Appendix A
References

/

References

Barbose, G., N. Darghouth, R. Wiser, and J. Seel. 2011. *Tracking the Sun IV, An Historical Summary of the Installed Cost of Photovoltaics in the United States from 1998 to 2010*, Lawrence Berkeley National Laboratory. September.

Black & Veatch. 2011. *Operating Descriptions for San Vicente Pump Station.* January.

Black & Veatch/Ebasco/EQE. 1993. *Emergency Storage Project SDCWA Aqueducts Repair Time Estimates* (1993 Vulnerability Report). Prepared for the San Diego County Water Authority. June.

Brown and Caldwell/Black & Veatch/CDM. 2012. *Recycled Water Study.* Prepared for the City of San Diego. July.

California Department of Water Resources (DWR). 2009a. *2009 California Water Plan Update*.

California Department of Water Resources (DWR). 2009b. *State Water Project Delivery Reliability Report.*

California Department of Water Resources (DWR). 2013. "California State Water Project Overview." Web site http://www.water.ca.gov/swp/index.cfm. Accessed October 2013.

California Solar Initiative. 2013. Current posted rebate amounts. Web site www.csi-trigger.com. Accessed May 2013.

Engineering News Record (ENR). 2012. "Construction Cost Index." October.

Metropolitan Water District of Southern California (MWD). 2010a. *Installation Restoration Program Update.*

Metropolitan Water District of Southern California (MWD). 2010b. *Regional Urban Water Management Plan*.

Metropolitan Water District of Southern California (MWD). 2010c. *Draft 2010 Integrated Water Resources Plan*. July.

Power Engineering. 2008. *Alvarado Hydroelectric Facility Evaluation*.

San Diego Association of Governments (SANDAG). 2011. *Series 12: 2050 Regional Growth Forecast*. Adopted on February 26, 2010.

San Diego County Water Authority (Water Authority). 1989. *The Water Distribution Plan, a Capital Improvement Program through the Year 2010*.

San Diego County Water Authority (Water Authority). 1993. *Emergency Storage Project SDCWA Aqueducts Repair Time Estimates Report*.

San Diego County Water Authority (Water Authority). 2000. *2000 Urban Water Management Plan*.

San Diego County Water Authority (Water Authority). 2002. *2003 Regional Water Facilities Master Plan.* Commonly called the "2003 Master Plan." Released December 2002, remained as a draft.

San Diego County Water Authority (Water Authority). 2007. *2007 Annual Report*.

San Diego County Water Authority (Water Authority). 2008. *Cost Estimating Guidelines*. January 5.

San Diego County Water Authority (Water Authority). 2009. *Camp Pendleton Seawater Desalination Project Feasibility Study*. Prepared by RBF Consulting. December.

San Diego County Water Authority (Water Authority). 2011a. *2010 Urban Water Management Plan (UWMP*). June.

San Diego County Water Authority (Water Authority). 2011b. *Water Smart, Embracing the 'New Normal.'* 2011 Annual Report. Web site http://viewer.zmags.com/publication/e1f8bdaf#/e1f8bdaf/1. Accessed September 2013.

San Diego County Water Authority (Water Authority). 2012. *Real Value, Water – Sustaining Our Quality of Life, Driving OurEconomy.* 2012 Annual Report. Web site http://sdcwa.org/annualreport/2012/. Accessed September 2013.

San Diego County Water Authority (Water Authority). 2013a. *Annual Water Supply Report*.

San Diego County Water Authority (Water Authority). 2013b. *Notice of Preparation of the Programmatic Environmental Impact Report*. Submitted to the California State Clearinghouse on April 15, 2013.

San Diego County Water Authority (Water Authority). 2013c. *Water Shortage and Drought Response Plan.* Web site http://www.sdcwa.org/water-shortage-and-drought-response-plan. Accessed August 2013.

San Diego County Water Authority (Water Authority). 2014. *Supplemental Program Environmental Impact Report.*

San Diego County Water Authority and Metropolitan Water District (Water Authority and MWD). 1993. *Environmental Impact Report*.

Timpe, C., and M.J.J. Scheepers. 2003. *SUSTELNET: A Look into the Future: Scenarios for Distributed Generation in Europe*.

United States Bureau of Reclamation (Reclamation). 2007. *Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead*.

United States Bureau of Reclamation (Reclamation). 2011. *Colorado River Basin Water Supply and Demand Study*. Draft Technical Reports.

United States Bureau of Reclamation (Reclamation). 2012. *Colorado River Basin Water Supply and Demand Study*. Draft Technical Reports.

United States Bureau of Reclamation (Reclamation). 2013. *Colorado River Basin Supply and Demand Study*. Web site http://www.usbr.gov/lc/region/programs/crbstudy.html. Accessed September 2013.

Appendix B
Abbreviations

Acronyms and Abbreviations

2003 Master Plan	2003 Regional Water Facilities Optimization and Water Master Plan Update
2010 UWMP	2010 Urban Water Management Plan
AAC	All American Canal
AF	acre-feet
AF/YR	AF per year
BCSD	bias-corrected and statistically downscaled
BDCP	Bay Delta Conservation Plan
Board	Board of Directors
CA	Constructed Analogue
CAP	Climate Action Plan
Carlsbad project	Carlsbad Seawater Desalination Project (Carlsbad project)
CC	Coachella Canal
CIP	Capital Improvement Program
CMWD	Carlsbad Municipal Water District
CP	Camp Pendleton Marine Corps Base
CRA	Colorado River Aqueduct
CSP	Carryover Storage Project
CVWD	Coachella Valley Water District
Del Mar	City of Del Mar
Delta	Sacramento–San Joaquin River Delta
DHCCP	Delta Habitat Conservation and Conveyance Program
Escondido	City of Escondido
ESP	Emergency Storage Project
FPUD	Fallbrook Public Utility District
GHG	green-house gas
HWD	Helix Water District

ICS	intentionally created surplus (ICS)
IID	Imperial Irrigation District
IPR	Indirect Potable Reuse
LWD	Lakeside Water District
MAF	million acre feet
MCB	Marine Corps Base
mgd	million gallons per day
MWD	Metropolitan Water District of Southern California
National City	City of National City
NeDWAF	Net Demand on Water Authority Facilities
NOP	Notice of Preparation
Oceanside	City of Oceanside
OMWD	Olivenhain Municipal Water District
OWD	Otay Water District
PDMWD	Padre Dam Municipal Water District
PEIR	Programmatic Environmental Impact Report
PET	potential evapotranspiration
Poway	City of Poway
QSA	Quantitative Settlement Agreement
Ramona MWD	Ramona Municipal Water District
Rincon del Diablo MWD	Rincon del Diablo Municipal Water District
RMWD	Rainbow Municipal Water District
RO	reverse osmosis
RUWMP	Regional Urban Water Management Plan
San Diego	City of San Diego
SANDAG	San Diego Association of Governments
SBID	South Bay Irrigation District
SC	service connection
SDWD	San Dieguito Water District

SFID	Santa Fe Irrigation District
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
TDS	total dissolved solids
UWMP	Urban Water Management Plan
VCMWD	Valley Center Municipal Water District
VIC	Variable Infiltration Capacity
VID	Vista Irrigation District
VWD	Vallecitos Water District
Water Authority	San Diego County Water Authority
WTP	Water Treatment Plant
Yuima	Yuima Municipal Water District

TABLE 1-2
Member Agencies of San Diego County Water Authority

Abbreviation	Agency
CMWD	Carlsbad Municipal Water District
CP	Camp Pendleton Marine Corps Base
Del Mar	City of Del Mar
Escondido	City of Escondido
FPUD	Fallbrook Public Utility District
HWD	Helix Water District
LWD	Lakeside Water District
National City	City of National City
Oceanside	City of Oceanside
OMWD	Olivenhain Municipal Water District
OWD	Otay Water District
PDMWD	Padre Dam Municipal Water District
Poway	City of Poway
Ramona MWD	Ramona Municipal Water District
Rincon del Diablo MWD	Rincon del Diablo Municipal Water District
RMWD	Rainbow Municipal Water District
San Diego	City of San Diego
SBID	South Bay Irrigation District
SDWD	San Dieguito Water District
SFID	Santa Fe Irrigation District
VCMWD	Valley Center Municipal Water District
VID	Vista Irrigation District
VWD	Vallecitos Water District
Yuima	Yuima Municipal Water District

Appendix C
Selected 2010 UWMP Tables

Table 2-4. Member Agency Additional Water Conservation (Acre-Feet)

	2015	2020	2025	2030	2035
Total Water Use Efficiency Target	-15,386	-76,705	-110,763	-138,592	-161,201
Verifiable Recycled Water Applied to Meet Water Use Efficiency Target [1,2]	8,649	29,754	38,529	41,312	43,673
Additional Conservation Required[3]	-6,737	-46,951	-72,234	-97,280	-117,528

[1]Excludes recycled supplies for agencies with SBX7-7 demand targets exceeding their baseline demands.
[2]Recycled supplies set equal to water use efficiency target for agencies with recycled supplies in excess of their target.
[3]Additional increment of conservation, beyond existing savings, required to meet water use efficiency target.

Table 2-5. Normal Year Regional Water Demand Forecast Adjusted for Water Conservation (AF)

	2015	2020	2025	2030	2035
Total Regional Baseline Demand	654,022	722,040	790,229	850,899	903,213
Additional Conservation	-6,737	-46,951	-72,234	-97,280	-117,528
Total Baseline Demand with SBX7-7 Conservation	647,285	675,089	717,995	753,619	785,685

Table 2-9. Member Agency Normal Year Imported Demand on the Water Authority [1'2'3'4] (AF)

Member Agency	2015	2020	2025	2030	2035
Carlsbad MWD	16,862	18,600	20,612	22,273	23,253
Del Mar, city of	1,222	1,224	1,236	1,251	1,266
Escondido, city of	23,734	21,337	22,913	23,931	24,601
Fallbrook PUD	14,140	15,047	16,338	17,528	18,318
Helix WD	33,441	32,126	33,754	35,823	37,898
Lakeside WD	4,114	4,424	4,600	4,734	5,045
Oceanside, city of	23,566	24,094	25,097	26,294	26,702
Olivenhain MWD	21,118	21,552	21,874	22,539	22,854
Otay WD	40,483	41,244	43,934	45,889	48,524
Padre Dam MWD	14,935	15,913	17,105	17,740	18,656
Pendleton, MCB Camp	850	850	850	850	850
Poway, city of	12,593	13,020	13,422	13,954	14,076

Source: *2010 Urban Water Management Plan*, *San Diego County Water Authority*, June 2011

Table 2-9. Member Agency Normal Year Imported Demand on the Water Authority [1'2'3'4] (AF) (continued)

Member Agency	2015	2020	2025	2030	2035
Rainbow MWD	21,537	21,070	22,446	24,078	26,137
Ramona MWD	11,213	10,635	11,455	12,159	12,539
Rincon del Diablo MWD	3,696	5,429	6,024	6,765	7,024
San Diego, city of	201,721	221,458	237,622	249,728	260,107
San Dieguito WD	4,736	5,025	5,453	5,677	5,836
Santa Fe ID	8,738	8,093	8,426	8,704	8,919
Sweetwater Authority	8,125	3,292	3,671	4,461	5,292
Vallecitos WD	18,666	17,454	18,777	19,547	19,949
Valley Center MWD	32,497	32,526	34,459	36,403	38,537
Vista ID	16,080	15,961	16,954	17,825	20,000
Yuima MWD	2,098	2,006	2,267	2,510	2,707
Sub-Total	**536,165**	**552,380**	**589,289**	**620,663**	**649,090**
Accelerated Forecast Growth [5]	2,224	4,421	6,605	8,776	10,948
Total	**538,389**	**556,801**	**595,894**	**629,439**	**660,038**

[1] Based on SANDAG 2050 Regional Growth Forecast
[2] Includes historic and projected water conservation
[3] Includes demands associated with member agency known near-term annexations
[4] Assumes member agency implementation of verifiable local supply projections
[5] Demands associated with accelerated forecasted growth are not attributed to individual member agencies and are listed for regional planning purposes
Definitions:
ID = Irrigation District; MWD = Municipal Water District; PUD = Public Utility District; WD = Water District

Table 5-2. Projected Surface Water Supply (Normal Year — AF/YR)

2010	2015	2020	2025	2030	2035
27,336[1]	48,206[2]	47,940	47,878	47,542	47,289

[1] Based on fiscal year 2010 totals.
[2] Post-2015 supply adjusted downward to account for increase in Cal Am demands from City of San Diego.

Table 5-3. Projected Groundwater Supply (Normal Year — AF/YR)

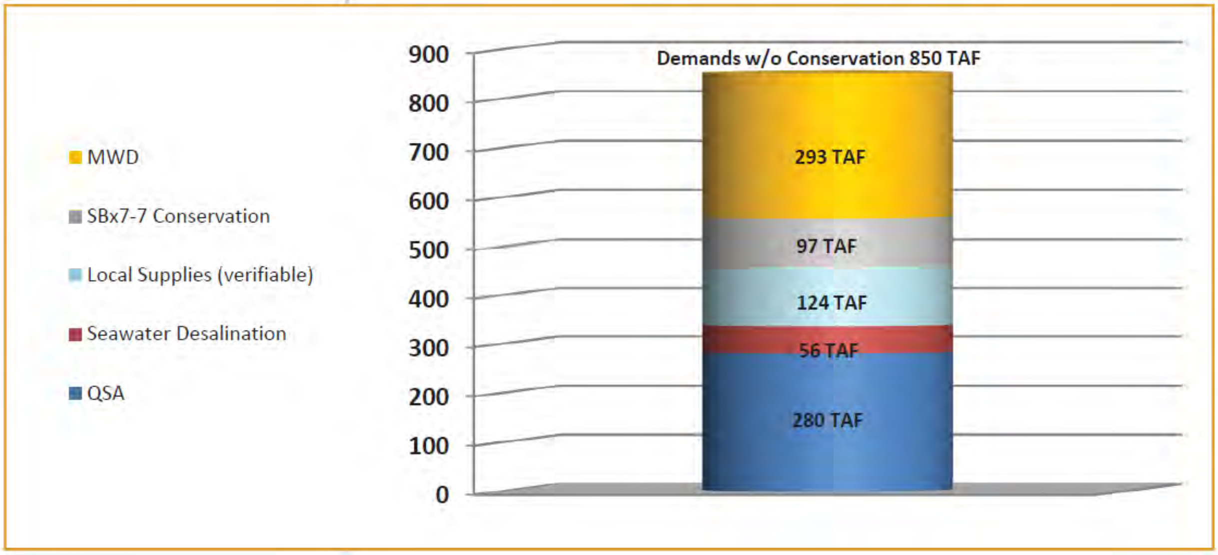
2010	2015	2020	2025	2030	2035
20,833	22,030	26,620	27,620	28,360	28,360

Table 5-5. Projected Recycled Water Use (Normal Year — AF/YR)

2010	2015	2020	2025	2030	2035
27,931	38,660	43,728	46,603	48,278	49,998

Source: *2010 Urban Water Management Plan, San Diego County Water Authority*, June 2011

Figure 10-1
2030 Projected Water Resource Mix (Normal Year)



Source: *2010 Urban Water Management Plan, San Diego County Water Authority,* June 2011

Appendix D
Development of Daily Demand Shapes

Contents

Introduction

Objective

The objective of this appendix is to describe how the daily demand shapes were developed reflecting recently observed member agency variability when used in combination with annual- and decadal-level demand projections prepared for the Urban Water Management Plan (UWMP). In general, the process for obtaining daily deliveries for each agency was to multiply the projected average annual demand by a factor for each day and for five annual hydroclimatic conditions, represented as year wetness types of wet, above normal, normal, dry, and critical conditions. The development of these daily demand factors is described herein, as follows: overall approach, data sources, methods, and conclusions. Attachment A presents the raw data summary, and Attachment B presents demand shapes for each member agency.

Overall Approach

The development of the daily demand shapes for each member agency was based on a three-step process described below. **Figure 2B-1** outlines this process graphically.

Step 1: Raw Time Series Gathering

1. Daily deliveries of water from the Water Authority system were the primary information collected and organized.
2. Water Authority deliveries, combined with member agency groundwater and reuse programs, were assumed to represent the patterns of demand.
3. The historical database contained missing or erroneous data for various periods and durations over the historical period July 1, 1996 through December 31, 2010.

Step 2: Data Compilation of Total Daily Historical Deliveries and PET Model Development

1. Historical daily treated and raw water deliveries to member agencies were compiled from the database provided by the Water Authority.
2. Consumptive use by each agency was assumed to be equal to WTP flows plus MWD untreated flows plus groundwater plus recycled water flows.
3. Daily delivery data was calculated simultaneously using a simple demand model based on potential evapotranspiration (PET model) integrating observed temperature, radiation, relative humidity, and other weather information and precipitation information. These parameters were the primary drivers of daily demand variability for the historical period of record: July 1, 1996 through December 31, 2010.

Step 3: Daily Demand Shape Development

1. Historical and PET daily deliveries were each normalized based on the annual average demand for each member agency. This resulted in a daily demand factor, typically

ranging between 0.7 and 1.7, reflecting that daily variability as a percentage of the annual average demand.

2. A band around the seven-day centered average daily PET demand shapes was created based on the PET model's daily demand factors to identify some of the historical data outliers (missing or erroneous data). The historical daily demand factor was used if it fell within the band, and the PET daily demand factor was used if it fell outside of the band.
3. Future daily demands were then developed by applying representative historical daily patterns to the future annual projected demands from the UWMP. Representative patterns were based on local hydroclimatic indexing, also known as year typing, consistent with local surface water hydrology.

Simulation of future conditions in the model integrated supplies, demands, and system operations. Hydroclimate influences on local supply availability and demands were synchronized based on historical patterns.

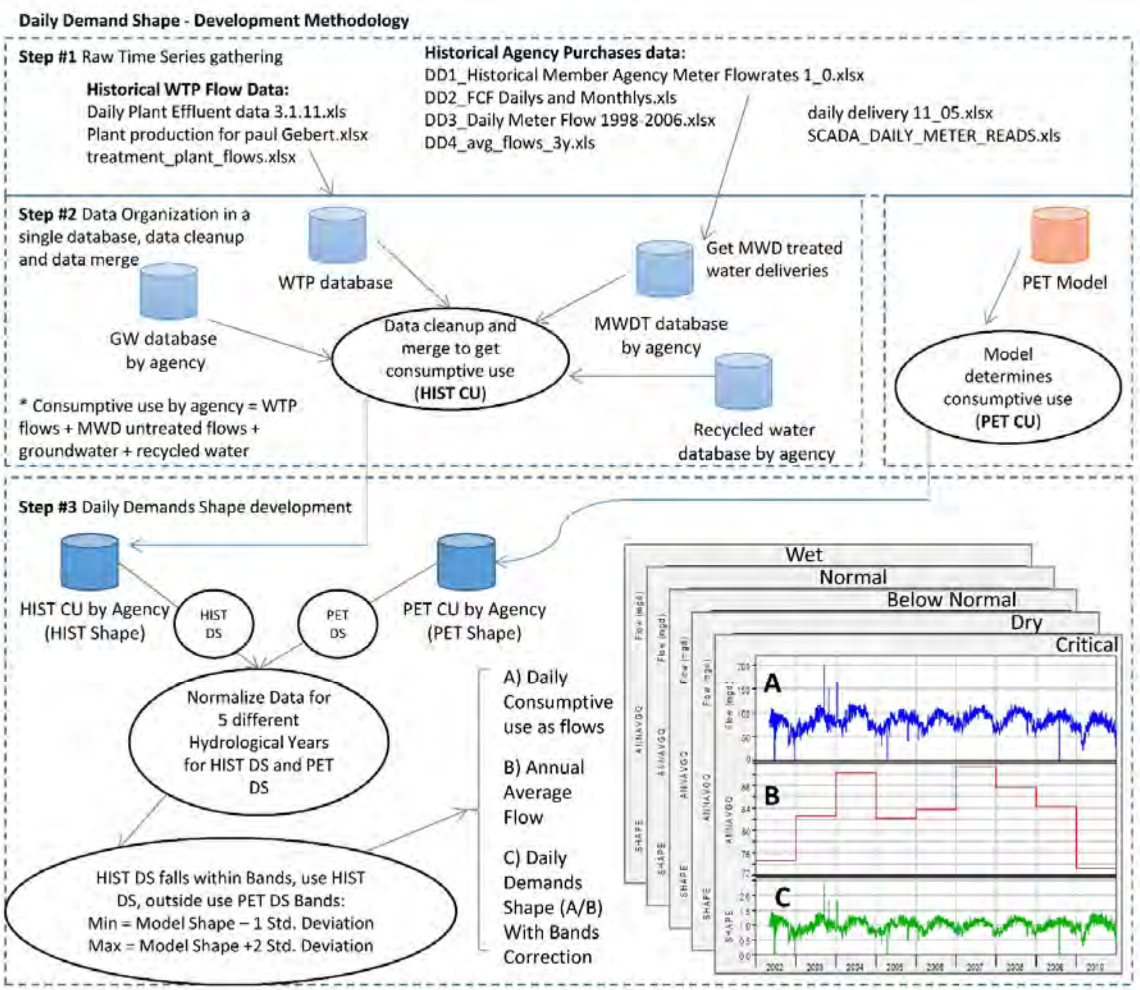


FIGURE 2B-1
Daily Demand Shape – Development Methodology

Data Sources

A number of data sources were reviewed to develop the historical daily delivery data set.

Historical Agency Purchases Data

Attachment A, Raw Data Summary, includes a matrix of the data sources for the historical agency purchases. This matrix shows, for each connection, which data source had available data in the ten categories listed below. Based on the data review and conversations with the Water Authority, data sources 1 through 5 and 7, as listed below, were used.

1. DD1_Historical Member Agency Meter Flowrates 1_0
2. DD3_Daily Meter Flow 1998-2006
3. DD2_FCF Dailys and Monthlys
4. DD4_avg_flows_3y
5. SCADA_DAILY_METER_READS
6. 2003 12pm_report
7. daily delivery 11_05
8. 5_1_04 to 9_30_05
9. 2006_CRC
10. 2007_CRC

Other Data

- Historical WTP Flow Groundwater and Recycled Water Data
    1. Daily Plant Effluent data 3.1.11.xls
    2. Plant production for paul Gebert.xlsx
    3. treatment_plant_flows.xlsx
    4. groundwater recycled by agency_080411
- Meter Capacity Information for All Member Agencies
    1. SDCWA_PipeCapacity w_TH comments.xlsx

Methods

Data Compilation of Total Daily Historical Deliveries

The raw data was used to calculate the total daily deliveries by agency as calculated by Equation 1.

Equation 1

$$CU_a = WTQ_a + GW_a + RCY_a + IN_a$$

Where:

a = Agency
CU_a= Total consumptive use (daily deliveries)
WTQ_a= Water treatment flows
GW_a= Groundwater production
RCY_a= Recycled water program flows
IN_a= Imported water consumption

Data Compilation of Total Daily Deliveries with Use of PET Model

While the data being analyzed ranged between the time period of July 1, 1996 through December 31, 2010, there were a number of gaps which varied by agency and were either actual missing data or points of erroneous data. It was agreed that data gaps were to be filled as a function of observed climate data (Potential ET minus Precipitation). The gaps were to be determined and replaced during daily demand shape development. A simple model based on available observed data and simulated PET was developed to assist in filling in the daily variability records. The following subsections provide background on this type of model and the description of the model used for the project.

PET Model Background

As part of studies simulating future climate and hydrologic conditions in the San Diego region, the project team has access to a physically-based hydrologic model. The project team, Scripps, and others have applied this model to a range of historic and future climate applications. The historical simulations use observed meteorology such as temperature, precipitation, wind speed, radiation, relative humidity, and other factors to simulate detailed hydroclimatic processes. Principal among these for this study was a Penman-Monteith daily estimate of historical evapotranspiration.

Potential evapotranspiration (PET) less actual precipitation (P) provides an estimate of the weather-based demand, and explains the primary variability in daily patterns. Outdoor residential, industrial, and agricultural demand variability are primarily captured with this term, PET minus P. Indoor and industrial demands contain less daily variability and therefore are not captured.

PET Model Description

The model is defined as:

$$D = (PET-P) \times A \times IE + B$$

D is the member agency demand; PET is the simulated daily potential evapotranspiration, P is precipitation; A is a calibration coefficient reflecting the irrigated area size; IE is a monthly calibration coefficient representing irrigation efficiency or irrigation practices; and B is a calibration coefficient based on the non-weather based demands (indoor use).

PET and P were available for each of the 24 member agencies.

The model was calibrated (through adjustments of A, IE, and B) separately for each member agency based on observed deliveries

The end result of this process was a complete delivery data set based on the PET model results for each member agency for the period of record matching the historical delivery data, July 1, 1996 through December 31, 2010. The data was then converted to a daily demand shape and used to fill missing or erroneous historical data.

