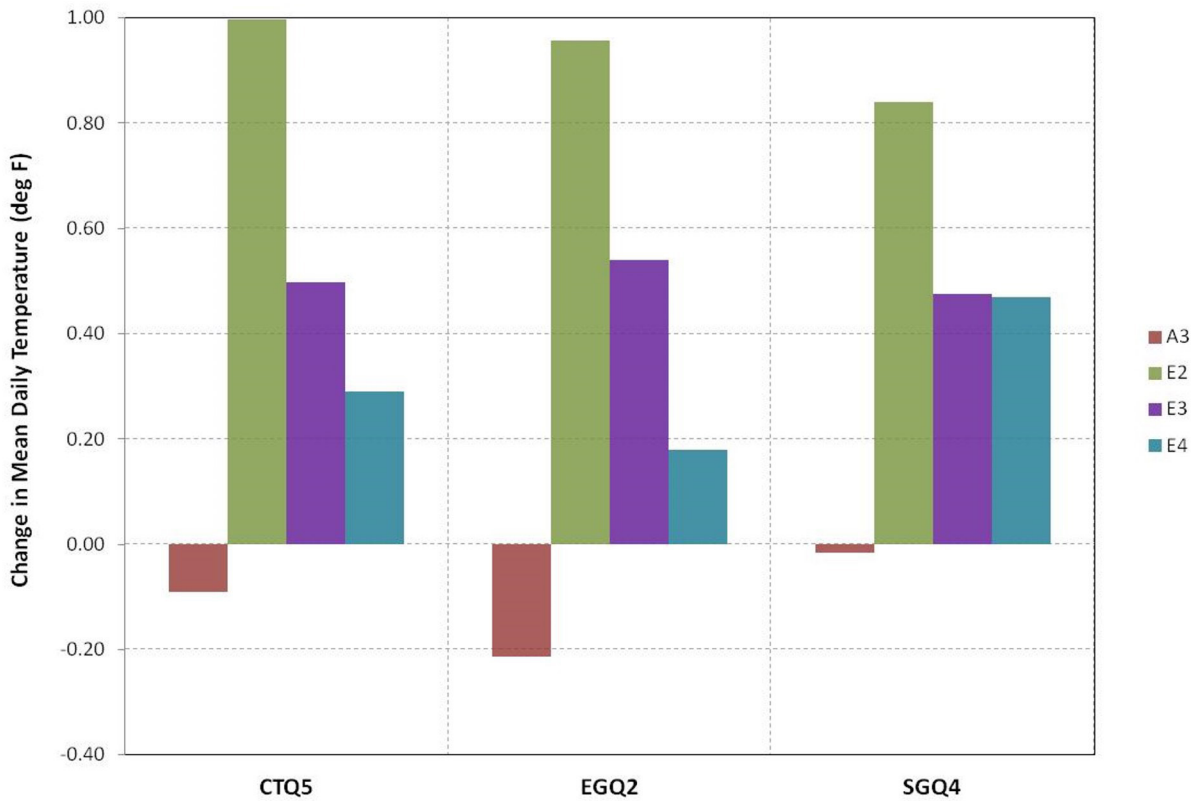

Figure 7-289. Change in Mean Daily Temperature on Sacramento River at Jelly's Ferry from July to September in Portfolio E

Figures 7-290 through 7-295 show exceedance plots and average changes of daily water temperatures from August through November with the Portfolio E actions relative to the Baseline in the San Joaquin River at Lost Lake, Gravelly Ford, and Vernalis for the same three scenarios. Under all simulated scenarios with E2, E3, and E4 actions, there were only minimal changes in water temperatures at Lost Lake, at Gravelly Ford, and at Vernalis relative to A3.

7.5.3.3 Hydropower and Greenhouse Gas Emissions

Figures 7-296 and 7-297 show the changes in net hydropower generation and in GHG emissions (that is, increase in GHG emissions in the SWP system or reduction in potential GHG offsets in the CVP system) in the CVP and SWP systems with Portfolio E actions relative to the Baseline. In the SWP system, there were substantial increases in net hydropower generation and reductions in GHG emissions with E2, E3, and E4 actions due to the large reductions in Banks pumping. In E4, net generation was about 600–1,700 GWh/year greater than in the Baseline, and GHG emissions were 67,000–208,000 mTCO2e lower than in the Baseline.

In the CVP system, there were smaller but still substantial increases in net hydropower generation of about 180–460 GWh/year and increases in potential GHG offsets of about 53,000–139,000 mTCO2e with the combined Portfolio E4 actions.

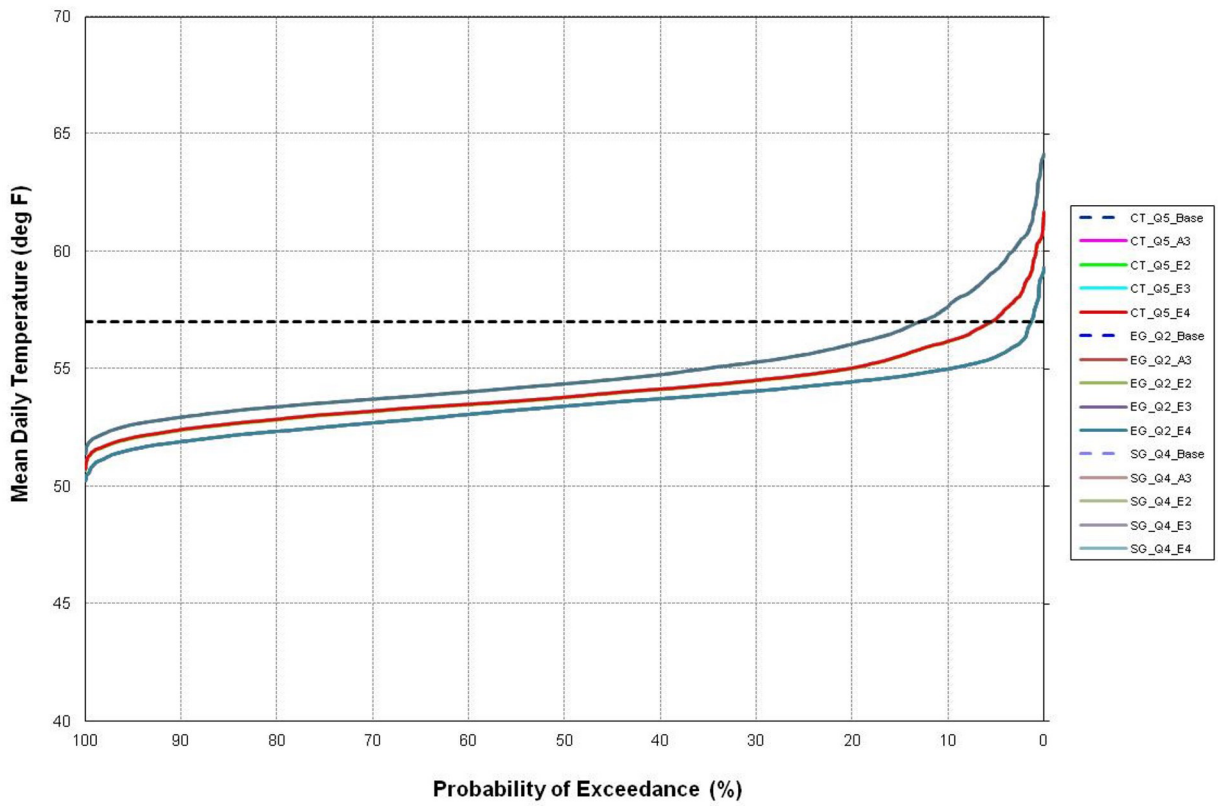

Figure 7-290. Exceedance of Mean Daily Temperature on San Joaquin River at Lost Lake from August to November in Portfolio E