Daily Demand Shape Development

The daily deliveries were converted into daily shapes by dividing the daily flows by the annual demand average value. Also included was the classification of daily shapes as a function of the year wetness condition (wet, above normal, normal, dry, and critical). The year wetness conditions were developed using San Diego Airport precipitation data from 1900. The annual precipitation from 1900 to 2010 was ranked and the water year was determined by the percentile intervals. The final result was 5 different water year classes:

- WET year (annual precipitation from 13.6″ and up)
- ABOVE NORMAL year (annual precipitation from 10.6″ to 13.6″)
- NORMAL year (annual precipitation from 8.6″ to 10.6″)
- DRY year (annual precipitation from 6.6″ to 8.6″)
- CRITICAL year (annual precipitation from 0 to 6.6″)

Some of the factors based on historical data were replaced with the PET model factors. Data was not only replaced when data was missing, but if the historical demand factor fell outside of the band of realistic values. The upper band limit was defined as two standard deviations above the average of the PET model factor, and the lower limit was set by one standard deviation below the average. If the historical factor was within this band, it was used; if outside the band, the PET model based demand factor was used.

Table 2B-1 summarizes the percent of data, per agency, that was replaced with the PET model. As shown, during the dry year, there were a number of agencies where 100 percent of the data was replaced. Two examples of this are Helix and San Dieguito/Santa Fe. During the period of historical data, Helix only had a portion of one year considered dry. This calculated into a factor that fell outside of the bands since it was an average but there was only data for a portion of a year. All data was replaced. San Dieguito/Santa Fe had no dry years during the period of record, and therefore all data was replaced with PET model data.

TABLE 2B-1
Percent of Historical Daily Shapes Replaced with PET Daily Shapes

Agency	Wet	Above Normal	Normal	Dry	Critical
Carlsbad	48%	41%	34%	41%	32%
ECRTWIP	n/a	n/a	n/a	n/a	n/a
Escondido	56%	21%	17%	32%	20%
Fallbrook	51%	25%	26%	35%	40%
Helix	34%	33%	31%	100%	22%
National City/South Bay	51%	47%	43%	100%	32%
Oceanside	57%	93%	62%	55%	52%
Olivenhain	19%	13%	35%	23%	13%
Otay	16%	16%	23%	20%	26%
Padre Dam	32%	33%	41%	30%	24%
Poway	39%	32%	50%	30%	25%
Rainbow	16%	22%	27%	23%	12%
Ramona	39%	32%	50%	47%	32%
Rincon	45%	19%	24%	26%	23%
San Diego Alvarado	37%	28%	37%	100%	79%
San Diego Miramar	36%	36%	93%	52%	21%
San Diego North	18%	12%	26%	9%	11%

TABLE 2B-1
Percent of Historical Daily Shapes Replaced with PET Daily Shapes

Agency	Wet	Above Normal	Normal	Dry	Critical
San Diego Otay	10%	16%	22%	100%	15%
San Diego SD11	38%	30%	77%	20%	23%
San Dieguito/Santa Fe	12%	5%	16%	100%	21%
Vallecitos	10%	10%	100%	11%	24%
Valley Center	16%	52%	99%	17%	20%
Vista	19%	9%	99%	18%	23%
Yuima	24%	10%	46%	18%	27%

Daily Demand Shape Development with Climate Change Adjustment

As part of the scenario planning approach considered in the Master Plan, future climate change influences on water demand were considered. Historical daily weather was adjusted for the projected changes in climate using over 100 projections of future climate as described in detail in Appendix 2-C. These changes in weather were then used to approximate changes in daily demands for each member agency. The changes in daily demands were used to adjust the historical daily demand patterns for each agency in scenarios considering future climate change.

Summary

The process for obtaining future daily demands was to multiply the UWMP's average annual demand by a multiplier factor for each day. Based on historical daily records, a year-long sequence of daily multiplier factors was determined for each year and agency so that numerous sequences were obtained for each member agency. A weather-correlated method based on potential evapotranspiration was used to fill in any missing daily factor gaps so that complete sequences of member agency daily factors could be generated. Each such annual sequence was then correlated with the historical weather for the year. Normalized daily patterns were available for five annual hydroclimatic conditions, represented as wet, above normal, below normal, dry, and critical year types. When applied to the future demand projections, the daily demand for any given year was selected based on the year type of the hydroclimate reference year used in the simulation to ensure correlation with local conditions.

Attachment B, Daily Demand Shapes, includes four plots for each member agency:

- Plot One – Historical raw data for delivery.
- Plot Two – Historical filtered daily delivery vs. simulated PET daily deliveries. The historical delivery plot was filtered based on flows that would stay between the 25th and 95th percentiles around the seven-day moving average of the PET model results.
- Plot Three – Demand shape measurements for normal wetness year condition based on: historical deliveries, those that are replaced by PET model, those that will not be used, and the 1 and 2 standard deviation bands.

- Plot Four – Daily demand shape for the five wetness year conditions: wet, above normal, normal, dry, and critical.

Figures 2B-2 through 2B-5 illustrate the four plots listed above using the City of San Diego's SD 11 connection as an example.

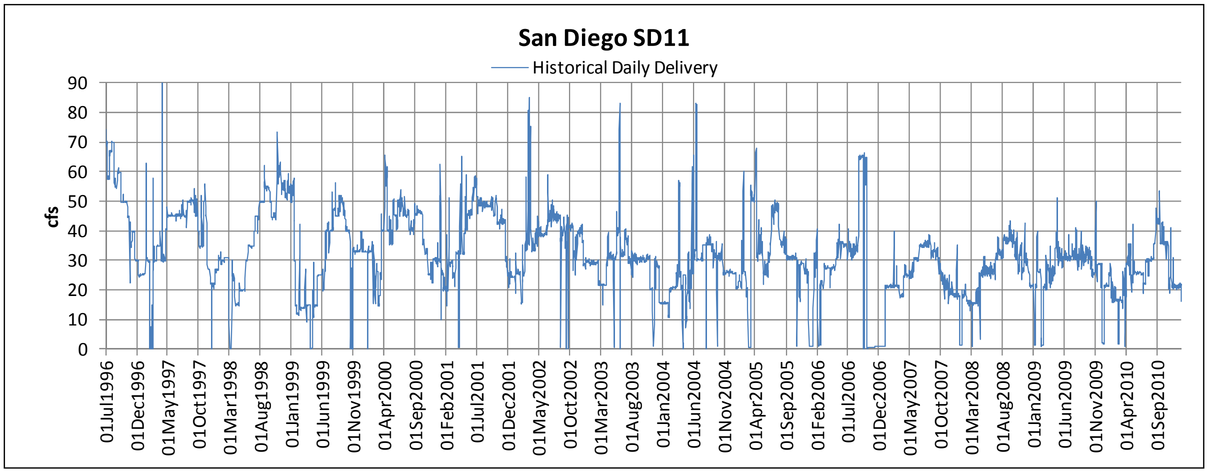


FIGURE 2B-2
San Diego 11 Connection – Historical Daily Deliveries

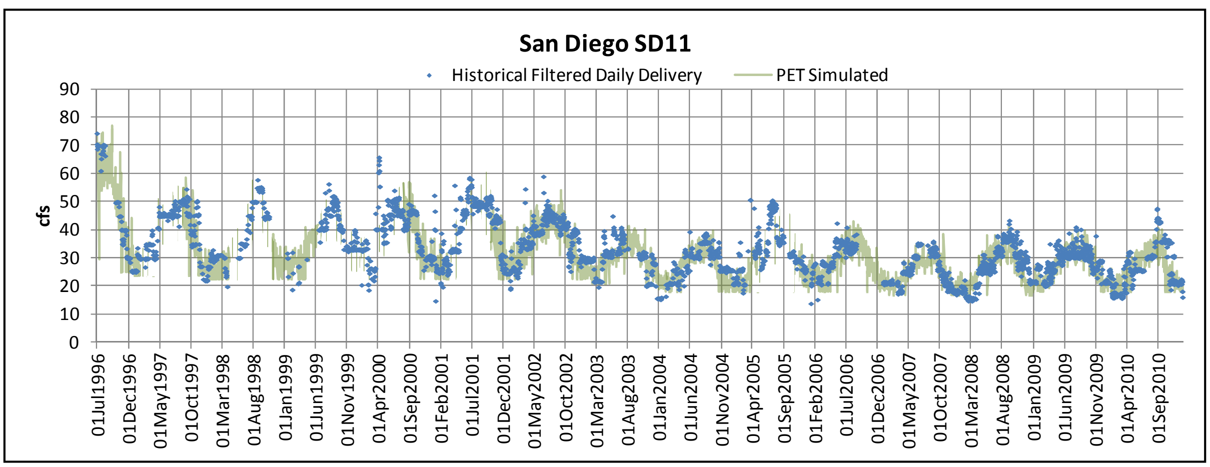


FIGURE 2B-3
San Diego 11 Connection – Historical Filtered and Simulated Daily Deliveries

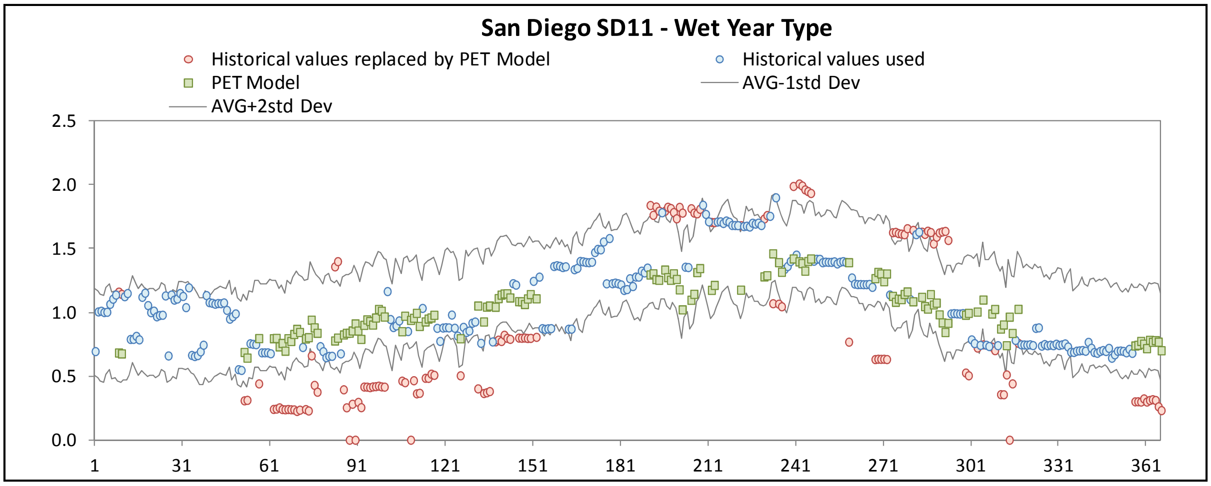


FIGURE 2B-4
San Diego 11 Connection – Daily Demand Factor Measurements for Wet Wetness Year

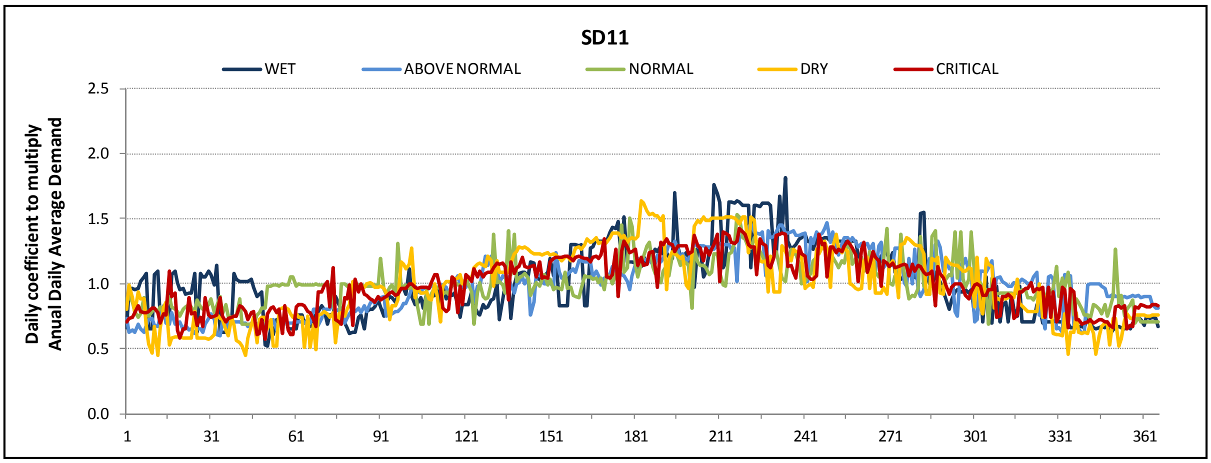


FIGURE 2B-5
San Diego 11 Connection – Daily Demand Shapes

Attachment A
Raw Data Summary

Connections	1996 to 2001	2001 to 2006	2007 to 2010	1997 to 2000 (fill in only)	1999 to 2006	2001 to 2003	2003 to 2005	2004	2005	2006
	1	2	3	4	5	6	7	8	9	10
CR1	CB 1	CR 1	CR1	CR1-FI-111 Avg	CR1	CR-1-SC	Carlsbad,01	CR-1-SC	CR-1-SC	CR-1-SC
CR3	CB 3	CR 3	CR3	CR3-FI-111 Avg	CR3	CR-3-SC	Carlsbad,03	CR-3-SC	CR-3-SC	CR-3-SC
CR4	CB 4	CR 4	CR4	CR4-FI-111 Avg	CR4	CR-4-SC	Carlsbad,04	CR-4-SC	CR-4-SC	CR-4-SC
CRT	CR	CR	CR	CR	CRT	CRT	CRT	CRT	CRT	CRT
ESC3	ESC 3	ESC 3	ESC3	ESC3-FI-111 Avg	ESC3	ESC-3-SC		ESC-3-SC	ESC-3-SC	ESC-3-SC
ESC4	ESC 4	ESC 4	ESC4	ESC4-FI-111 Avg	ESC4	ESC-4-SC		ESC-4-SC	ESC-4-SC	ESC-4-SC
ESCU	ESC	ESC	ESC	ESC	ESCU	ESCU	ESCU	ESCU	ESCU	ESCU
DLZ1			DLZ1						DLZ-1 (SD-02)	DLZ-1 (SD-02)
FB3		FB 3	FB3	FB3-FI-111 Avg	FB3	FB-3-SC		FB-3-SC	FB-3-SC	FB-3-SC
FB4	FB 4	FB 4	FB4	FB4-FI-111 Avg	FB4	FB-4-SC		FB-4-SC	FB-4-SC	FB-4-SC
FB6		FB 6	FB6	FB6-FI-111 Avg		FB-6-SC		FB-6-SC	FB-6-SC	FB-6-SC
FBT	FB	FB	FB	FB	FBT	FBT	FBT	FBT	FBT	FBT
HLX2	HLX 2	HLX2		HLX2-FI-111 Avg	HLX2	HLX-2-SC		HLX-2-SC	HLX-2-SC	HLX-2-SC
HLX1	HLX 1	HLX 1	HLX1	HLX1-FI-111 Avg	HLX1	HLX-1-SC		HLX-1-SC	HLX-1-SC	HLX-1-SC
HLX6	HLX 6/7/8	HLX 6	HLX6					HLX-6-SC	HLX-6-SC	HLX-6-SC
HLX7		HLX 7	HLX7					HLX-7-SC	HLX-7-SC	HLX-7-SC
HLX8		HLX 8	HLX8					HLX-8-SC	HLX-8-SC	HLX-8-SC
HLXU	HLX-U	HLX-U	HLX-U	HLX-U	HLXU	HLXU	HLXU	HLXU	HLXU	HLXU
HLX5	HLX 5	HLX 5	HLX5		HLX5	HLX-5-SC		HLX-5-SC	HLX-5-SC	HLX-5-SC
HLXT	HLX-T	HLX-T	HLX-T	HLX-T	HLXT	HLXT	HLXT	HLXT	HLXT	HLXT
NCSB1	NCSB 1/2	NCSB 1	NCSB1	NCSB1-FI-111 Avg	NCSB1	NCSB-1-SC		NCSB-1-SC	NCSB-1-SC	NCSB-1-SC
NCSB3	NCSB 3	NCSB 3	NCSB 3	NCSB 3		NCSB-3V2-SC		NCSB-3V1-SC	NCSB-3V1-SC	NCSB-3V2-SC
NCSBU	NCSBU	NCSBU	NCSBU	NCSBU	NCSBU	NCSBU	NCSBU	NCSBU	NCSBU	NCSBU
NCSB4	NCSB 4	NCSB 4	NCSB4	NCSB4-FI-111 Avg	NCSB4	NCSB-4-SC		NCSB-4-SC	NCSB-4-SC	NCSB-4-SC
NCSB5		NCSB 5	NCSB5	NCSB5-FI-111 Avg		NCSB-5-SC		NCSB-5-SC	NCSB-5-SC	NCSB-5-SC
NCSBT	NCSBT	NCSB	NCSB	NCSB	NCSBT	NCSBT	NCSBT	NCSBT	NCSBT	NCSBT
OCS2	OC 2	OCS 2	OCS2	OCS2-FI-111 Avg		OCS-2-SC		OCS-2-SC	OCS-2-SC	OCS-2-SC
OCS5	OC 5	OCS 5	OCS5	OCS5-FI-111 Avg	OCS5	OCS-5-SC	Oceanside,05	OCS-5-SC	OCS-5-SC	OCS-5-SC
OCSU	OCS-U	OCS-U	OCS-U	OCS-U	OCSU	OCSU	OCSU	OCSU	OCSU	OCSU
OCS3	OC 3	OCS 3	OCS3	OCS3-FI-111 Avg	OCS3	OCS-3-SC	Oceanside,03	OCS-3-SC	OCS-3-SC	OCS-3-SC
OCS4	OC 4	OCS 4	OCS4	OCS4-FI-111 Avg	OCS4	OCS-4-SC	Oceanside,04	OCS-4-SC	OCS-4-SC	OCS-4-SC
OCS6	OC 6	OCS 6	OCS6	OCS6-FI-111 Avg	OCS6	OCS-6-SC	Oceanside,06	OCS-6-SC	OCS-6-SC	OCS-6-SC
OCST	OCS-T	OCS-T	OCS-T	OCS-T	OCST	OCST	OCST	OCST	OCST	OCST
OLIV1	OLIV 1	OLIV 1	OLIV1	OLIV1-FI-111 Avg	OLIV1	OLIV-1-SC		OLIV-1-SC	OLIV-1-SC	OLIV-1-SC
OLIV2	OLIV 2/7	OLIV 2	OLIV2	OLIV2-FI-111 Avg	OLIV2	OLIV-2-SC		OLIV-2-SC	OLIV-2-SC	OLIV-2-SC
OLIV3	OLIV 3	OLIV 3	OLIV3	OLIV3-FI-111 Avg	OLIV3	OLIV-3-SC		OLIV-3-SC	OLIV-3-SC	OLIV-3-SC
OLIV4	OLIV 4/6	OLIV4	OLIV4	OLIV4-FI-111 Avg	OLIV4	OLIV-4-SC		OLIV-4-SC	OLIV-4-SC	OLIV-4-SC
OLIV5	OLIV 5	OLIV 5	OLIV5	OLIV5-FI-111 Avg	OLIV5	OLIV-5-SC		OLIV-5-SC	OLIV-5-SC	OLIV-5-SC
OLIVT	OLIV-T	OLIV-T	OLIV-T	OLIV-T	OLIVT	OLIVT	OLIVT	OLIVT	OLIVT	OLIVT
OLIV8	OLIV 8	OLIV 8	OLIV8			OLIV-8-SC		OLIV-8-SC	OLIV-8-SC	OLIV-8-SC
OTP1		OLIV TP1	OTP1			OCS-TP-SC	Oceanside,TP	OLIV-TP1-SC	OLIV-TP1-SC	OCS-TP-SC
OLIVU	OLIV-U	OLIV-U	OLIV-U	OLIV-U	OLIVU	OLIVU	OLIVU	OLIVU	OLIVU	OLIVU
OTAY10	OTAY 9/10	OTAY 10	OTAY10	OTAY10-FI-111 Avg	OTAY10	OTAY-10-SC	Otay,10	OTAY-10-SC	OTAY-10-SC	OTAY-10-SC
OTAY11	OTAY 5/11	OTAY 11	OTAY11	OTAY11-FI-111 Avg	OTAY11	OTAY-11-SC	Otay,11	OTAY-11-SC	OTAY-11-SC	OTAY-11-SC
OTAY12	OTAY 4/12	OTAY 12	OTAY12	OTAY12-FI-111 Avg	OTAY12	OTAY-12-SC	Otay,12	OTAY-12-SC	OTAY-12-SC	OTAY-12-SC
OTAY13	OTAY 13	OTAY 13	OTAY13	OTAY13-FI-111 Avg	OTAY13	OTAY-13-SC	Otay,13	OTAY-13-SC	OTAY-13-SC	OTAY-13-SC
OTAYT	OTAY	OTAY	OTAY	OTAY	OTAYT	OTAYT	OTAYT	OTAYT	OTAYT	OTAYT
PD4	PD 4	PD 4	PD4	PD4-FI-111 Avg	PD4	PD-4-SC	Padre Dam,04	PD-4-SC	PD-4-SC	PD-4-SC
PDT	PD	PD	PD	PD	PDT	PDT	PDT	PDT	PDT	PDT
OTAY8	OTAY 8	OTAY 8	OTAY8					OTAY-8-SC	OTAY-8-SC	OTAY-8-SC
OTAY14	OTAY 14	OTAY 14	OTAY14					OTAY-14-SC	OTAY-14-SC	OTAY-14-SC
LKS1			LKS1							
PD6	PD 6		PD6							
PD7			PD7							
ECRTWIP	ECRTWIP	ECRTWIP	ECRTWIP	ECRTWIP	ECRTWIP	ECRTWIP	ECRTWIP	ECRTWIP	ECRTWIP	ECRTWIP
POW1	POW 1	POW 1	POW1	POW1-FI-111 Avg	POW1	POW-1-SC		POW-1-SC	POW-1-SC	POW-1-SC
POW3	POW 3	POW3	POW3	POW3-FI-111 Avg	POW3	POW-3-SC		POW-3-SC	POW-3-SC	POW-3-SC
POW4	POW 4	POW 4	POW4	POW4-FI-111 Avg	POW4	POW-4-SC		POW-4-SC	POW-4-SC	POW-4-SC
POWU	POW	POW	POW	POW	POWU	POWU	POWU	POWU	POWU	POWU
RAM1	RAM 1	RAM 1	RAM1	RAM1-FI-111 Avg	RAM1	RAM-1-SC	Ramona,01	RAM-1-SC	RAM-1-SC	RAM-1-SC
RAMU	RAM-U	RAM-U	RAM-U	RAM-U	RAMU	RAMU	RAMU	RAMU	RAMU	RAMU
RAM2	RAM 2	RAM 2	RAM2	RAM2-FI-111 Avg	RAM2	RAM-2-SC		RAM-2-SC	RAM-2-SC	RAM-2-SC
RAM3	RAM 3	RAM 3	RAM3	RAM3-FI-111 Avg	RAM3	RAM-3-SC	Ramona,03	RAM-3-SC	RAM-3-SC	RAM-3-SC
RAMT	RAM-T	RAM-T	RAM-T	RAM-T	RAMT	RAMT	RAMT	RAMT	RAMT	RAMT
RB1		RB 1	RB1	RB1-FI-111 Avg	RB1	RB-1-SC		RB-1-SC	RB-1-SC	RB-1-SC
RB3	RB 3	RB 3	RB3	RB3-FI-111 Avg	RB3	RB-3-SC		RB-3-SC	RB-3-SC	RB-3-SC