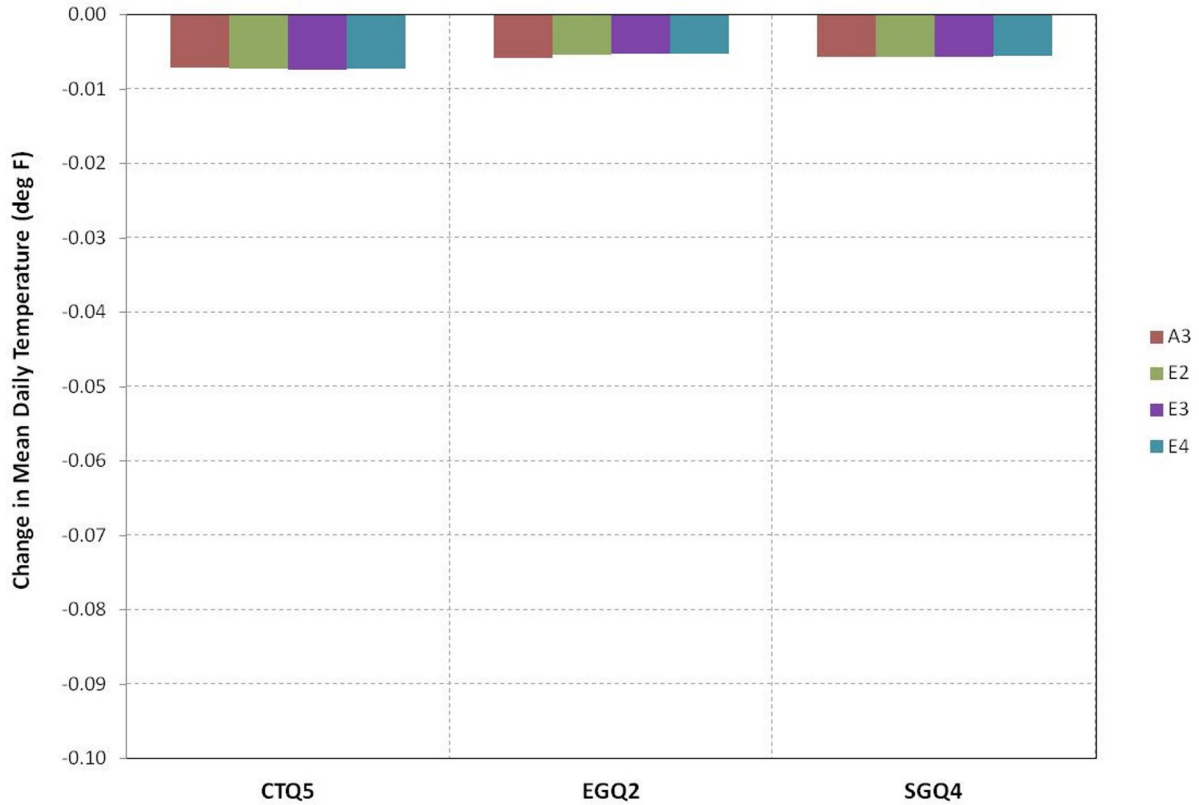

Figure 7-291. Change in Mean Daily Temperature on San Joaquin River at Lost Lake from August to November in Portfolio E

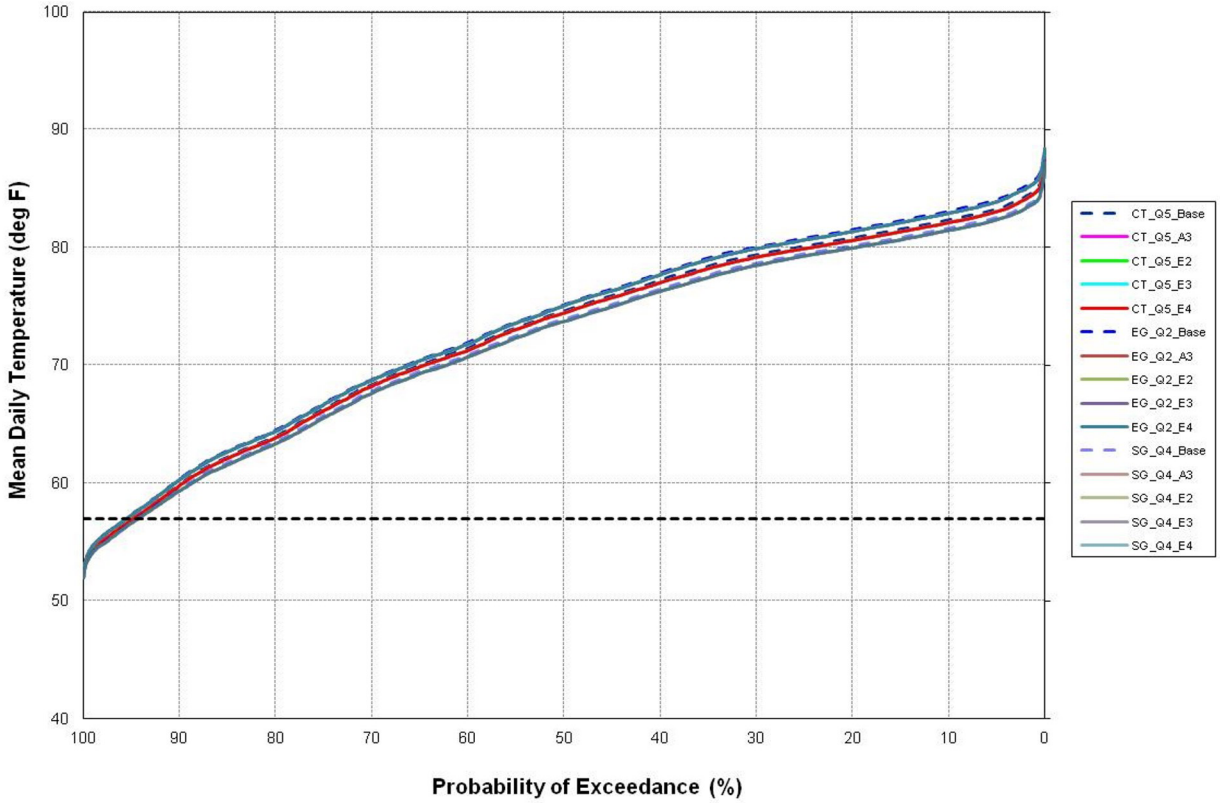

Figure 7-292. Exceedance of Mean Daily Temperature on San Joaquin River at Gravelly Ford from August to November in Portfolio E