Connections	1996 to 2001	2001 to 2006	2007 to 2010	1997 to 2000 (fill in only)	1999 to 2006	2001 to 2003	2003 to 2005	2004	2005	2006
	1	2	3	4	5	6	7	8	9	10
RB5	RB 5									
RB6	RB 6	RB 6	RB6	RB6-FI-111 Avg	RB6	RB-6-SC		RB-6-SC	RB-6-SC	RB-6-SC
RB7	RB 7	RB 7	RB7	RB7-FI-111 Avg	RB7	RB-7-SC		RB-7-SC	RB-7-SC	RB-7-SC
RB8		RB 8	RB8	RB8-FI-111 Avg		RB-8-SC		RB-8-SC	RB-8-SC	RB-8-SC
RB9		RB 9	RB9	RB9-FI-111 Avg		RB-9-SC		RB-9-SC	RB-9-SC	RB-9-SC
RB10		RB 10	RB10	RB10-FI-111 Avg	RB10	RB-10-SC		RB-10-SC	RB-10-SC	RB-10-SC
RB11	RB 11	RB 11	RB11	RB11-FI-111 Avg	RB11	RB-11-SC		RB-11-SC	RB-11-SC	RB-11-SC
RB12	RB 12	RB12	RB12	RB12-FI-111 Avg	RB12					
RBT	RB	RB	RB	RB	RBT	RBT	RBT	RBT	RBT	RBT
RIN1	RIN 1	RIN 1	RIN1	RIN1-FI-111 Avg	RIN1	RIN-1-SC		RIN-1-SC	RIN-1-SC	RIN-1-SC
RIN3	RIN 3	RIN 3	RIN3	RIN3-FI-111 Avg	RIN3	RIN-3-SC		RIN-3-SC	RIN-3-SC	RIN-3-SC
RINT	RIN	RIN	RIN	RIN	RINT	RINT	RINT	RINT	RINT	RINT
SD5A	SD 5A		SD5A	SD5A-FI-111 Avg	SD5A	SD-5A-SC		SD-5A-SC	SD-5A-SC	SD-5A-SC
SD5B	SD 5B		SD5B	SD5B-FI-111 Avg	SD5B	SD-5B-SC		SD-5B-SC	SD-5B-SC	SD-5B-SC
SD5C	SD 5C		SD5C	SD5C-FI-111 Avg	SD5C	SD-5C-SC		SD-5C-SC	SD-5C-SC	SD-5C-SC
SDMIRAU	SD-MIRA	SD-MIRA	SD-MIRA	SD-MIRA	SD-MIRA	SD-MIRA	SD-MIRA	SD-MIRA	SD-MIRA	SD-MIRA
SD6A	SD 6A		SD6A	SD6A-FI-111 Avg	SD6A	SD-6A-SC		SD-6A-SC	SD-6A-SC	SD-6A-SC
SD7	SD 7		SD7	SD7-FI-111 Avg	SD7	SD-7-SC		SD-7-SC	SD-7-SC	SD-7-SC
SD20_Flow	SD 20	SD 20	SD20_Flow	SD20-FI-111 Avg		SD-20-SC		SD-20-SC	SD-20-SC	SD-20-SC
SDOTAYU	SD-LO	SD-LO	SD-LO	SD-LO	SDOTAYU	SDOTAYU	SDOTAYU	SDOTAYU	SDOTAYU	SDOTAYU
SD12	SD 12	SD 12	SD12	SD12-FI-111 Avg	SD12	SD-12-SC		SD-12-SC	SD-12-SC	SD-12-SC
SD23TA		SD 23T A	SD23TA			SD-23TA-SC		SD-23TA-SC	SD-23TA-SC	SD-23TA-SC
SD23TB			SD23TB			SD-23TB-SC		SD-23TB-SC	SD-23TB-SC	SD-23TB-SC
SDALVAU	SD-ALVA-U	SD-ALVA-U	SD-ALVA-U	SD-ALVA-U	SDALVAU					
SD10	SD 10	SD 10	SD10	SD10-FI-111 Avg	SD10	SD-10-SC		SD-10-SC	SD-10-SC	SD-10-SC
SD14	SD 14	SD 14	SD14	SD14-FI-111 Avg	SD14	SD-14-SC		SD-14-SC	SD-14-SC	SD-14-SC
SD15	SD 15	SD 15	SD15	SD15-FI-111 Avg	SD15	SD-15-SC		SD-15-SC	SD-15-SC	SD-15-SC
SDNT	SD-N	SD-N	SD-N	SD-N	SDNT	SDNT	SDNT	SDNT	SDNT	SDNT
SD11	SD 11	SD 11	SD11	SD11-FI-111 Avg	SD11	SD-11-SC	SD11	SD-11-SC	SD-11-SC	SD-11-SC
SD18	SD 18	SD 18	SD18			SD-18-SC		SD-18-SC	SD-18-SC	SD-18-SC
SD19	SD (13)/19	SD 19	SD19	SD19-FI-111 Avg	SD19	SD-19-SC		SD-19-SC	SD-19-SC	SD-19-SC
SD21		SD 21	SD21			SD-21-SC		SD-21-SC	SD-21-SC	SD-21-SC
SDALVAT	SD-ALVA-T	SD-ALVA-T	SD-ALVA-T	SD-ALVA-T	SDALVAT	SDALVAT	SDALVAT	SDALVAT	SDALVAT	SDALVAT
SDSF3	SDSF 3		SDSF3	SDSF3-FI-111 Avg	SDSF3	SDSF-3-SC	San Dieguito,03	SDSF-3-SC	SDSF-3-SC	SDSF-3-SC
SDSFT	SDSF-T		SDSF-T	SDSF-T	SDSFT	SDSFT	SDSFT	SDSFT	SDSFT	SDSFT
SDSF4	SDSF 4		SDSF4	SDSF4-FI-111 Avg		SDSF-4-SC		SDSF-4-SC	SDSF-4-SC	SDSF-4-SC
SDSFU	SDSF-U		SDSF-U	SDSF-U	SDSFU	SDSFU	SDSFU	SDSFU	SDSFU	SDSFU
VAL2	VAL 2		VAL2	VAL2-FI-111 Avg	VAL2	VAL-2-SC	Vallecitos,02	VAL-2-SC	VAL-2-SC	VAL-2-SC
VAL5	VAL 5			VAL5-FI-111 Avg	VAL5	VAL-5-SC	Vallecitos,05	VAL-5-SC		
VAL 6	VAL 6									
VAL7	VAL 7		VAL7	VAL7-FI-111 Avg	VAL7	VAL-7-SC	Vallecitos,07	VAL-7-SC	VAL-7-SC	VAL-7-SC
VAL8	VAL 8		VAL8	VAL8-FI-111 Avg	VAL8	VAL-8-SC	Vallecitos,08	VAL-8-SC	VAL-8-SC	VAL-8-SC
VAL9			VAL9					VAL-9-SC	VAL-9-SC	VAL-9-SC
VAL10	VAL 4/10		VAL10		VAL4/10	VAL-10-SC		VAL-10-SC	VAL-10-SC	VAL-10-SC
VALT	VAL		VAL	VAL	VALT	VALT	VALT	VALT	VALT	VALT
VC1A	VC 1A		VC1A	VC1A-FI-111 Avg	VC1A	VC-1A-SC	Valley Center,01A	VC-1A-SC	VC-1A-SC	VC-1A-SC
VC1B	VC 1B		VC1B	VC1B-FI-111 Avg	VC1B	VC-1B-SC	Valley Center,01B	VC-1B-SC	VC-1B-SC	VC-1B-SC
VC2	VC 2		VC2	VC2-FI-111 Avg	VC2	VC-2-SC	Valley Center,02	VC-2-SC	VC-2-SC	VC-2-SC
VC3	VC 3		VC3	VC3-FI-111 Avg	VC3	VC-3-SC	Valley Center,03	VC-3-SC	VC-3-SC	VC-3-SC
VC4	VC 4			VC4-FI-111 Avg		VC-4-SC	Valley Center,04	VC-4-SC	VC-4-SC	VC-4-SC
VC5	VC 5		VC5	VC5-FI-111 Avg	VC5	VC-5-SC	Valley Center,05	VC-5-SC	VC-5-SC	VC-5-SC
VC6	VC 6		VC6	VC6-FI-111 Avg	VC6	VC-6-SC	Valley Center,06	VC-6-SC	VC-6-SC	VC-6-SC
VC7	VC 7		VC7	VC7-FI-111 Avg	VC7	VC-7-SC	Valley Center,07	VC-7-SC	VC-7-SC	VC-7-SC
VC8	VC 8		VC8			VC-8-SC		VC-8-SC	VC-8-SC	VC-8-SC
VCT	VC		VC	VC	VCT	VCT	VCT	VCT	VCT	VCT
VID1	VID 1		VID1	VID1-FI-111 Avg	VID1	VID-1-SC	VID,01	VID-1-SC	VID-1-SC	VID-1-SC
VID3	VID 3		VID3	VID3-FI-111 Avg	VID3	VID-3-SC	VID,03	VID-3-SC	VID-3-SC	VID-3-SC
VID8	VID 8		VID8	VID8-FI-111 Avg	VID8	VID-8-SC	VID,08	VID-8-SC	VID-8-SC	VID-8-SC

Connections	1996 to 2001	2001 to 2006	2007 to 2010	1997 to 2000 (fill in only)	1999 to 2006	2001 to 2003	2003 to 2005	2004	2005	2006
	1	2	3	4	5	6	7	8	9	10
VID9	VID 9		VID9	VID9-FI-111 Avg	VID9	VID-9-SC	VID,09	VID-9-SC	VID-9-SC	VID-9-SC
VID10	VID 10		VID10	VID10-FI-111 Avg	VID10	VID-10-SC	VID,10	VID-10-SC	VID-10-SC	VID-10-SC
VID11	VID 11		VID11	VID11-FI-111 Avg	VID11	VID-11-SC	VID,11	VID-11-SC	VID-11-SC	VID-11-SC
VIDT	VID		VID	VID	VIDT	VIDT	VIDT	VIDT	VIDT	VIDT
YWD1	YWD 1		YWD1	YWD1-FI-111 Avg	YWD1	YWD-1-SC		YWD-1-SC	YWD-1-SC	YWD-1-SC
YWD2	YWD 2		YWD2	YWD2-FI-111 Avg		YWD-2-SC		YWD-2-SC	YWD-2-SC	YWD-2-SC
YWDT	YWD		YWD	YWD	YWDT	YWDT	YWDT	YWDT	YWDT	YWDT

Notes:

	Indicates no data
x	Although data point shown, there may still be gaps within that data set
x	Summation per agency

File ID	Date Start	Date End	File	Comment
DT_1	7/1/1996	3/12/2001	DD1_Historical Member Agency Meter Flowrates 1_0	Data called out through 6/30/2001 - but actually data empty after 3/12/2001
DT_2	3/13/2001	12/31/2006	DD3_Daily Meter Flow 1998-2006	For infill for overlapping data, alphabetically from SDSF to YWD no data
DT_3	1/1/2007	12/31/2010	DD2_FCF Dailys and Monthlys	Full set, only partially missing
DT_4	1/1/1997	2/14/2000	DD4_avg_flows_3y	For infill and/or to check the first source
DT_5	6/8/1999	6/18/2006	SCADA_DAILY_METER_READS	For infill and/or to check the first/second source - no data7/22/02 to 6/23/03
DT_6	3/13/2001	10/14/2003	2003 12pm_report	Either Start/End reading, not actual reading
DT_7	10/1/2003	11/21/2005	daily delivery 11_05	
DT_8	4/29/2004	10/5/2004	5_1_04 to 9_30_05	Either Start/End reading, not actual reading
DT_9	4/25/2005	10/4/2005	2006_CRC	Either Start/End reading, not actual reading
DT_10	4/26/2006	10/3/2006	2007_CRC	Either Start/End reading, not actual reading

Attachment B
Daily Demand Shapes for Water Authority Member Agencies

Figure X. Daily demand summary for Carlsbad.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

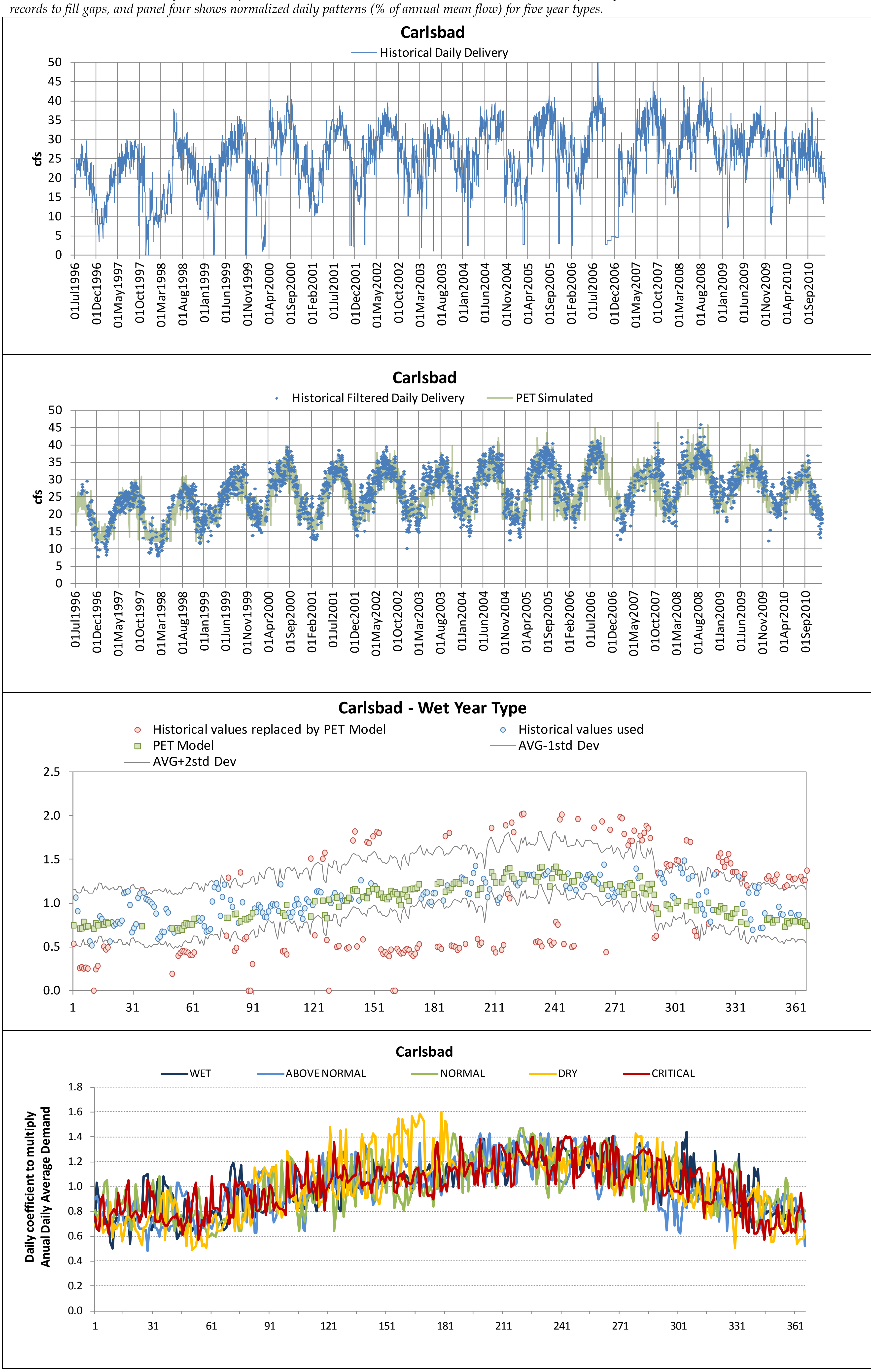


Figure X. Daily demand summary for Escondido.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

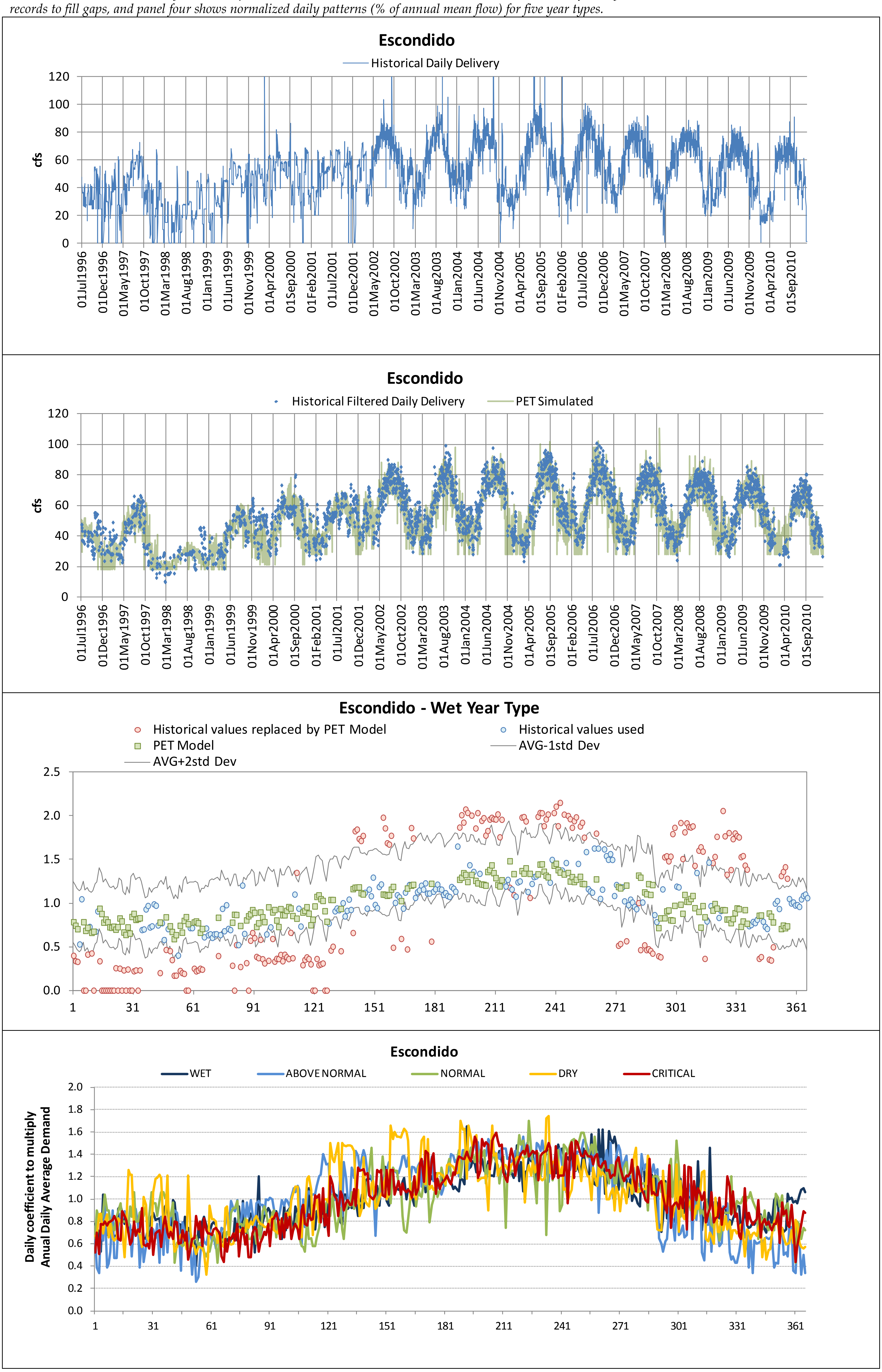


Figure X. Daily demand summary for Fallbrook.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

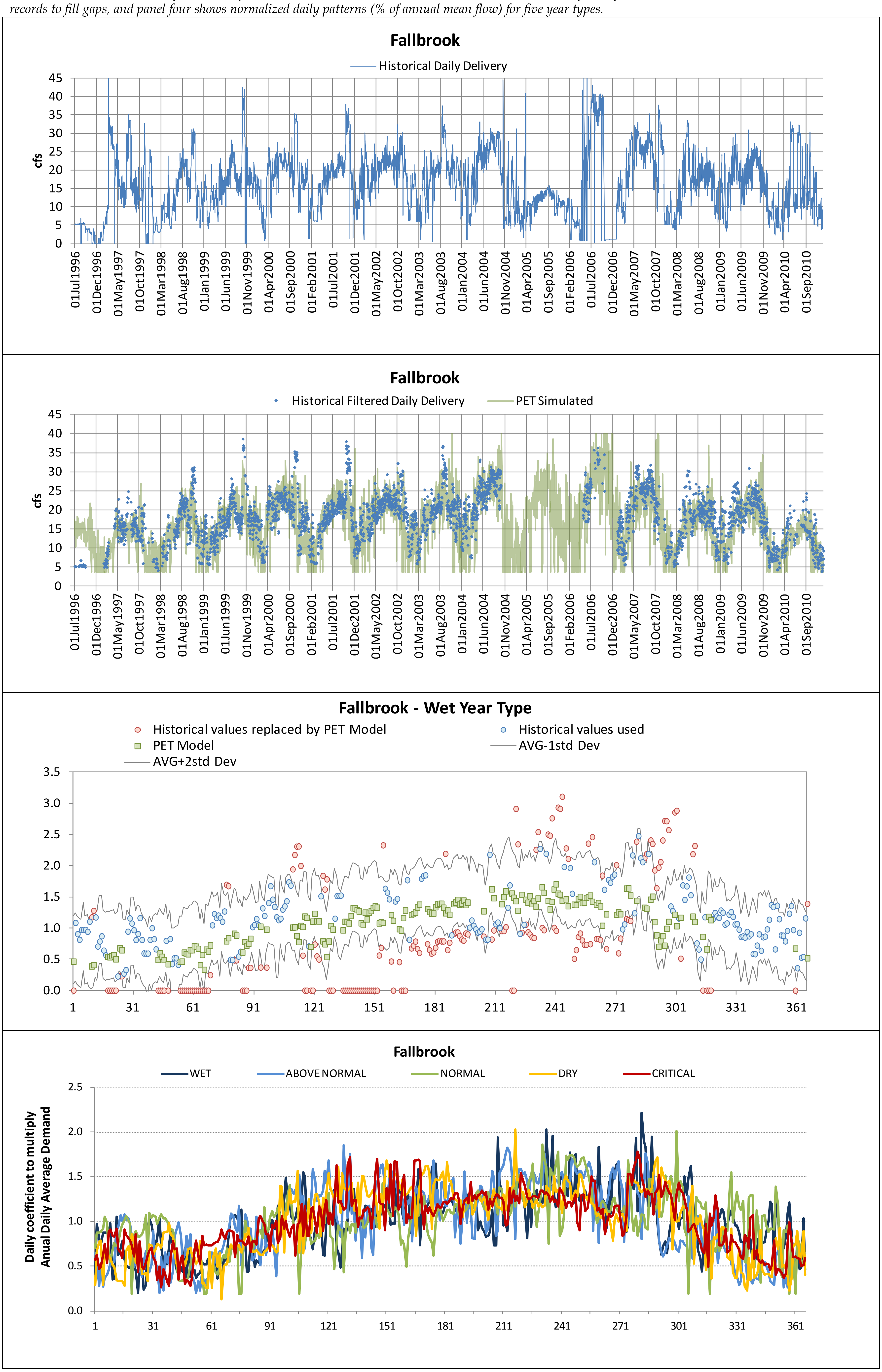


Figure X. Daily demand summary for Helix.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

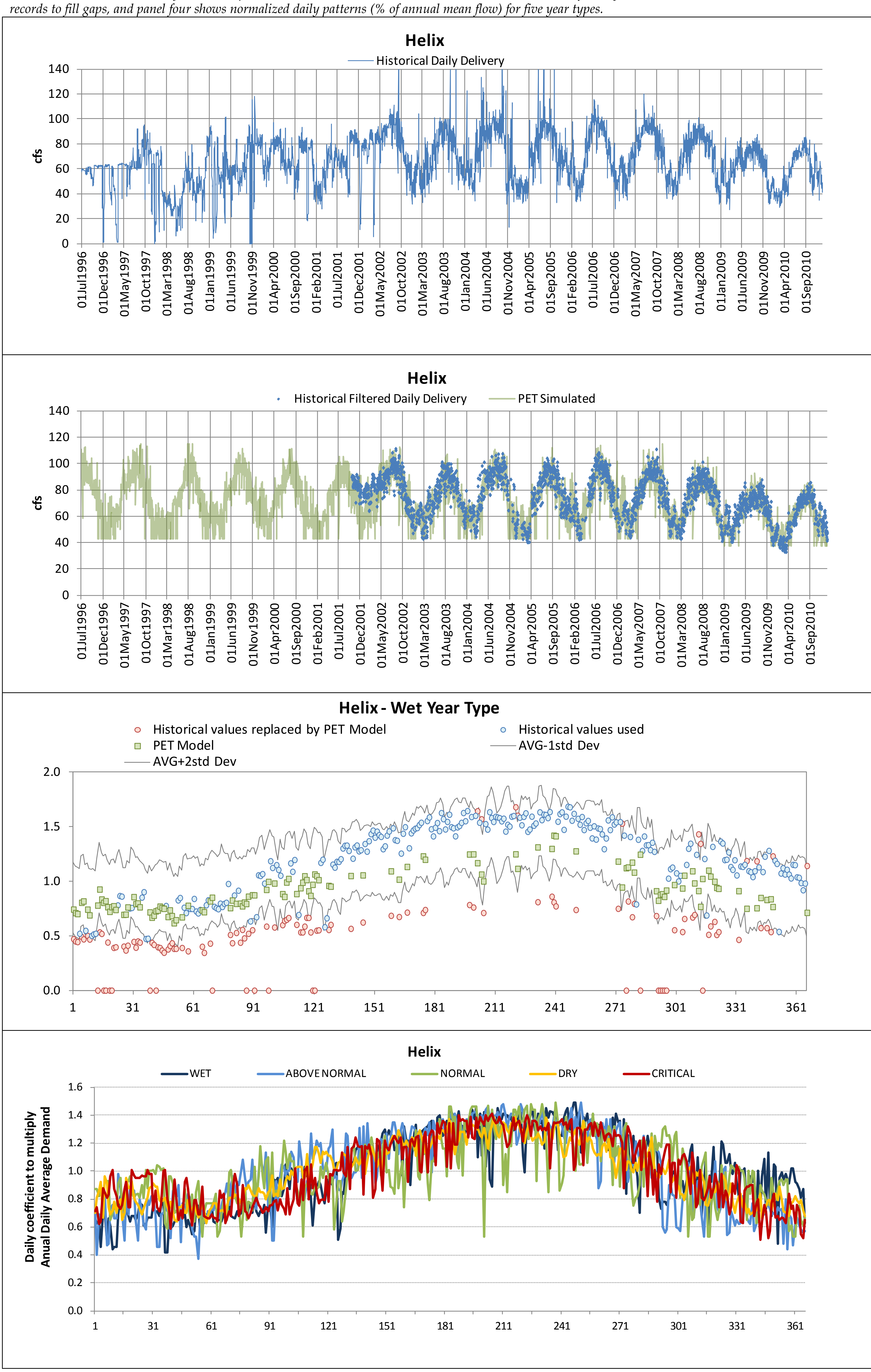


Figure X. Daily demand summary for National City/South Bay.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

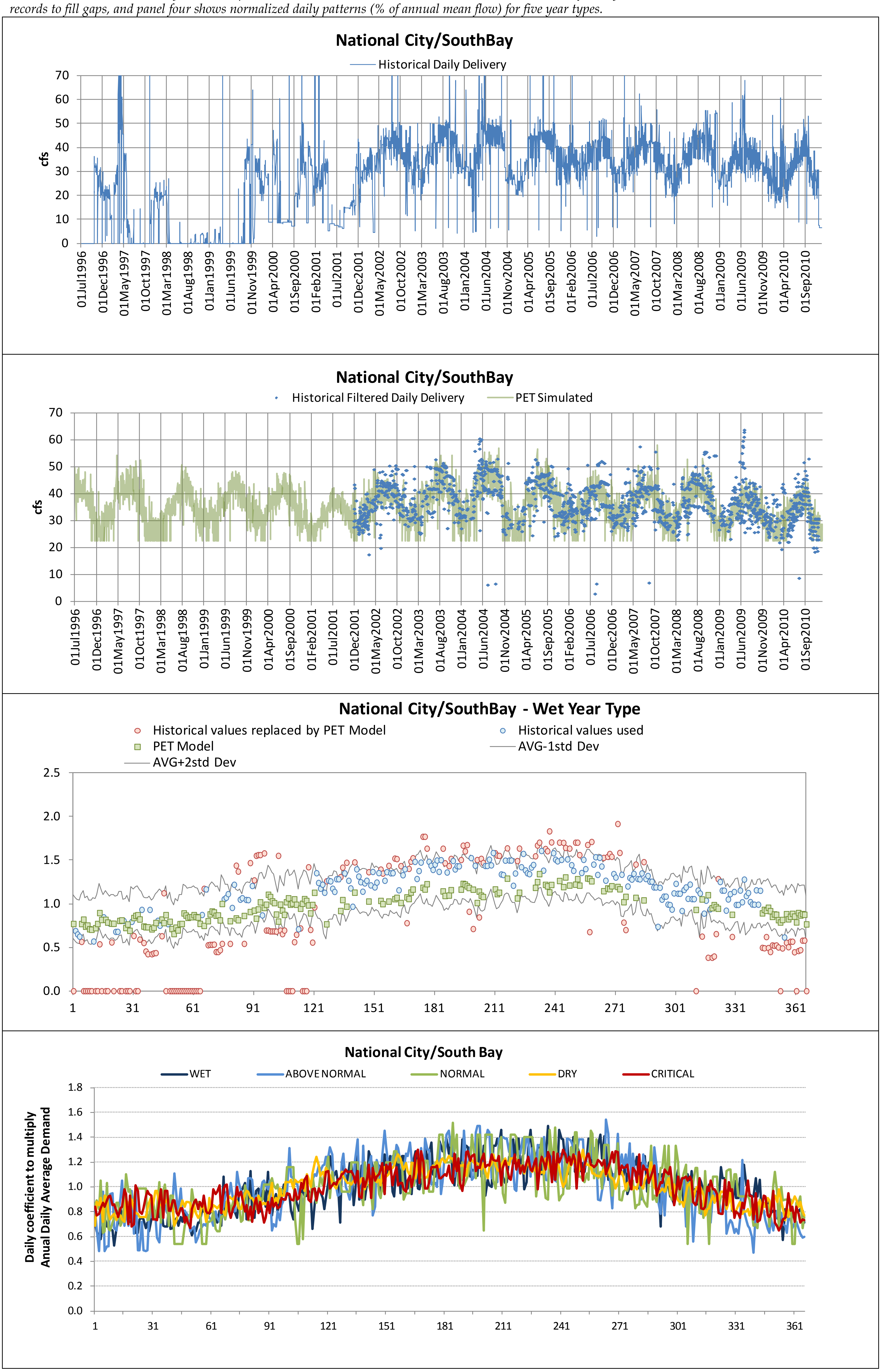


Figure X. Daily demand summary for Oceanside.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

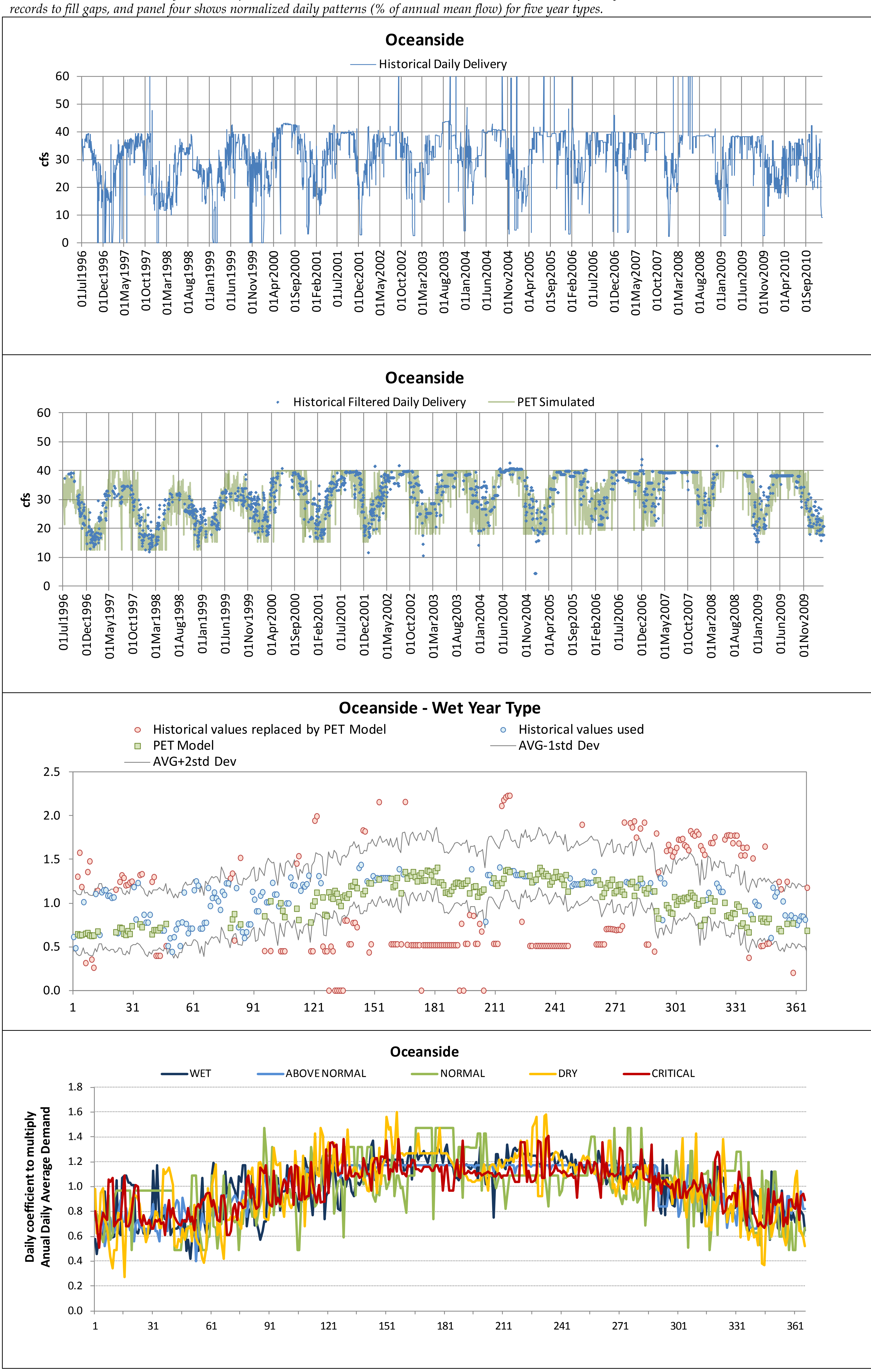


Figure X. Daily demand summary for Olivenhain.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

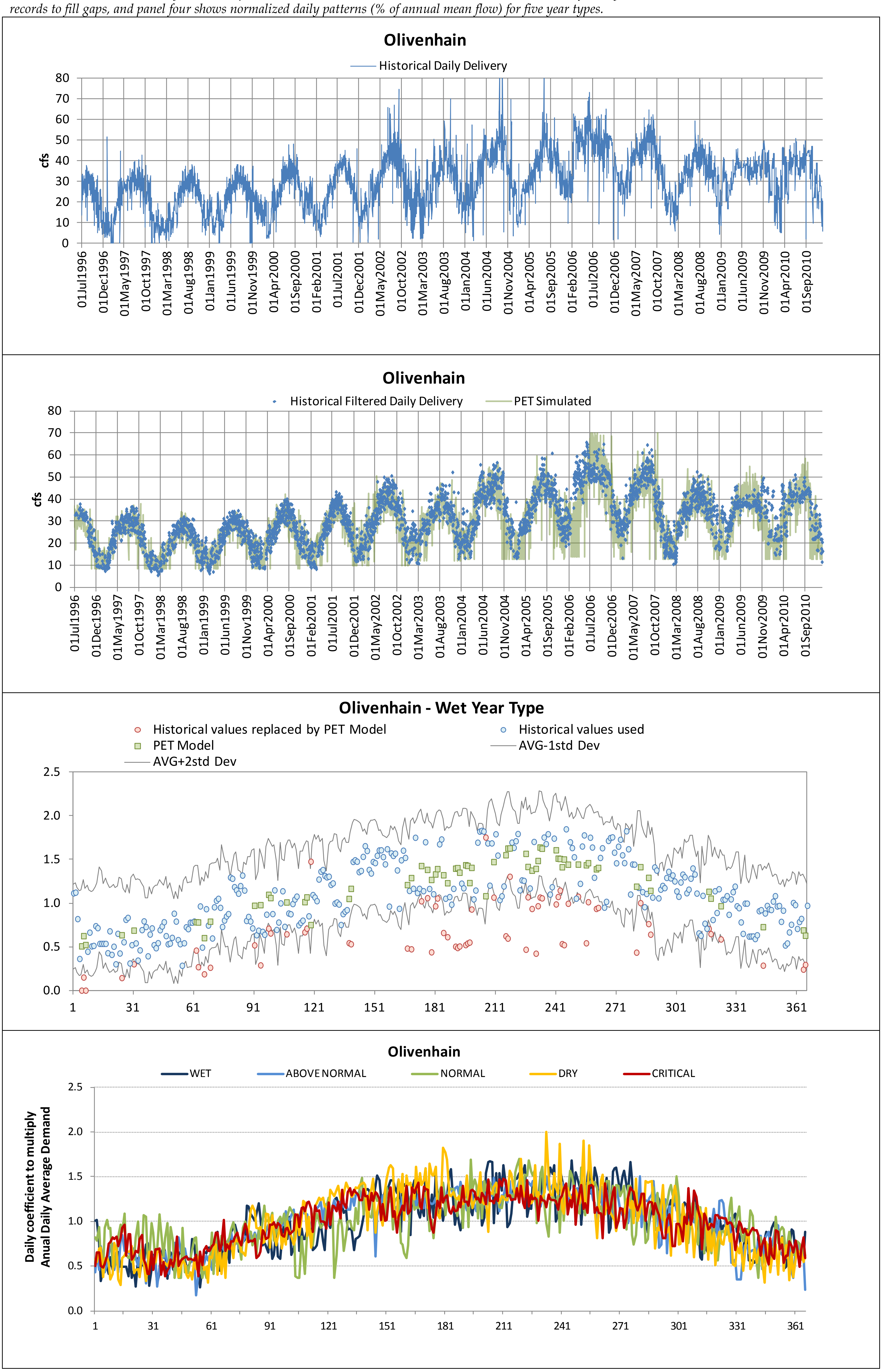


Figure X. Daily demand summary for Otay Water District.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

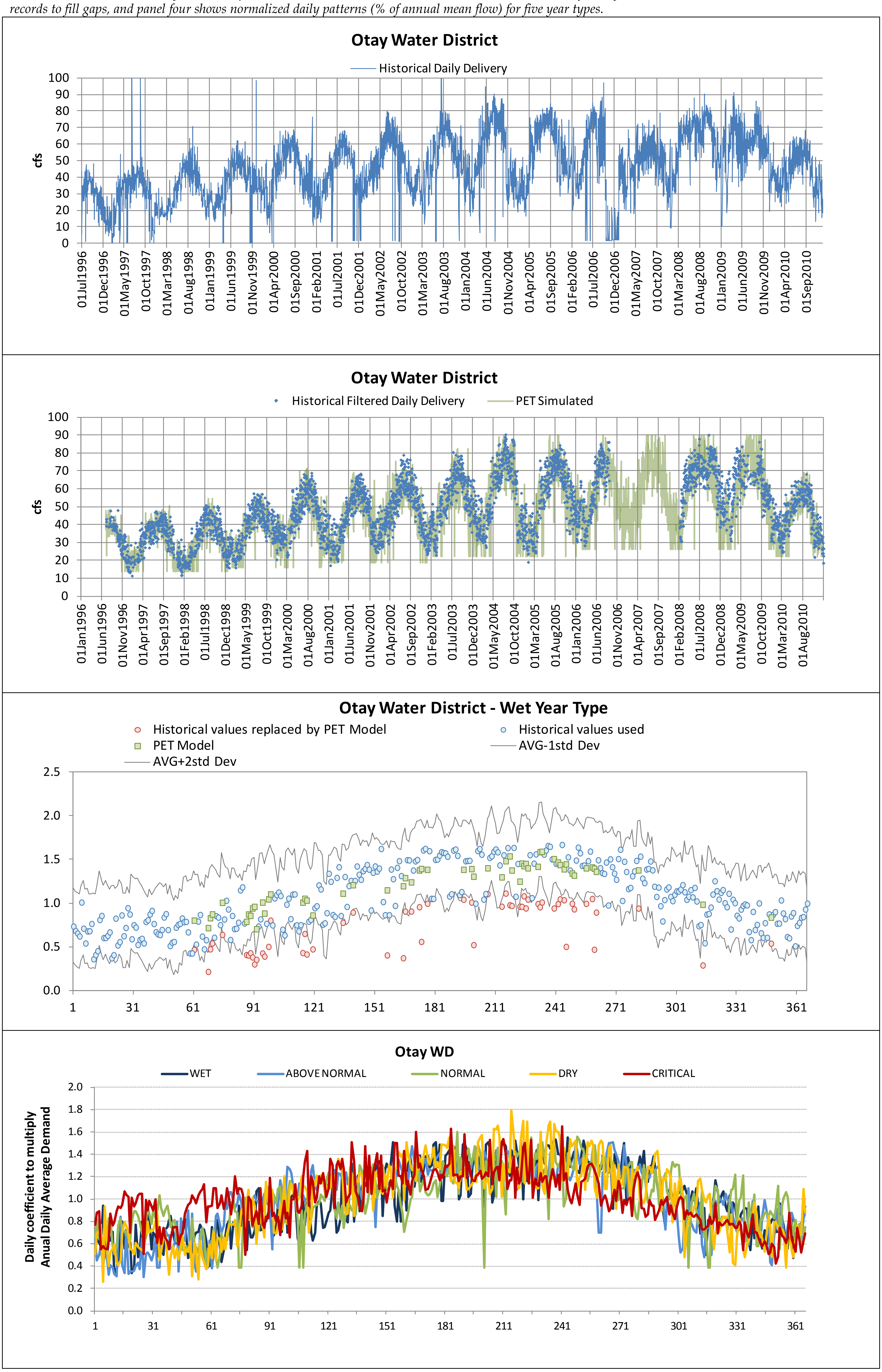


Figure X. Daily demand summary for Padre Dam.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

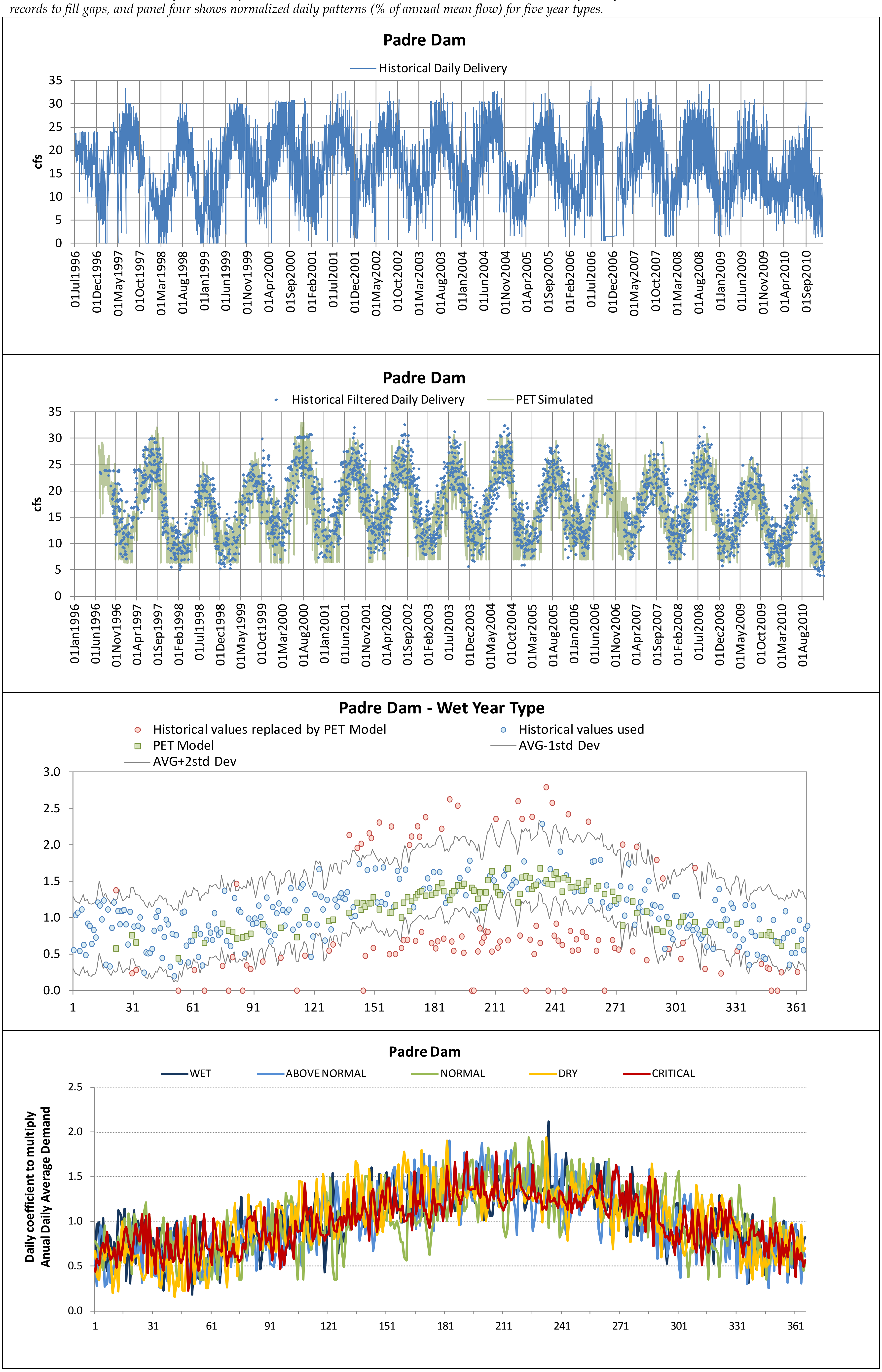


Figure X. Daily demand summary for Poway.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

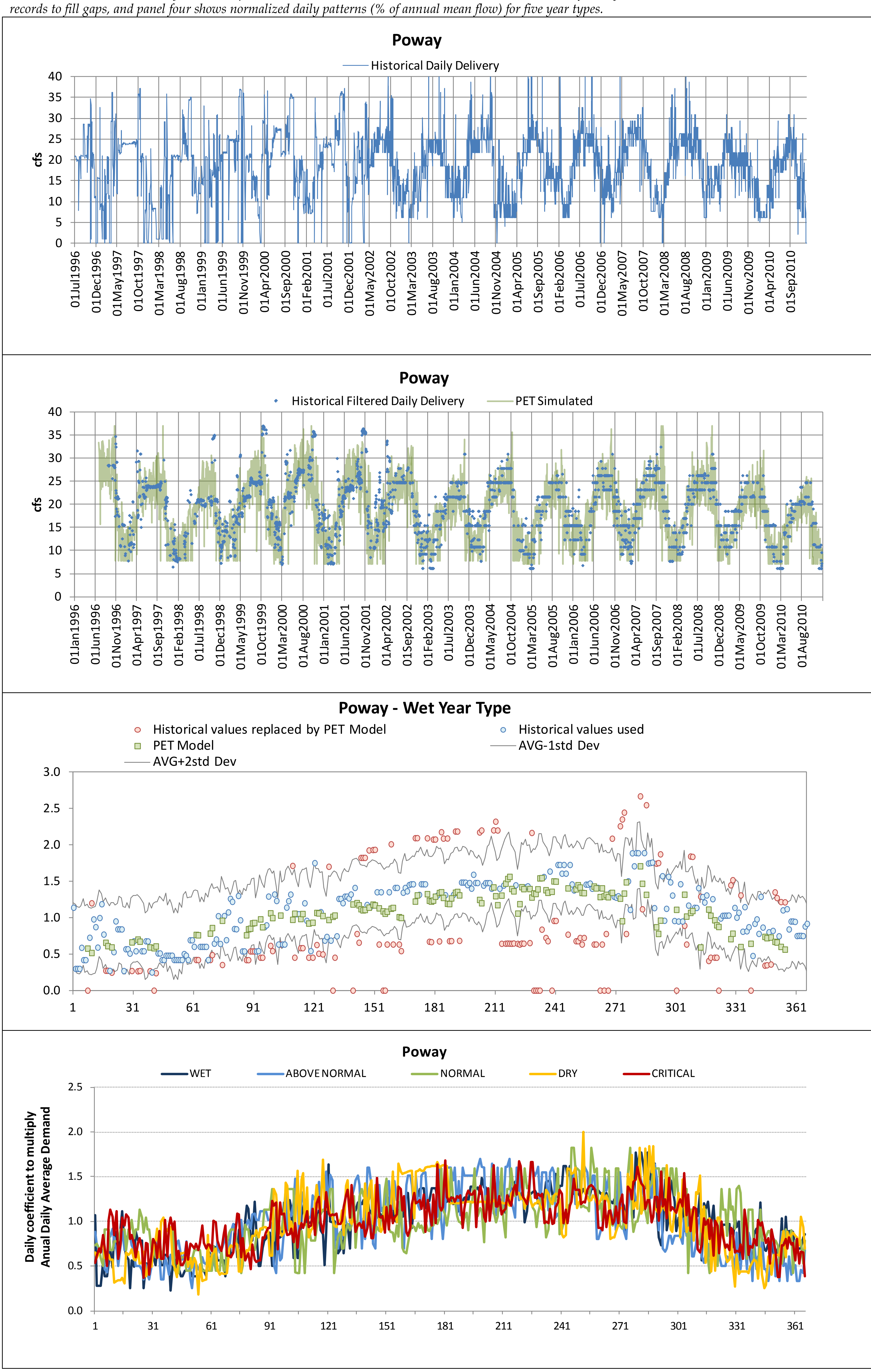


Figure X. Daily demand summary for Ramona.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