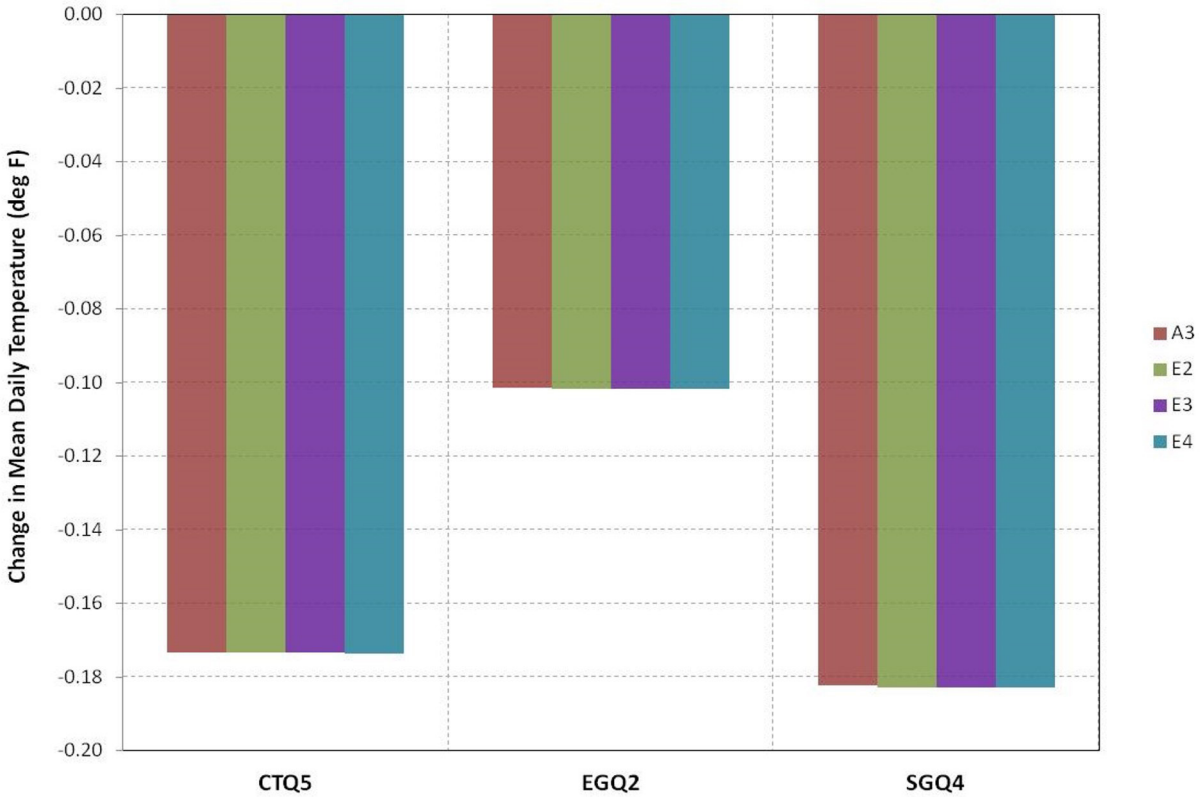

Figure 7-293. Change in Mean Daily Temperature on San Joaquin River at Gravelly Ford from August to November in Portfolio E