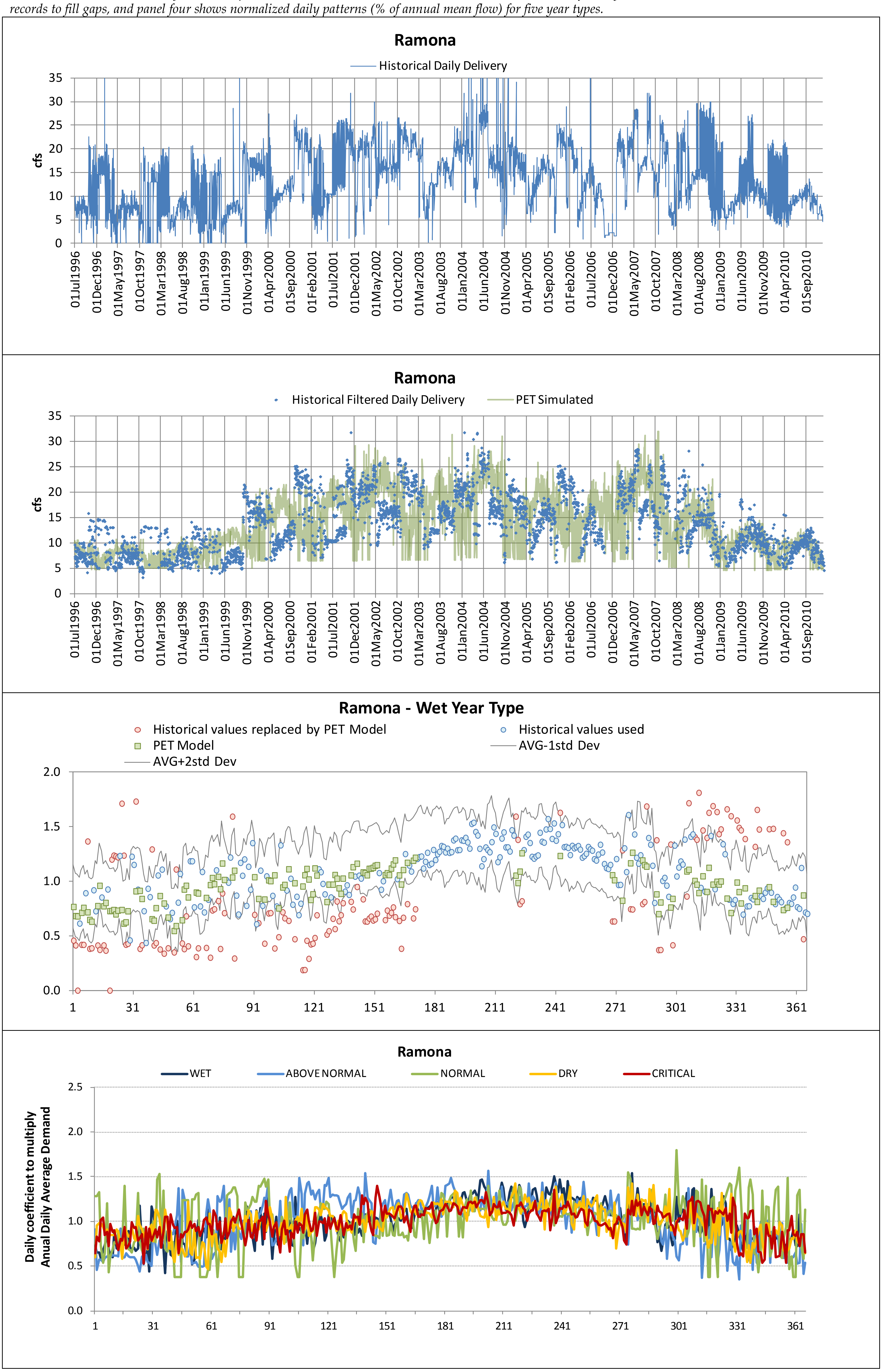


Figure X. Daily demand summary for Rainbow.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

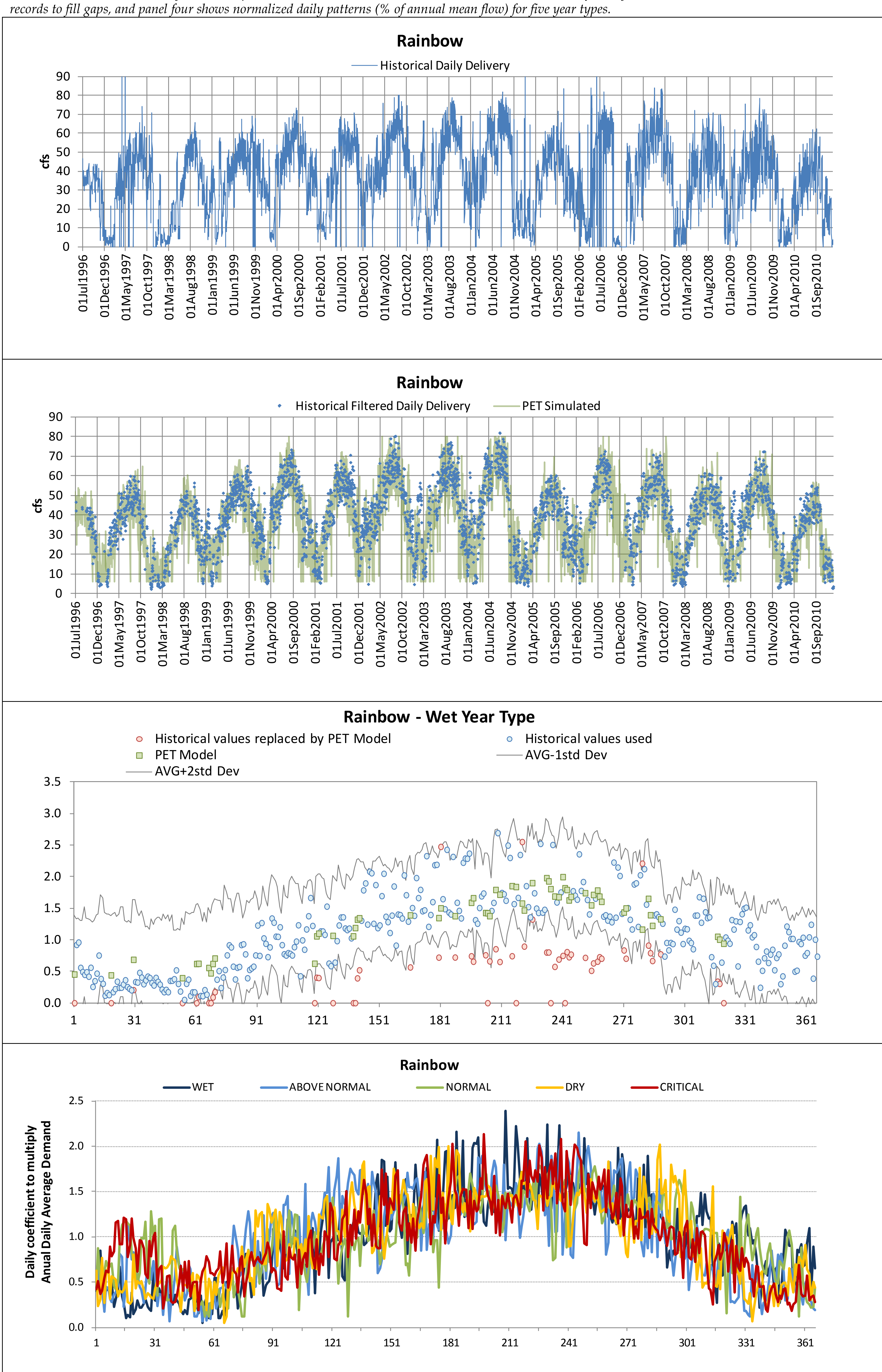


Figure X. Daily demand summary for Rincon.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

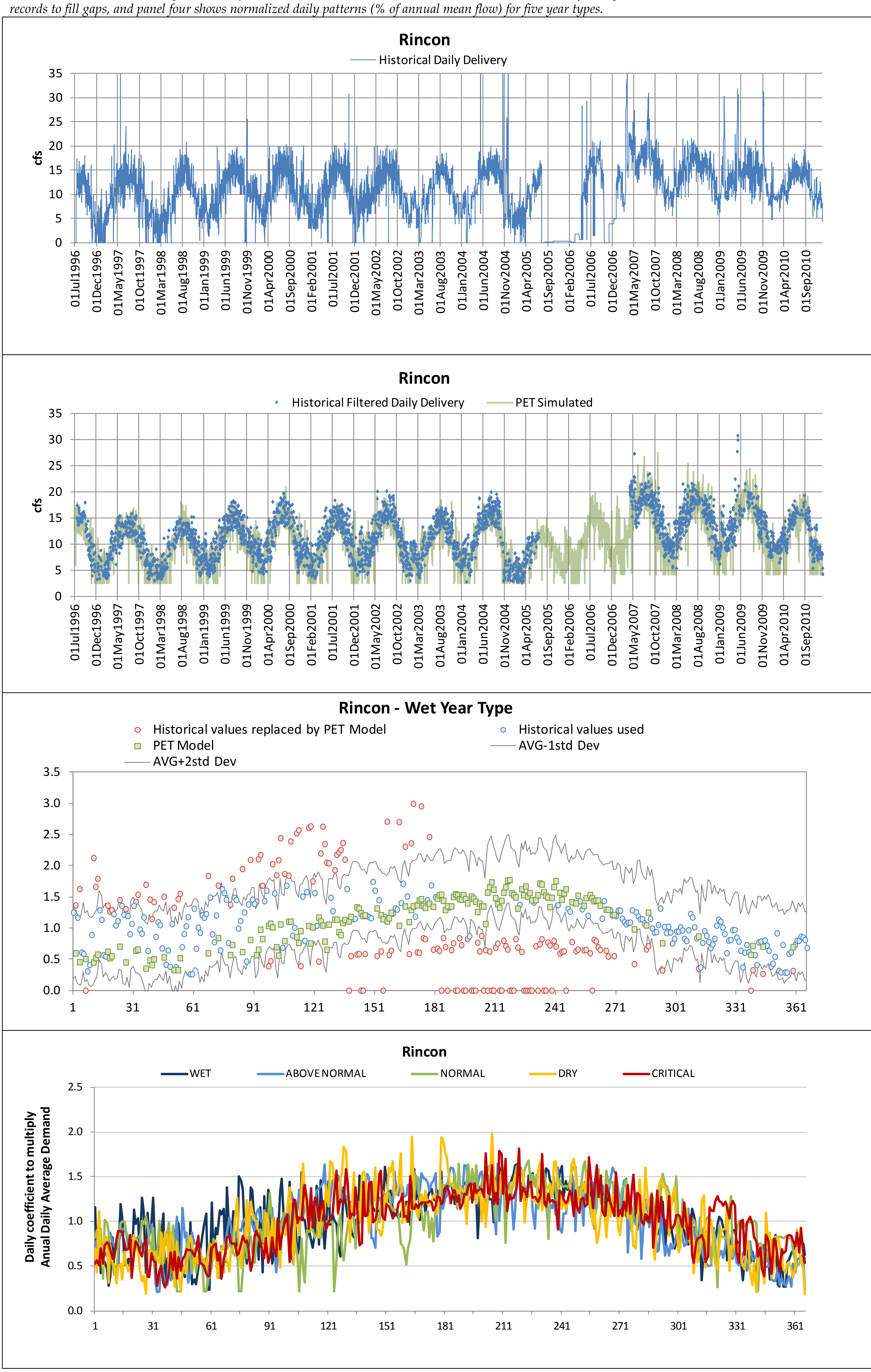


Figure X. Daily demand summary for San Diego SD 11.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

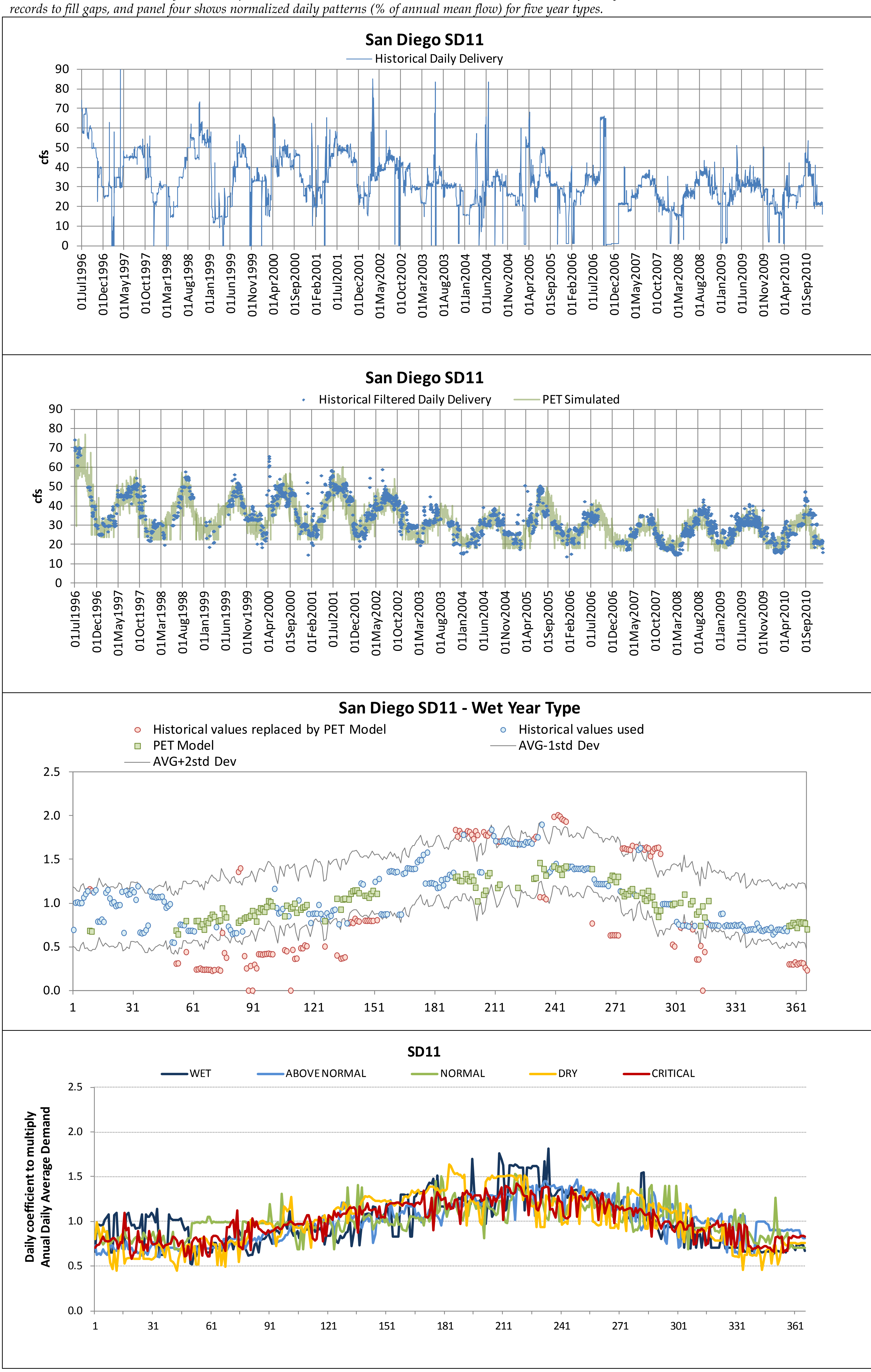


Figure X. Daily demand summary for San Diego Alvarado.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

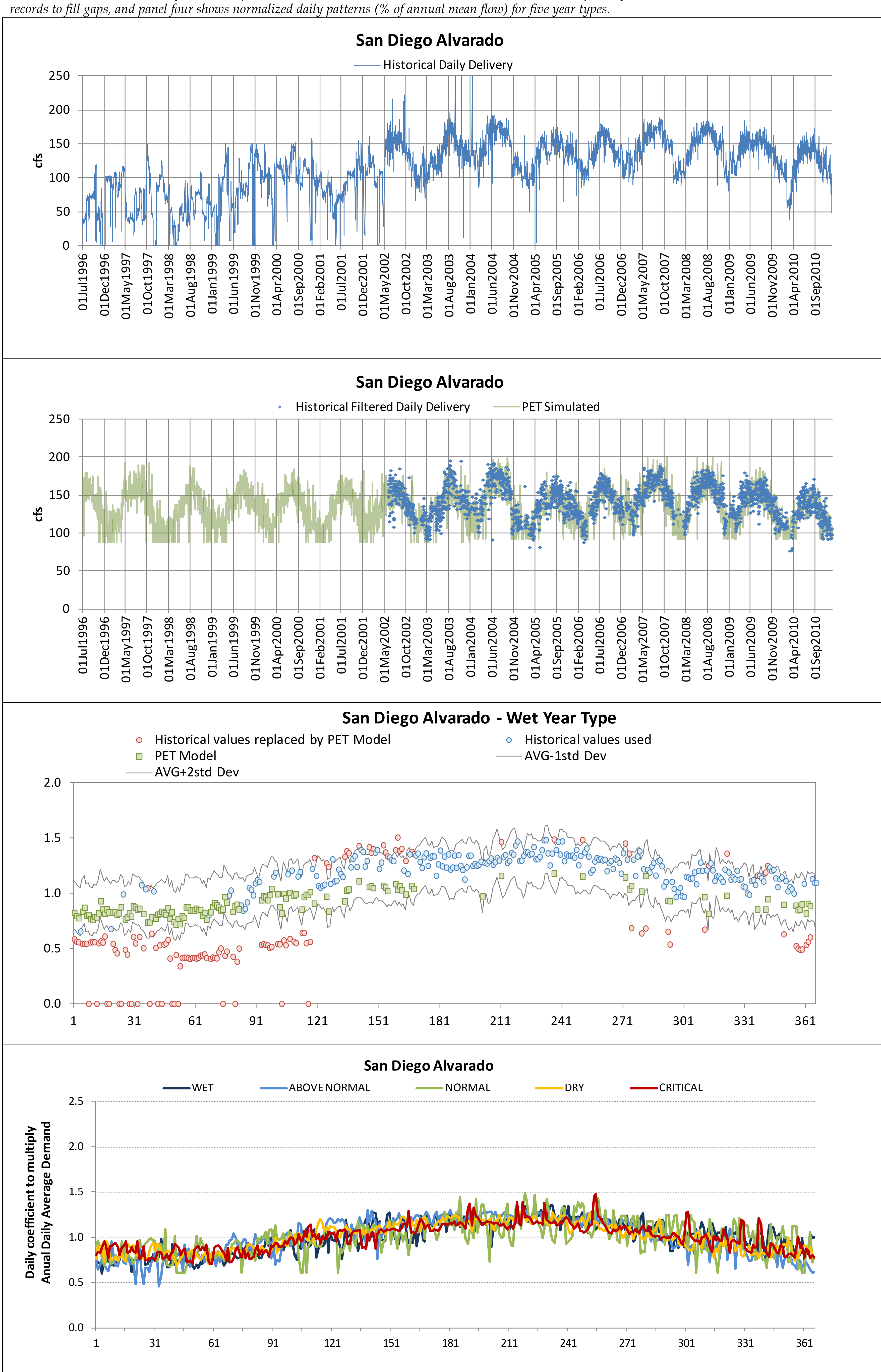


Figure X. Daily demand summary for San Diego Miramar.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

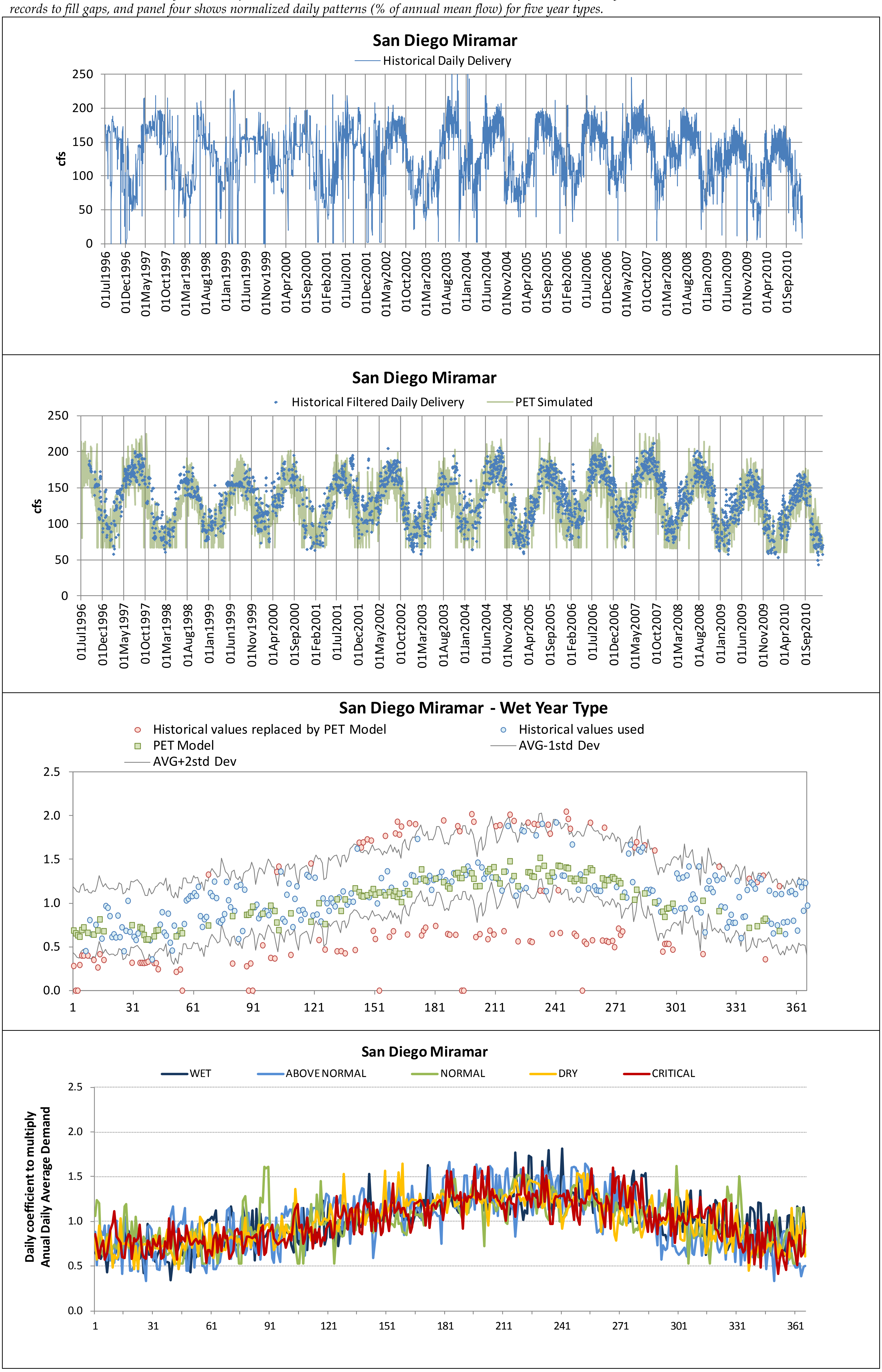


Figure X. Daily demand summary for San Diego North.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

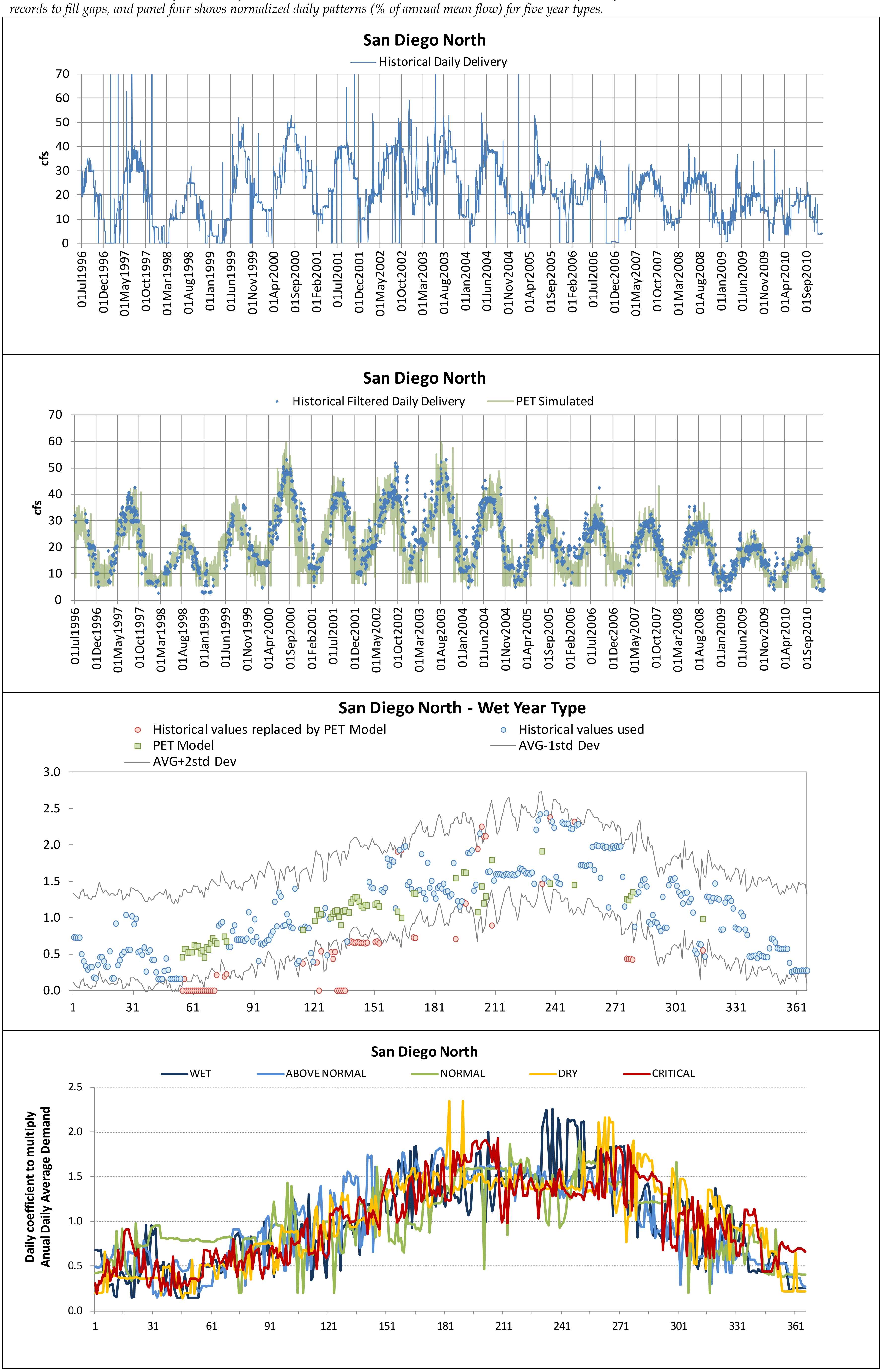


Figure X. Daily demand summary for San Diego Otay.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

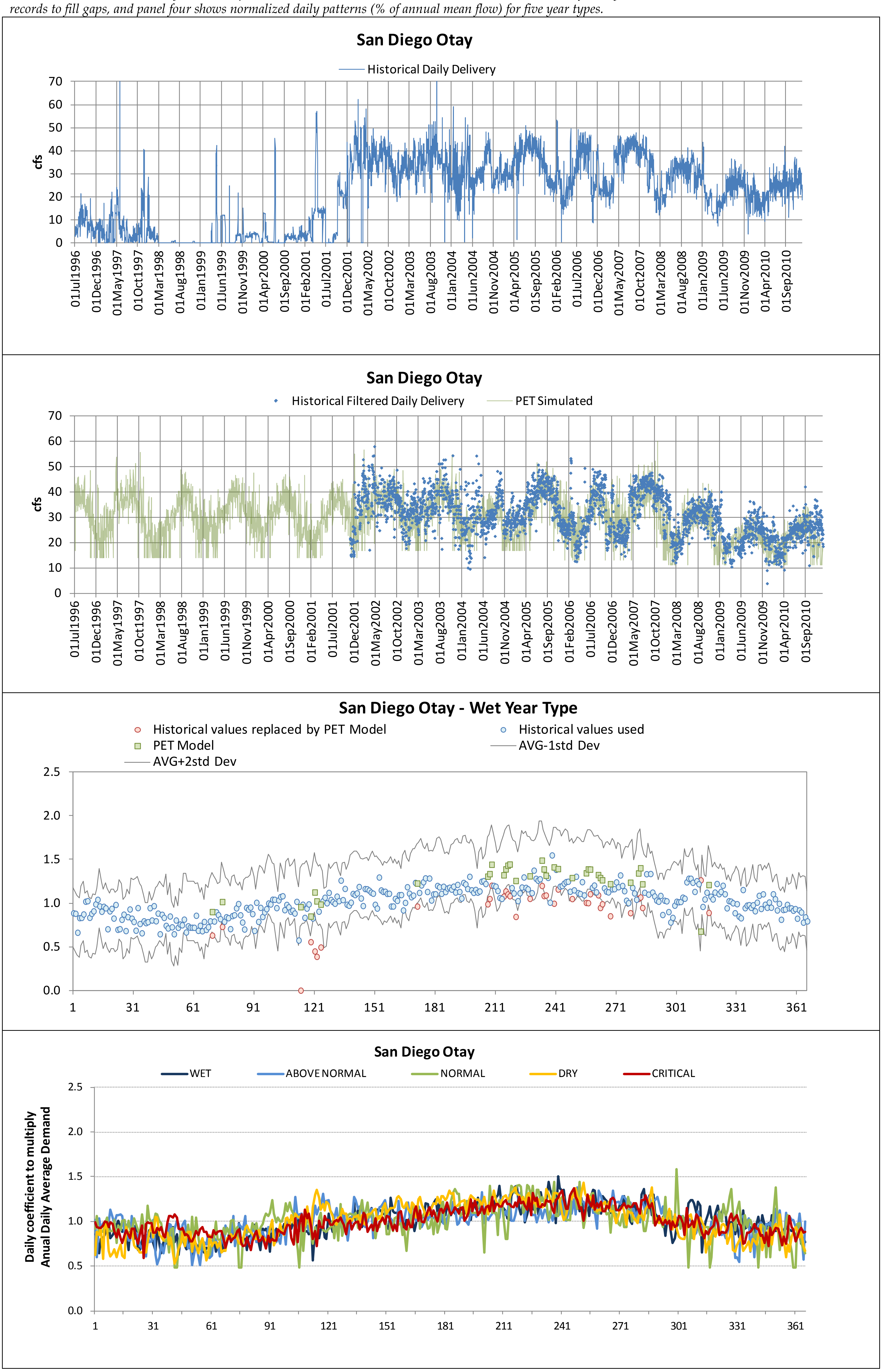


Figure X. Daily demand summary for San Dieguito/Santa Fe.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

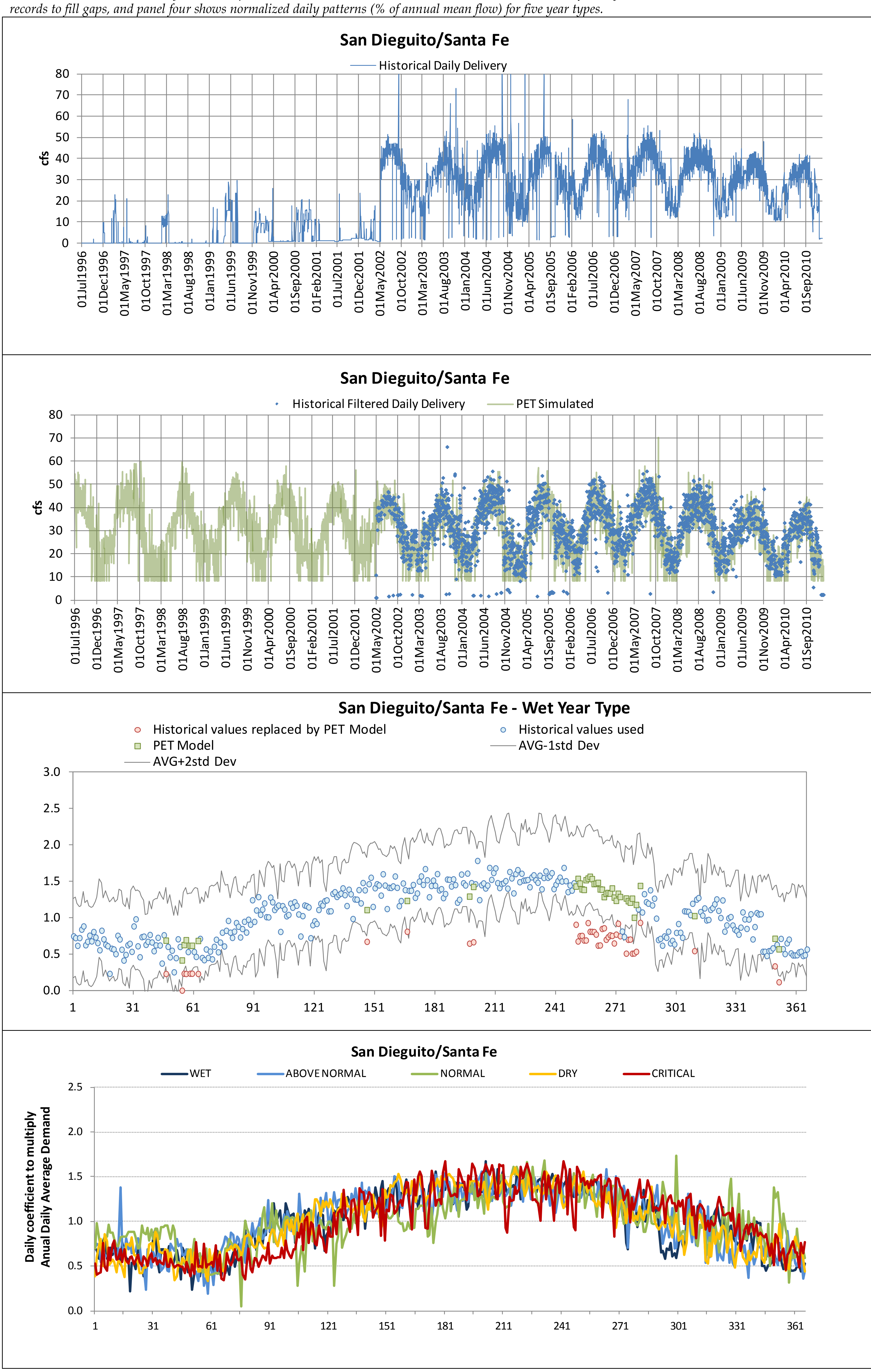


Figure X. Daily demand summary for Vallecitos.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

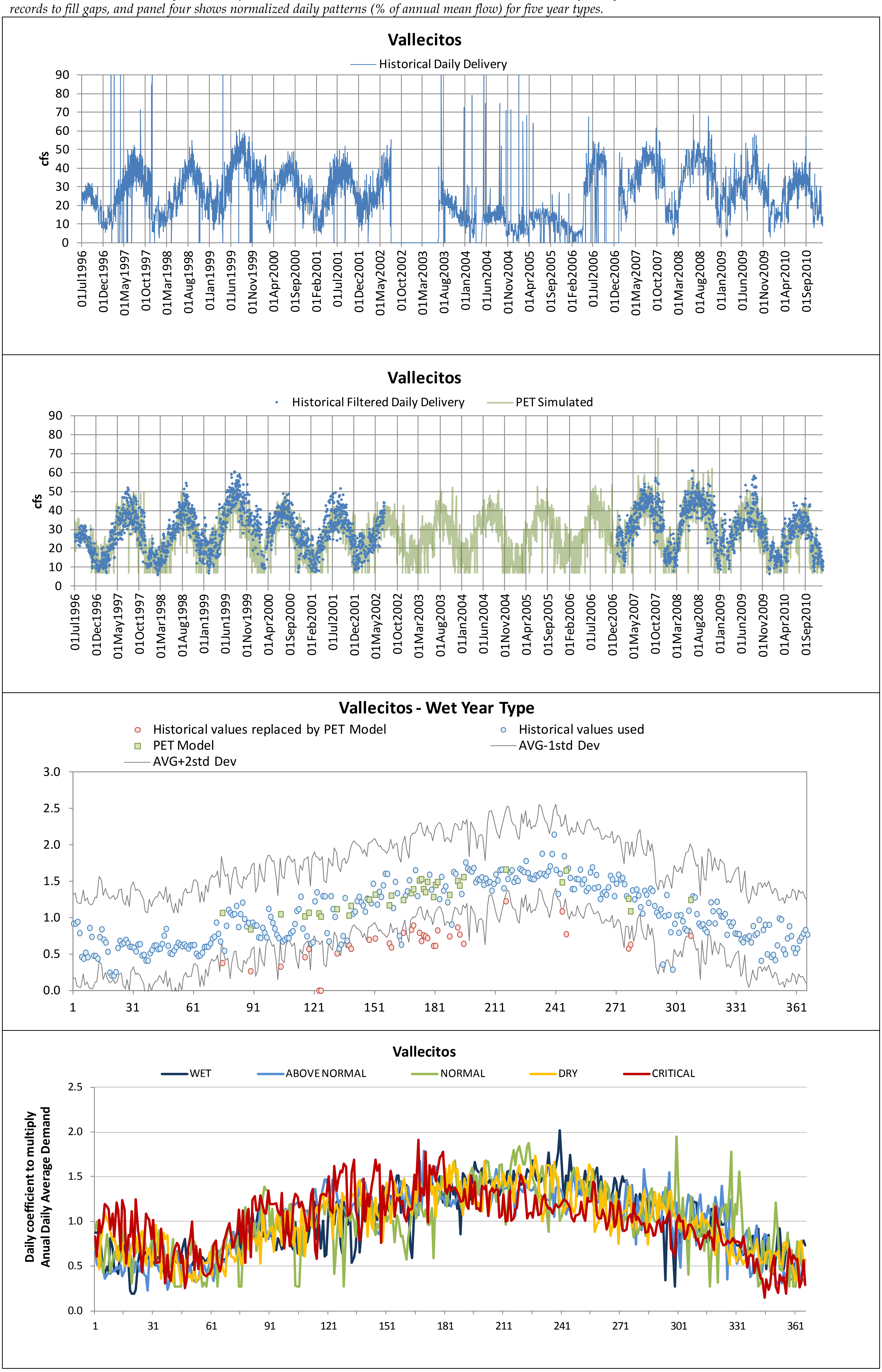


Figure X. Daily demand summary for Valley Center.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

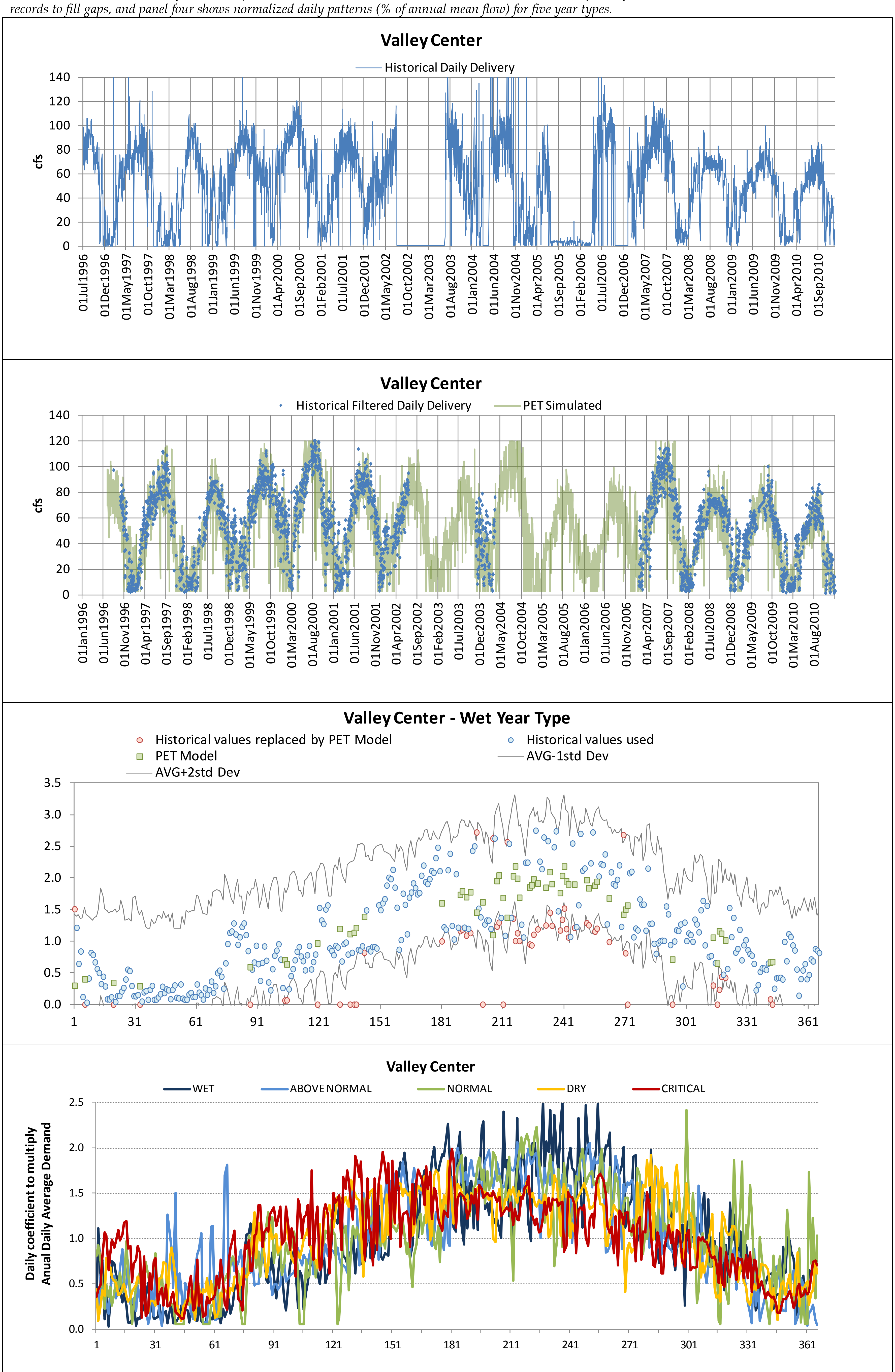


Figure X. Daily demand summary for Vista.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.

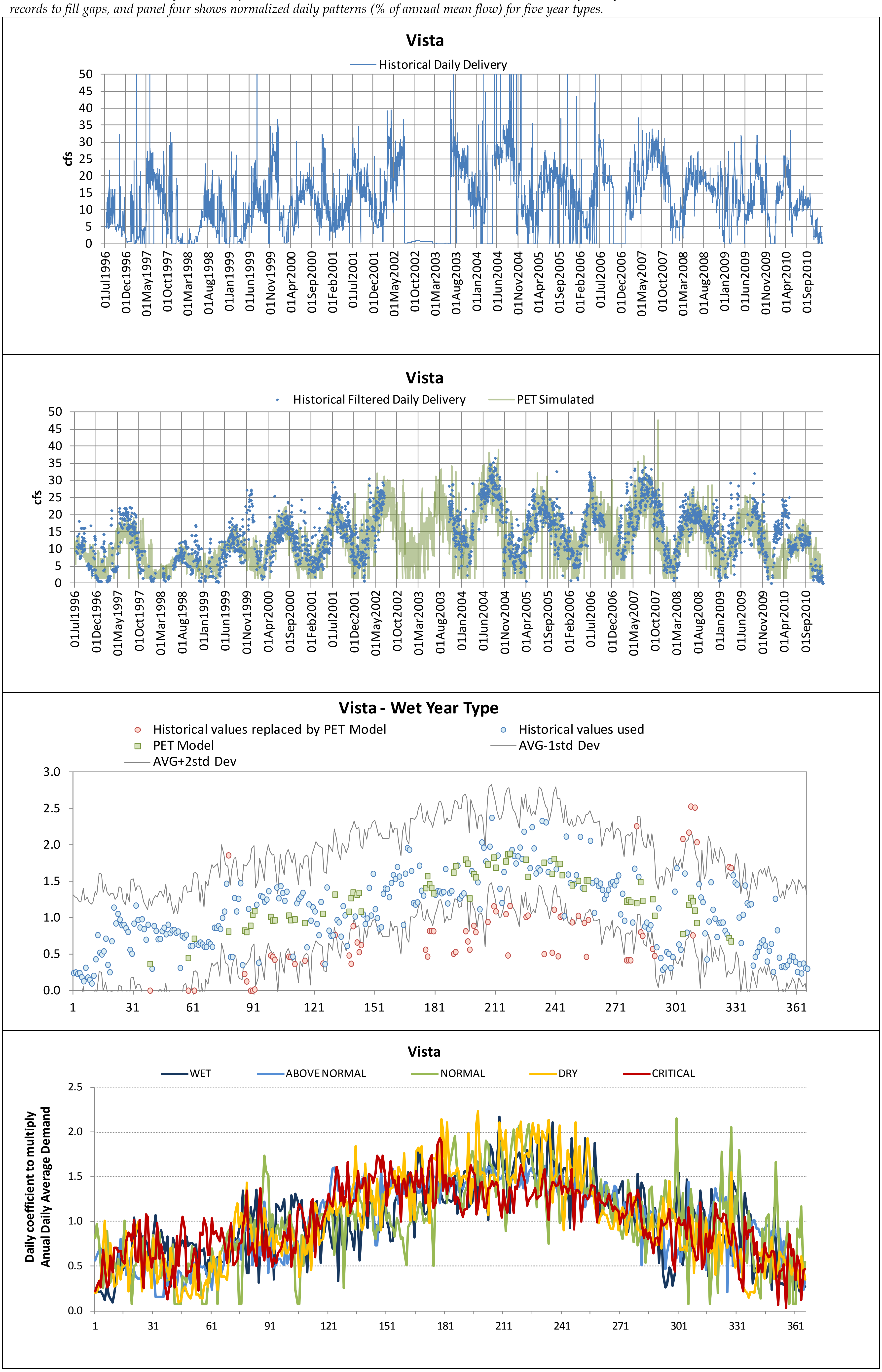
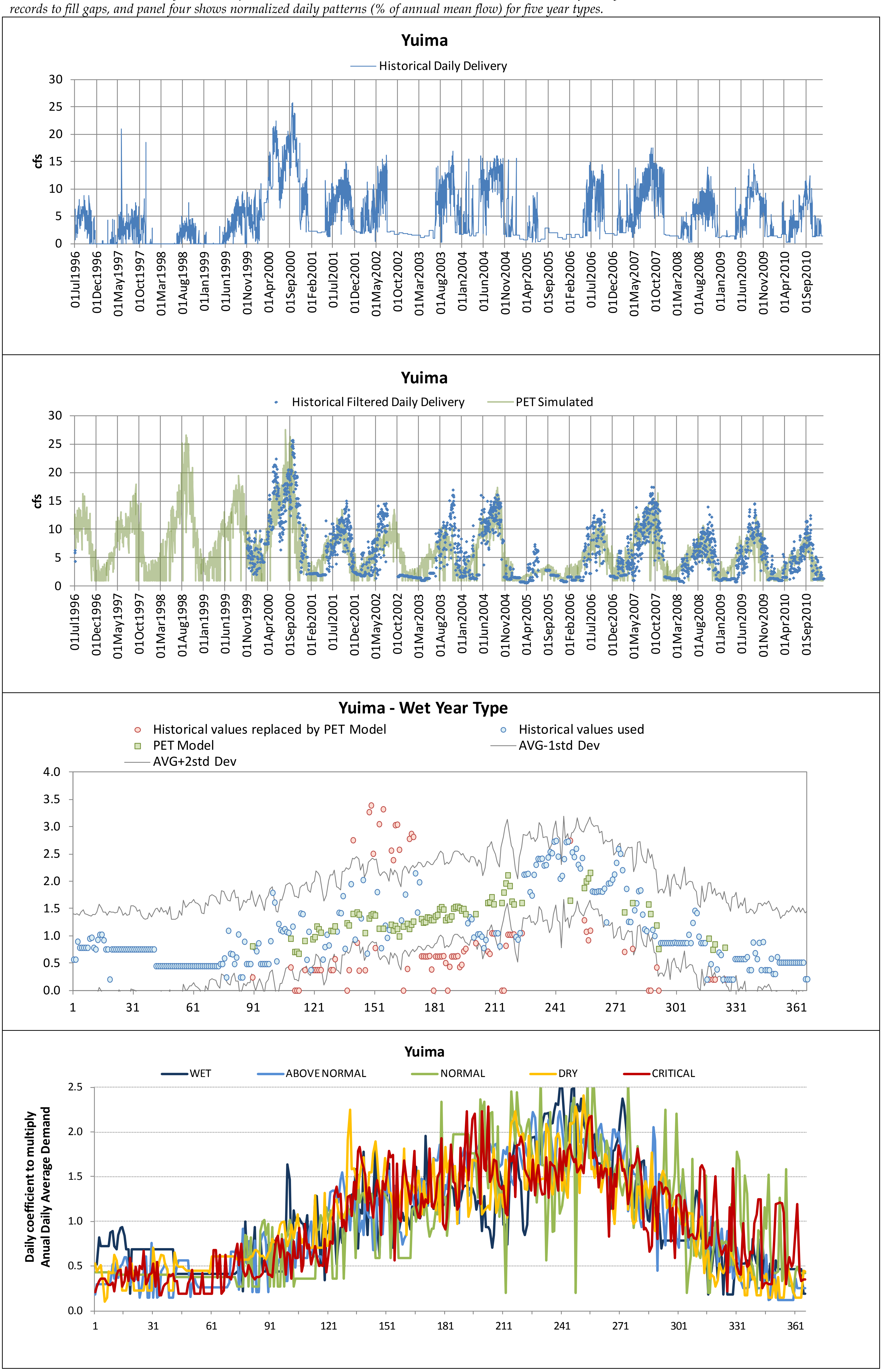


Figure X. Daily demand summary for Yuima.