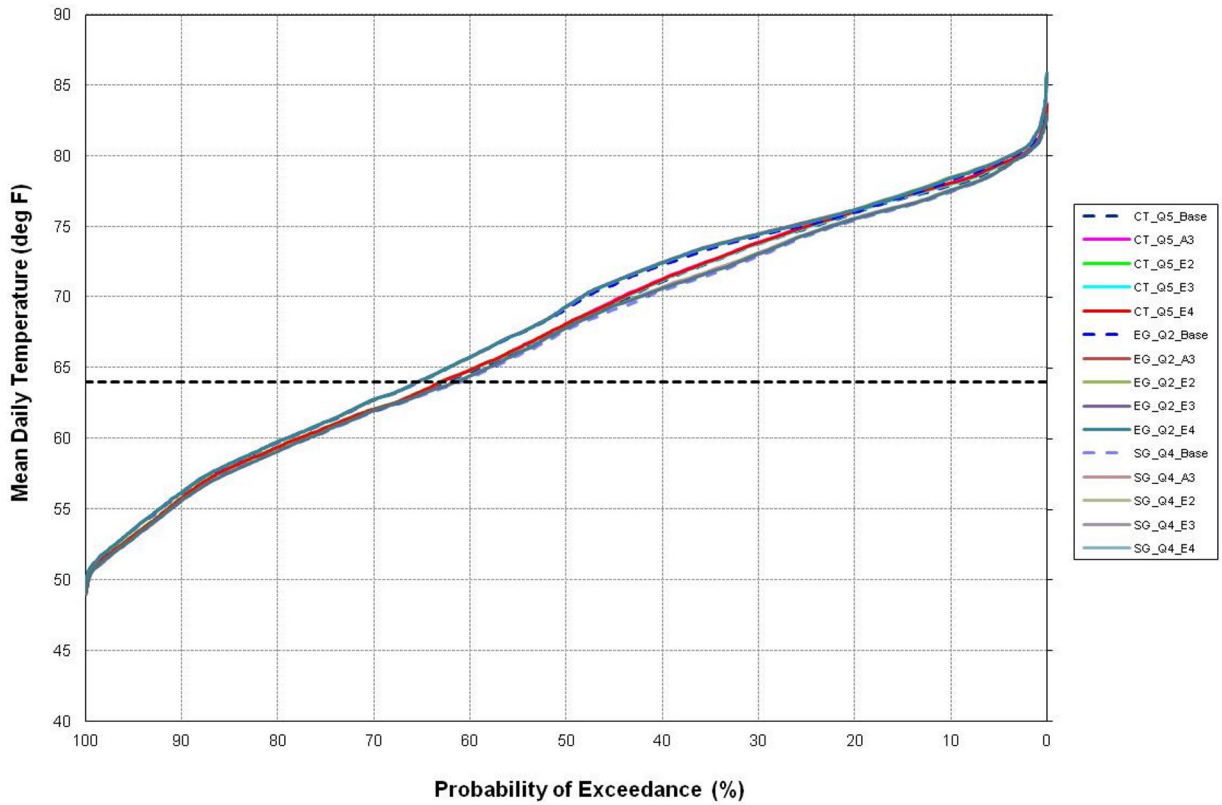

Figure 7-294. Exceedance of Mean Daily Temperature on San Joaquin River at Vernalis from August to November in Portfolio E