Panel one shows historical daily deliveries, panel two shows measured (blue) and simulated (red) deliveries for July 1996 – December 2010. Panel three shows records to fill gaps, and panel four shows normalized daily patterns (% of annual mean flow) for five year types.



Appendix E
Analysis of Potential Future Climate Effects on Water Authority Demands

Growing scientific consensus suggests that climate change will be inevitable as the result of increased concentrations of greenhouse gases and related temperature increases. A set of climate analysis was conducted for the Water Authority member agencies. A total of 112 future climate projections used in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4), subsequently bias-corrected and statistically downscaled (BCSD), were obtained from Lawrence Livermore National Laboratory (LLNL) under the World Climate Research Program's (WCRP) Coupled Model Intercomparison Project Phase 3 (CMIP3). This archive of contains climate projections generated from 16 different GCMs developed by national climate centers and for SRES emission scenarios A2, A1b, and B1. Many of the GCMs were simulated multiple times for the same emission scenario due to differences in starting climate system state, thus the number of available projections is greater than simply the product of GCMs and emission scenarios. These projections have been bias corrected and spatially downscaled to 1/8th degree (~12km) resolution over the contiguous United States. In addition, another six climate simulations were obtained that were downscaled using a different statistical downscaling method called Constructed Analogue (CA).

- Ensemble climate model mean projections suggest warming symptoms across the Water Authority. The annual average temperature is projected to be increased by about 1°C by the end of 2035 with respect to the model simulated historical average over 1971 through 2000. By 2035, the ensemble climate model projections suggest more than 0.7°C warming in monthly average temperature with respect to model simulated historical average, with larger warming projections in summer and fall.
- Warming projected by the six climate model simulations downscaled by the CA method, in general, exhibit a smaller increase for the 2011-2035 with respect to the increase projected by the full 112 BCSD downscaled climate model ensemble.
- Projected changes in demand are increased annually by 0.7 percent to 2.7 percent for the period 2011-2035 with respect to historical period 1971-2000. Demand is expressed by Potential evapotranspiration (PET) simulated by Variable Infiltration Capacity (VIC) hydrologic model using one of the six climate model simulations downscaled by the CA method. CA downscaled simulation was used since there is an availability of daily meteorological data from this method that requires for the VIC simulation. In general, higher change is projected in the member agencies that are located inland across the Water Authority region.
- There are strong seasonal patterns in the projected change in demand. Spring months show an increase in demand. May shows the highest increase and varies from approximately 4 percent to approximately 9 percent, with higher increase for the member agencies located at the Inland.

Figure 1. Centroids of Water Authority Member Agencies. Locations of downscaled climate model grid cell center are also shown.

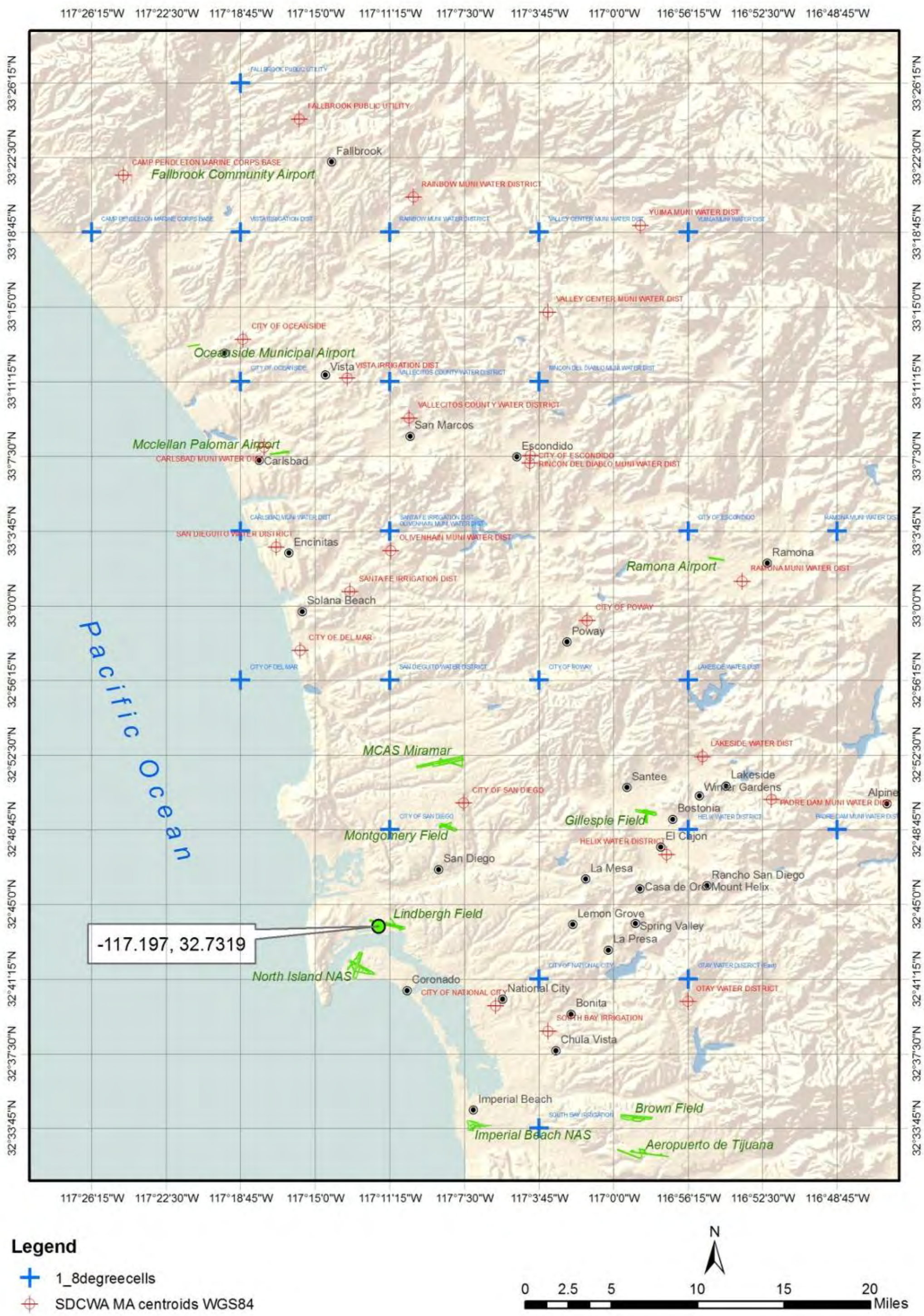


Figure 2. Annual average temperature and summer average temperature from the observational station located at the San Diego Airport area for the period 1914 through 2010. Values also shows from an interpolated dataset developed at the University of Washington and Santa Clara University for the period 1949 through 2010. Observed station annual average temperature exhibits a positive trend of 0.18°C per decade. Values above climatological average computed over the period 1971 through 2000 are shown in red colors.

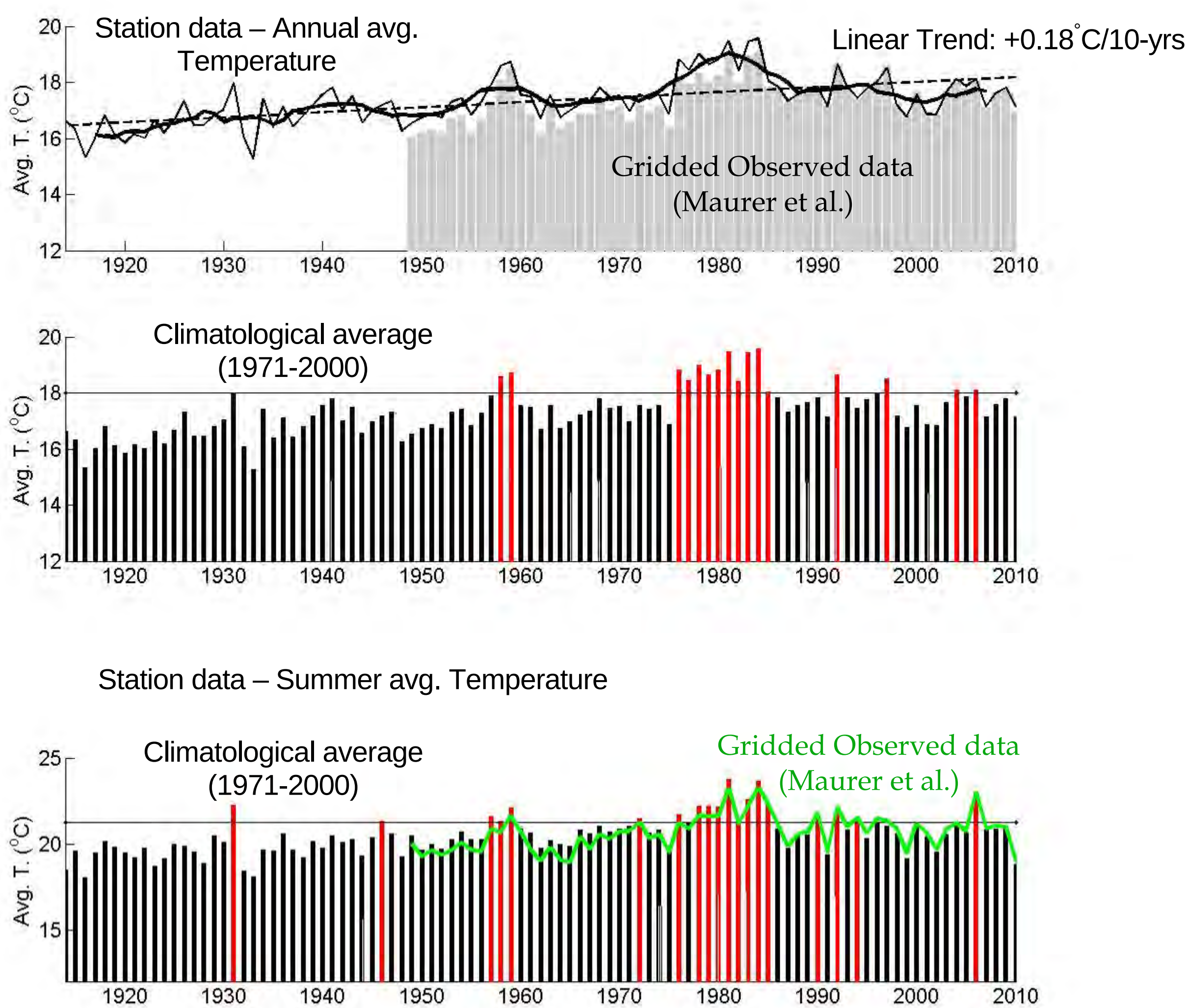
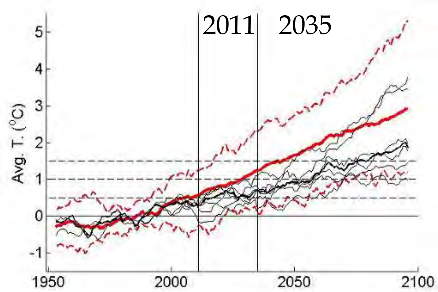
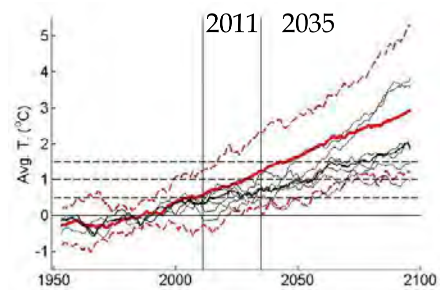


Figure 3 below shows the projected changes in annual average temperature, for all 24 member agencies of the Water Authority. Solid color curves show the median value and the dotted color curves extend from minimum and maximum of the 112 climate model simulations. The change is computed with respect to model simulated historical period 1971-2000 for each of the simulations. Vertical lines bound the time period use for the Water Authority Master Plan. In the figures, six climate model simulations that are used for the California Climate Change Assessment are shown in black colors. Data have been averaged over 7 years moving window to reduce the year-to-year variations.

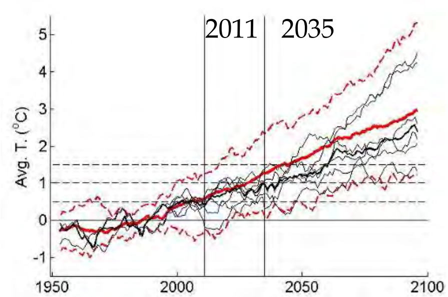
City of Del Mar



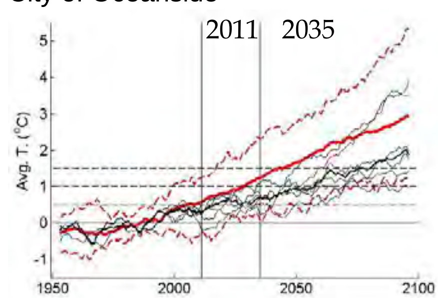
City of National City



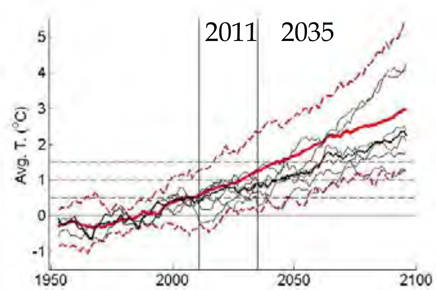
City of Escondido



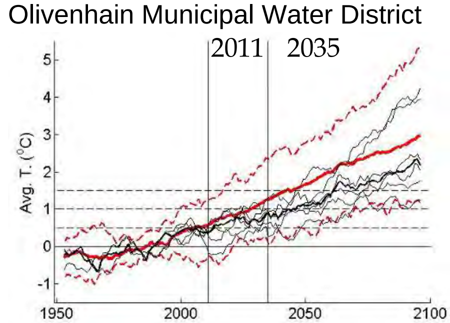
City of Oceanside



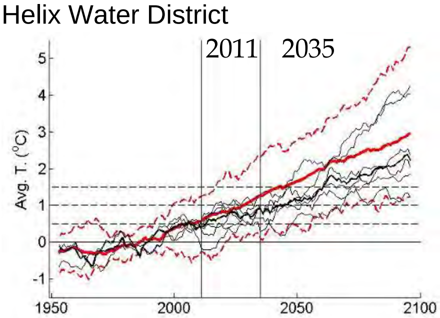
Fallbrook Public Utility District



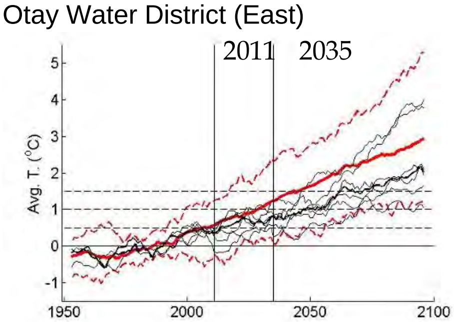
Olivenhain Municipal Water District



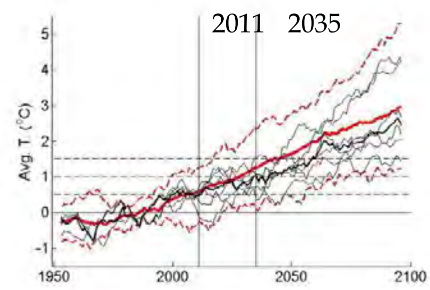
Helix Water District



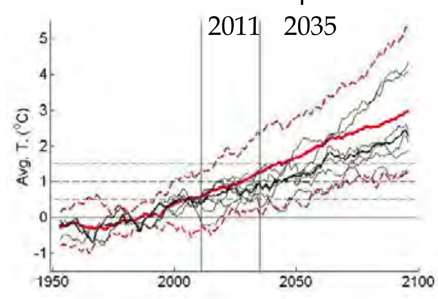
Otay Water District (East)



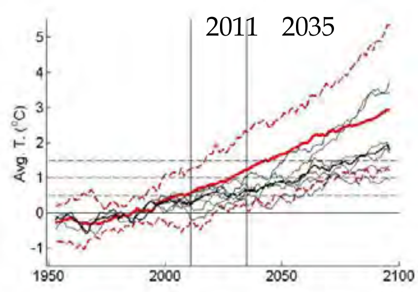
Padre Dam Municipal Water District



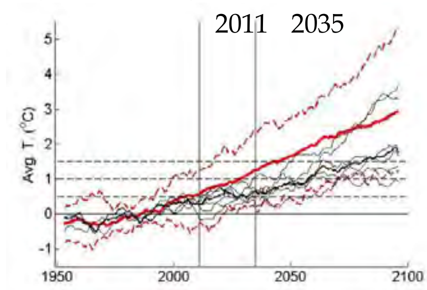
Rincon del Diablo Municipal Water District



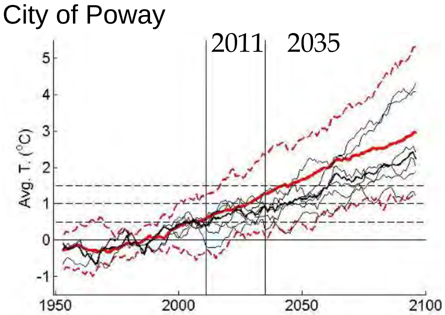
Camp Pendleton Marine Corps Base



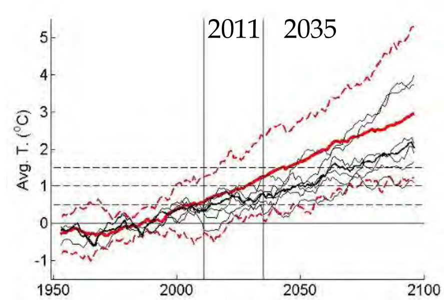
City of San Diego



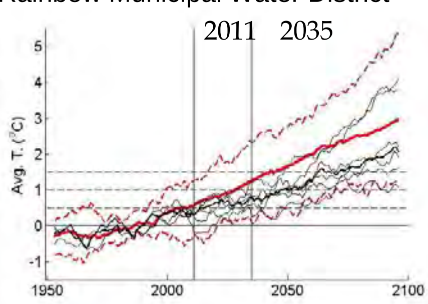
City of Poway



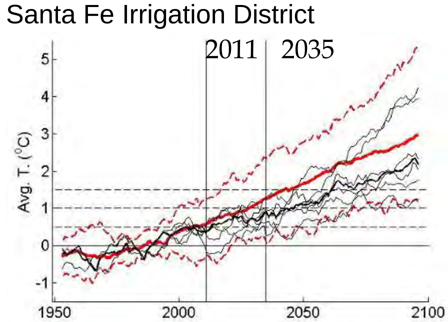
San Dieguito Water District



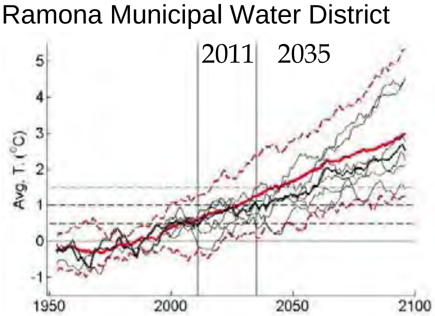
Rainbow Municipal Water District



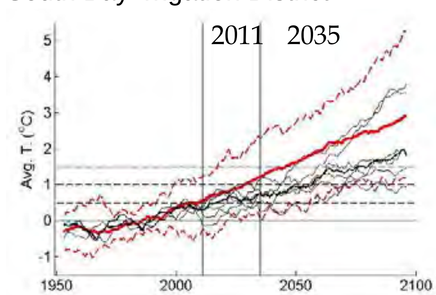
Santa Fe Irrigation District



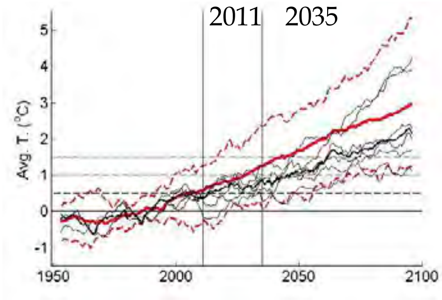
Ramona Municipal Water District



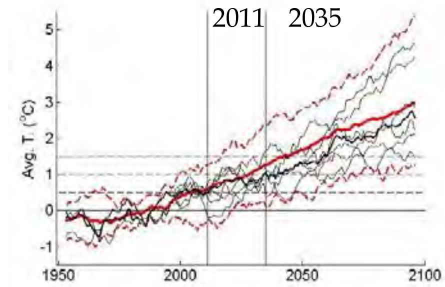
South Bay Irrigation District



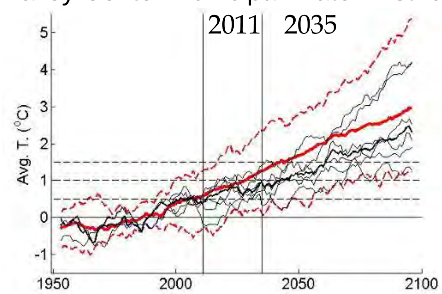
Vallecitos Water District



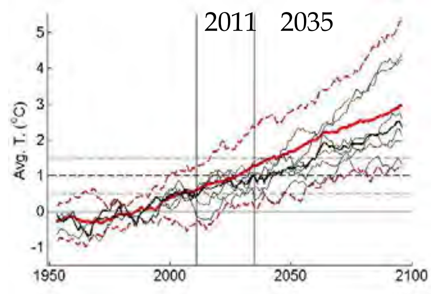
Yuima Municipal Water District



Valley Center Municipal Water District



Lakeside Water District



Vista Irrigation District

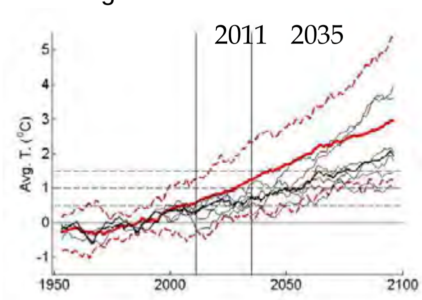


Table 1 below shows the projected change in mean monthly temperatures in the period 2011 through 2035, for all 24 member agencies of the SDCWA. The changes for the period 2011-2035 are computed from the climatologies computed over the period 1971 through 2000. The values are computed from the 112 downscaled climate model simulations.

Member Agency	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CITY OF OCEANSIDE	0.74	0.78	0.75	0.81	0.82	0.88	0.95	0.97	1.00	0.96	0.89	0.79
CITY OF DEL MAR	0.74	0.78	0.74	0.80	0.81	0.86	0.93	0.95	0.98	0.95	0.89	0.79
CARLSBAD MUNI WATER DIST	0.74	0.78	0.75	0.81	0.82	0.87	0.95	0.97	0.99	0.96	0.89	0.79
CAMP PENDLETON MARINE CORPS BASE	0.73	0.77	0.74	0.81	0.82	0.87	0.95	0.97	0.99	0.95	0.88	0.78
CITY OF NATIONAL CITY	0.74	0.78	0.75	0.81	0.81	0.86	0.93	0.95	0.98	0.95	0.89	0.79
SOUTH BAY IRRIGATION	0.73	0.77	0.74	0.80	0.79	0.85	0.91	0.93	0.96	0.94	0.88	0.79
OLIVENHAIN MUNI WATER DIST	0.75	0.79	0.75	0.82	0.82	0.88	0.95	0.98	1.00	0.97	0.90	0.79
CITY OF SAN DIEGO	0.74	0.78	0.75	0.81	0.81	0.86	0.93	0.96	0.99	0.96	0.89	0.79
SAN DIEGUITO WATER DISTRICT	0.74	0.79	0.75	0.81	0.81	0.87	0.94	0.97	0.99	0.96	0.89	0.79
VISTA IRRIGATION DIST	0.73	0.78	0.74	0.81	0.82	0.88	0.95	0.97	1.00	0.96	0.88	0.78
SANTA FE IRRIGATION DIST	0.75	0.79	0.75	0.82	0.82	0.88	0.95	0.98	1.00	0.97	0.90	0.79
OTAY WATER DISTRICT (East)	0.74	0.78	0.75	0.81	0.81	0.87	0.93	0.95	0.98	0.95	0.89	0.79
YUIMA MUNI WATER DIST	0.74	0.79	0.76	0.82	0.83	0.89	0.96	0.99	1.01	0.97	0.90	0.79
CITY OF POWAY	0.75	0.79	0.76	0.82	0.82	0.88	0.95	0.97	1.00	0.97	0.90	0.80
HELIX WATER DISTRICT	0.75	0.79	0.75	0.81	0.82	0.87	0.94	0.97	1.00	0.97	0.90	0.79
VALLECITOS COUNTY WATER DISTRICT	0.74	0.79	0.75	0.82	0.82	0.88	0.95	0.97	1.00	0.97	0.89	0.79
RAINBOW MUNI WATER DISTRICT	0.74	0.78	0.75	0.82	0.83	0.88	0.96	0.98	1.01	0.97	0.89	0.79
FALLBROOK PUBLIC UTILITY	0.73	0.78	0.75	0.82	0.83	0.89	0.96	0.98	1.00	0.96	0.88	0.78
RINCON DEL DIABLO MUNI WATER DIST	0.75	0.79	0.76	0.82	0.83	0.88	0.95	0.98	1.01	0.97	0.90	0.79
VALLEY CENTER MUNI WATER DIST	0.74	0.79	0.75	0.82	0.83	0.89	0.96	0.98	1.01	0.97	0.89	0.79
CITY OF ESCONDIDO	0.75	0.79	0.76	0.82	0.82	0.88	0.95	0.98	1.00	0.97	0.90	0.80
PADRE DAM MUNI WATER DIST	0.74	0.79	0.75	0.81	0.82	0.87	0.94	0.96	1.00	0.96	0.89	0.80
RAMONA MUNI WATER DIST	0.75	0.79	0.76	0.82	0.82	0.88	0.95	0.98	1.01	0.97	0.90	0.80
LAKESIDE WATER DIST	0.75	0.79	0.76	0.82	0.82	0.88	0.95	0.97	1.00	0.97	0.90	0.79

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Coast	0.74	0.78	0.75	0.81	0.81	0.87	0.94	0.96	0.99	0.96	0.89	0.79
Inland	0.74	0.79	0.75	0.82	0.82	0.88	0.95	0.97	1.00	0.97	0.89	0.79

Figure 4. Projected change in monthly temperature suggested by downscaled climate model simulations. The changes are computed from the climatologies computed over the period 1971 through 2000. The values are computed from the 112 downscaled climate model simulations. Projected changes are spatially averaged for the member agencies categorizing the member agencies whether they are located at the coast or inland.