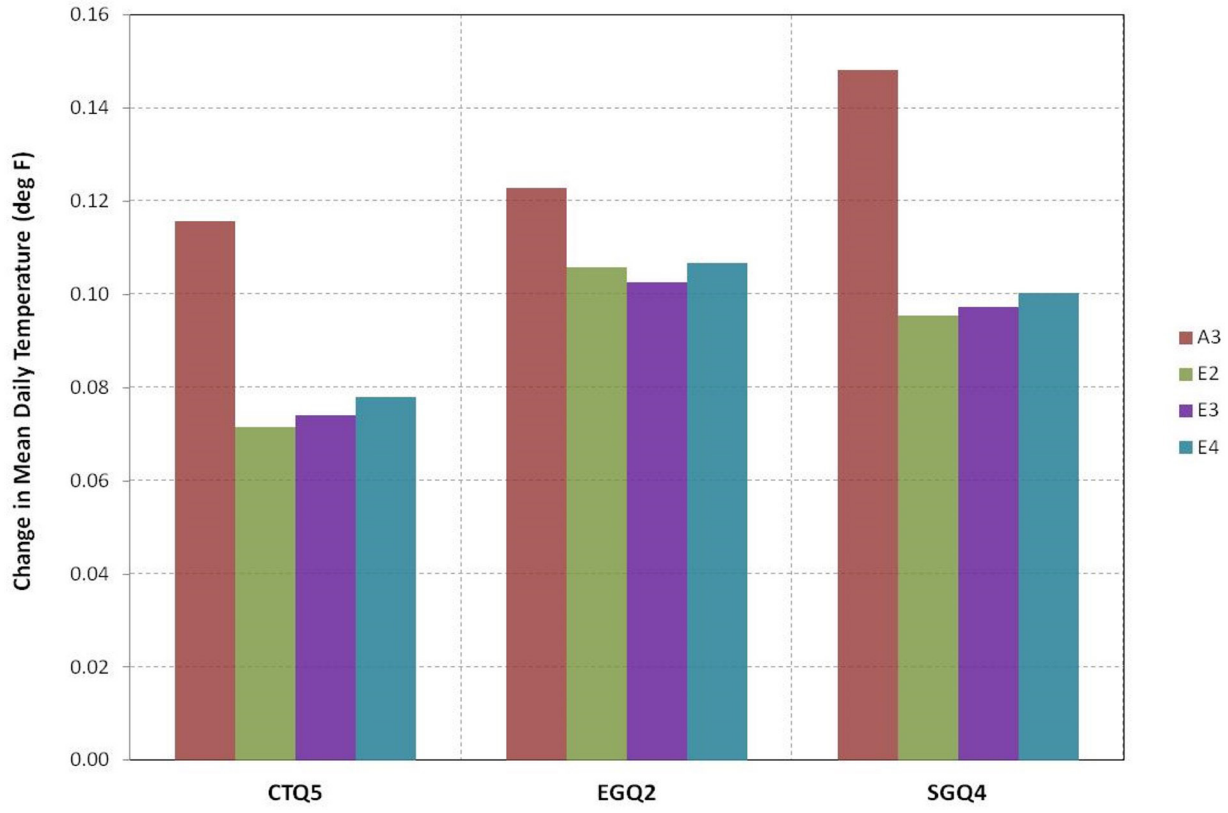

Figure 7-295. Change in Mean Daily Temperature on San Joaquin River at Vernalis from August to November in Portfolio E

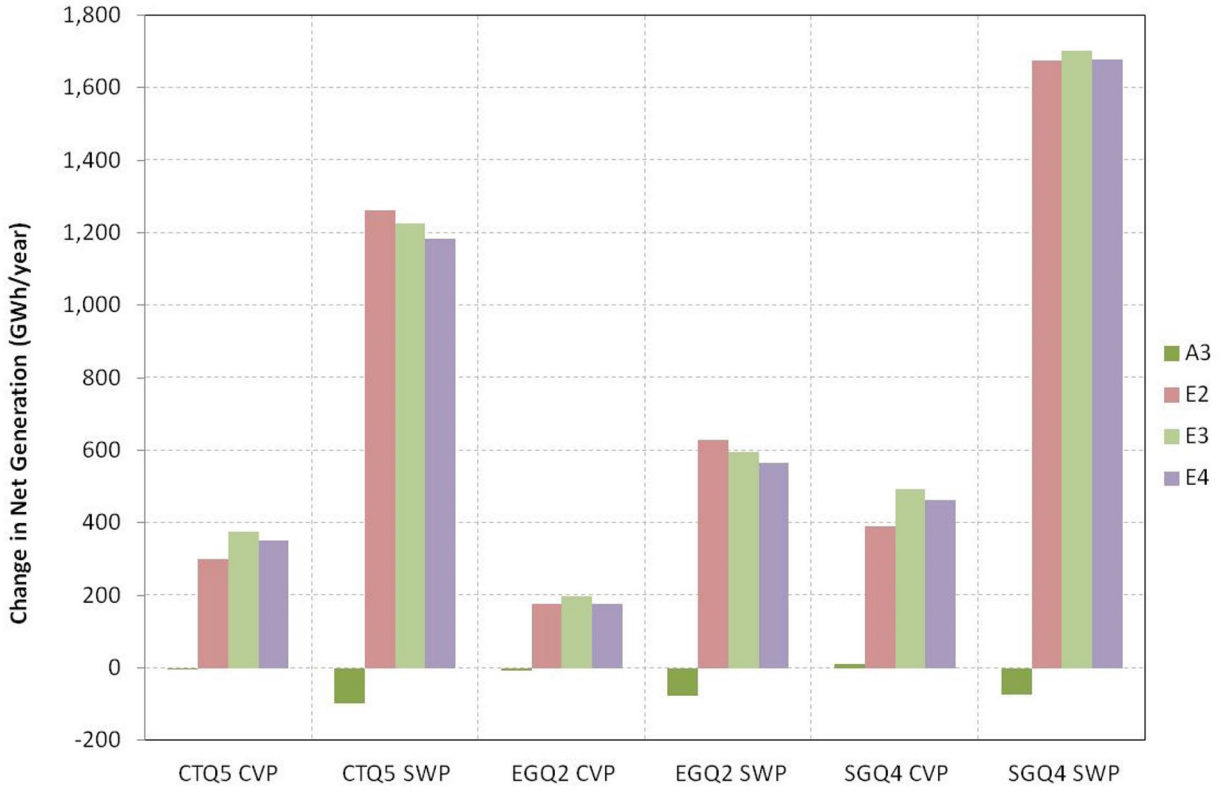

Figure 7-296. Change in Average Annual Net Energy Generation for the CVP and SWP Systems in Portfolio E

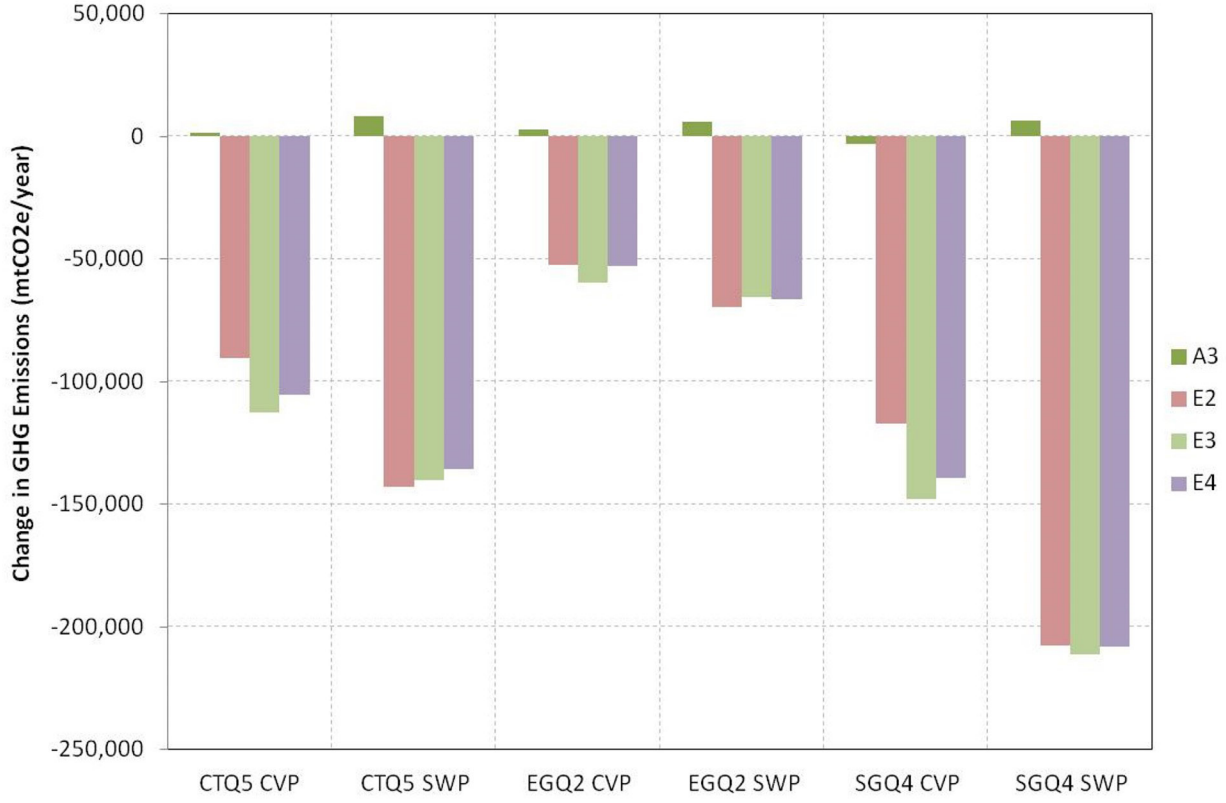

Figure 7-297. Change in Average Annual Greenhouse Gas Emissions for the CVP and SWP Systems in Portfolio E

This page intetionally left blank