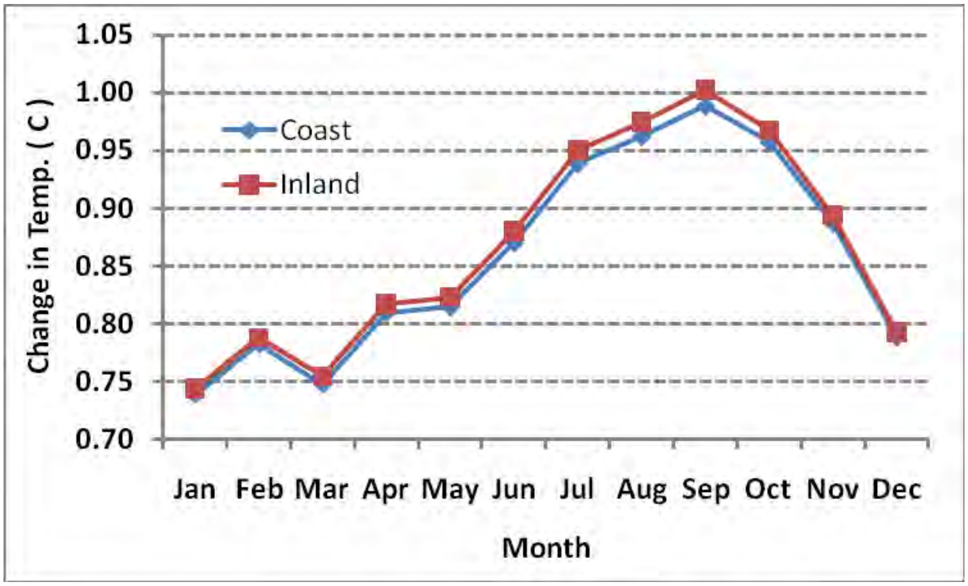
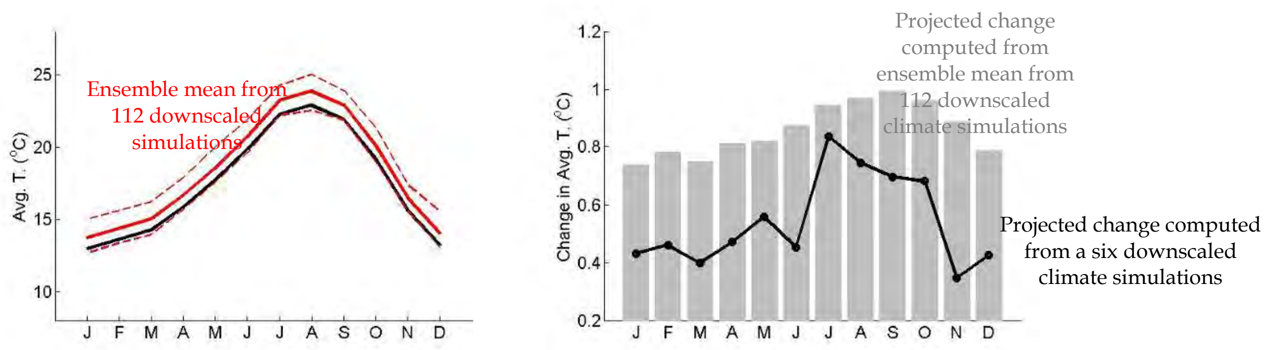
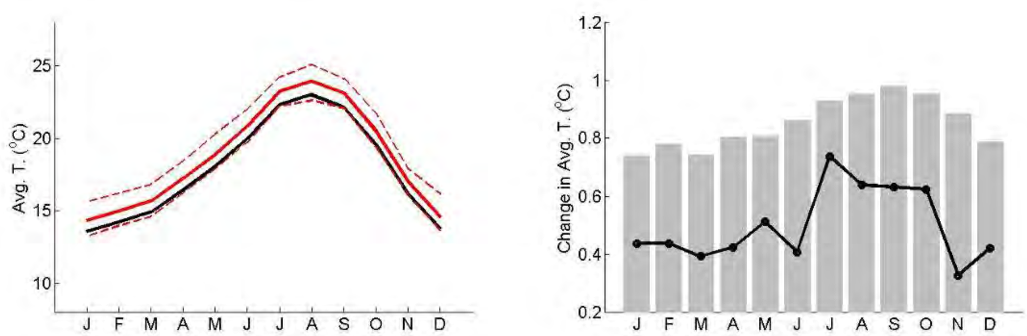


Figure 5. Left panels of the figure below, show the monthly average temperatures from climate model simulated historical period and climate model projections, for all 24 member agencies of the Water Authority. Black color curves show the historical average temperature computed from the model simulated years 1971 through 2000 (left, black color curves) and solid red color curves show monthly value computed from the climate model projections for the periods 2011 through 2035 (left, red color curves). The dotted color curves extend from minimum and maximum of the 112 downscaled climate model simulations. Bars in the right panels show the mean of the difference between the periods 1971 through 2000 with the period 2011 through 2035 computed from the 112 downscaled climate model simulations. In the right panels, black color solid curves show the mean of the difference between the periods 1971 through 2000 with the period 2011 through 2035, but computed from the six climate model simulations that are used for the California Climate Change Assessment.

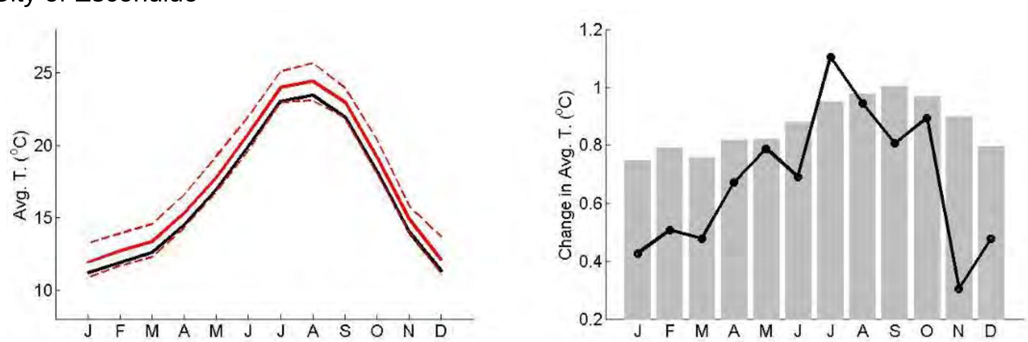
Carlsbad Municipal Water District



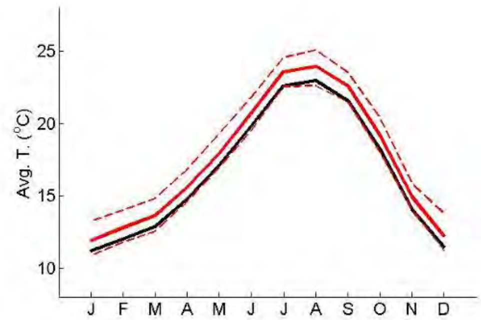
City of Del Mar

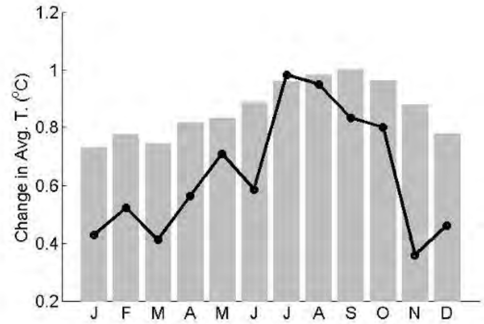


City of Escondido

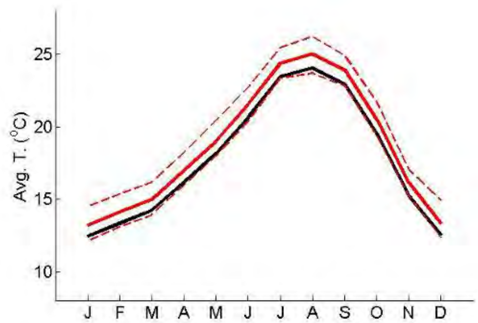


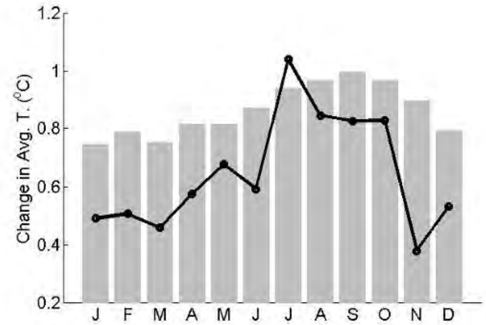
Fallbrook Public Utility District



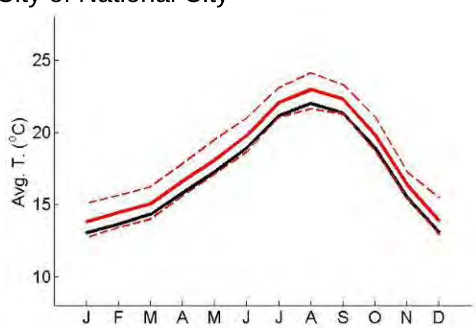


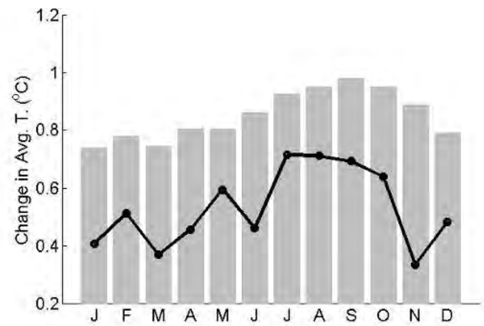
Helix Water District



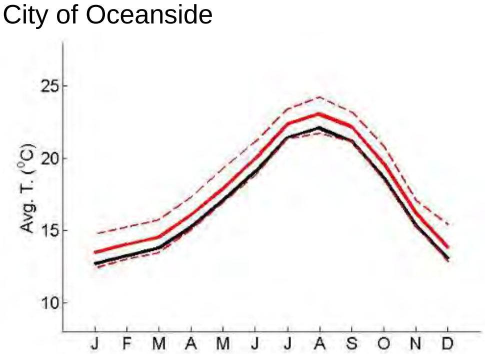


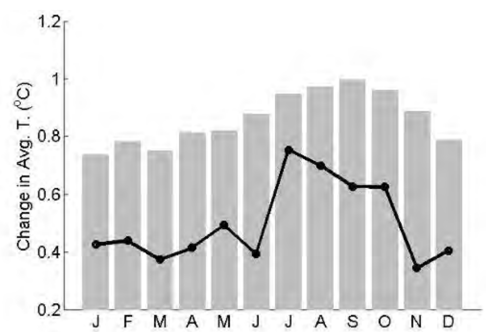
City of National City



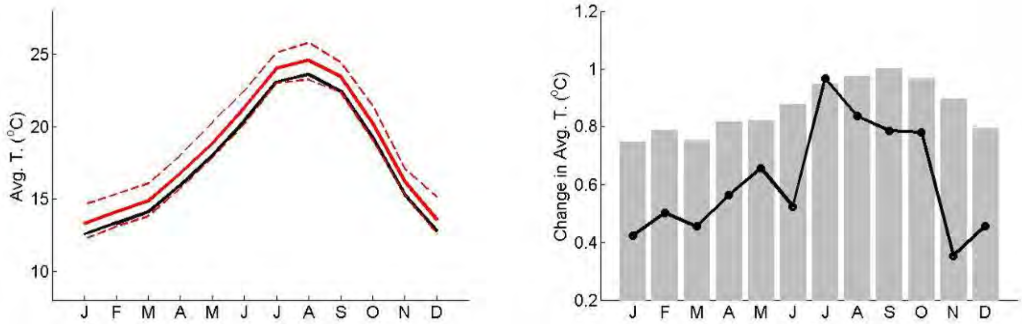


City of Oceanside

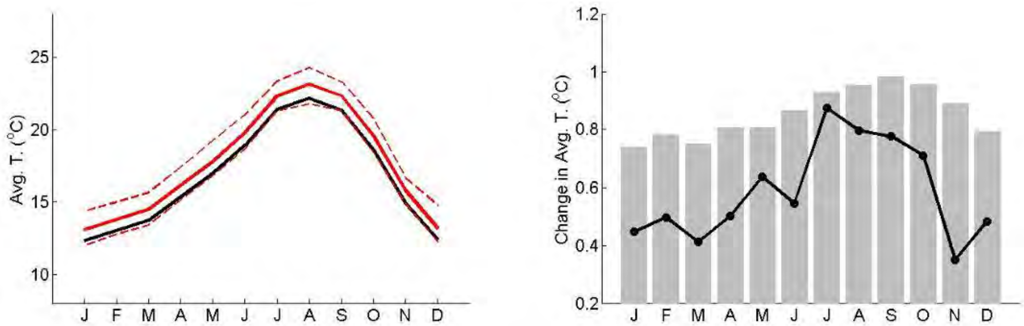




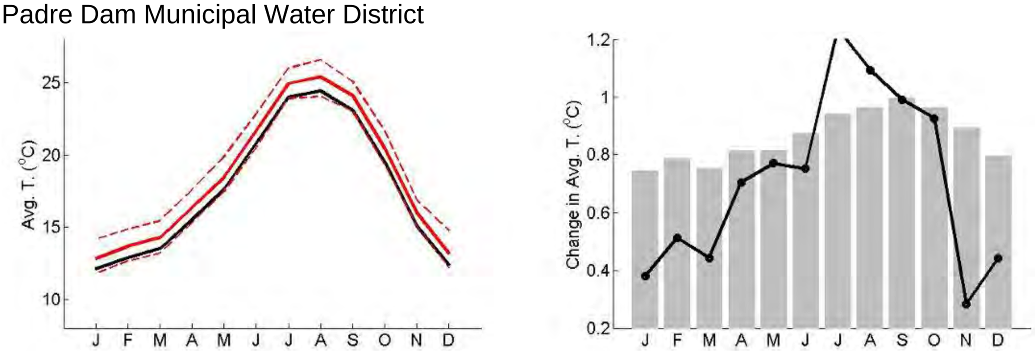
Olivenhain Municipal Water District



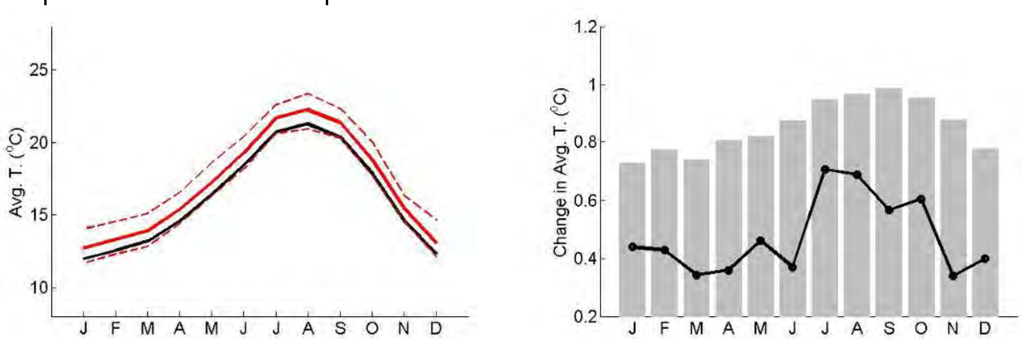
Otay Water District (East)



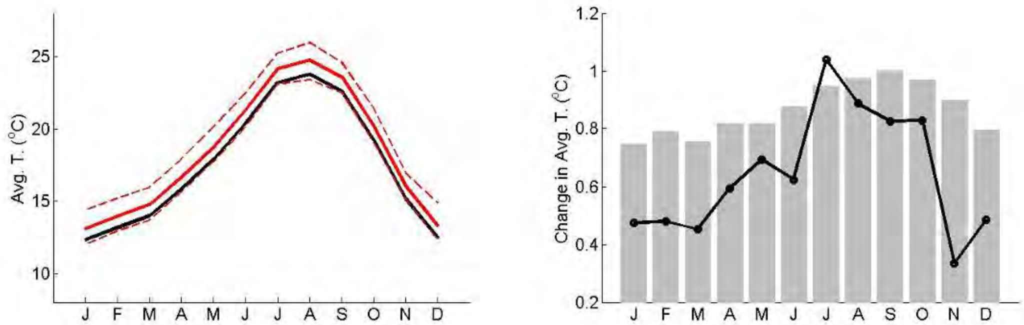
Padre Dam Municipal Water District



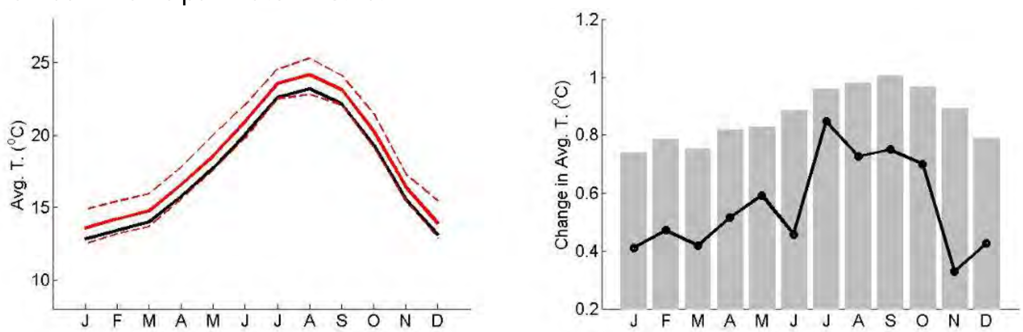
Camp Pendleton Marine Corps Base



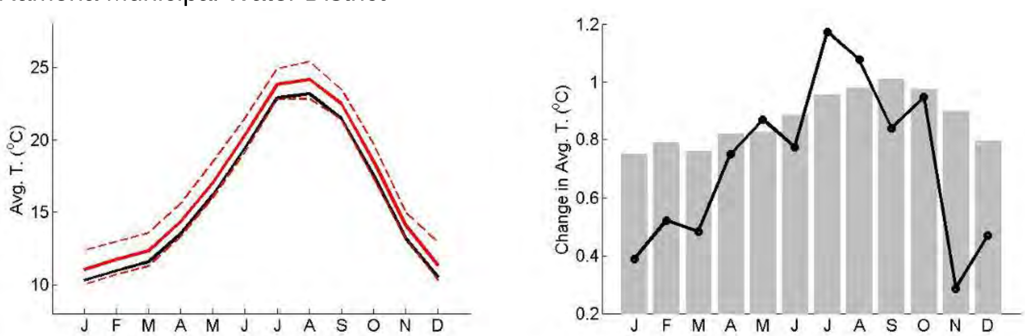
City of Poway



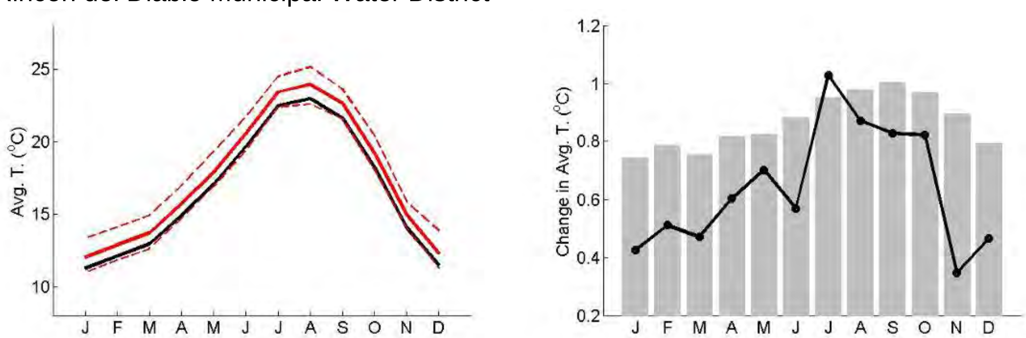
Rainbow Municipal Water District



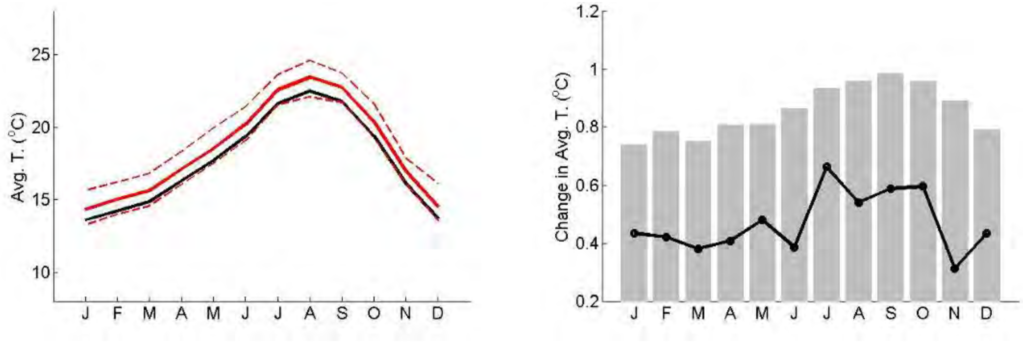
Ramona Municipal Water District



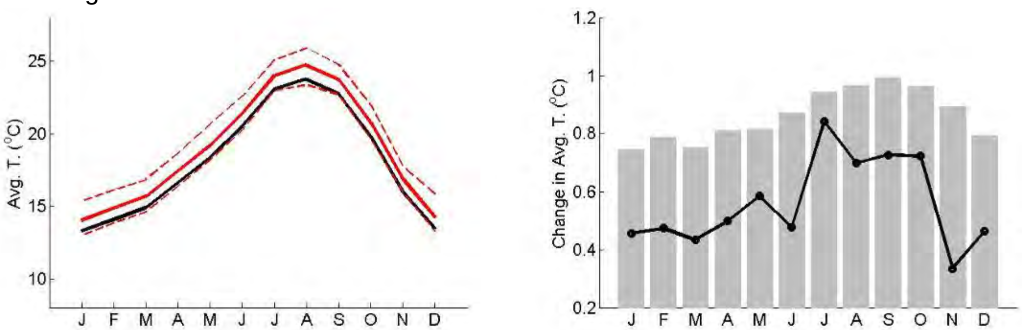
Rincon del Diablo Municipal Water District



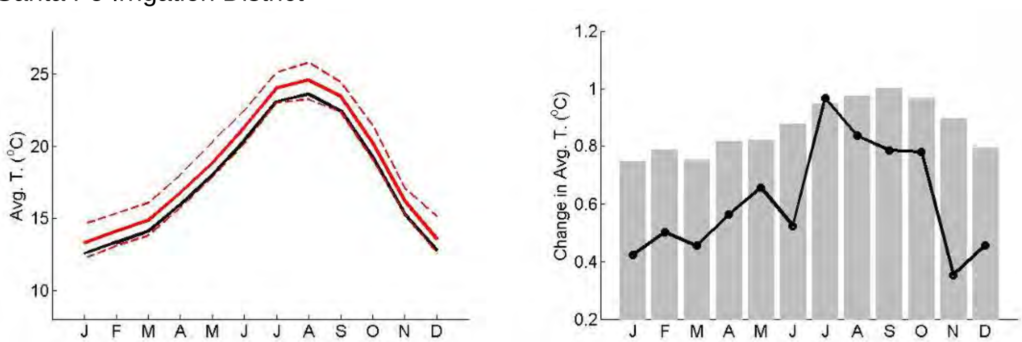
City of San Diego



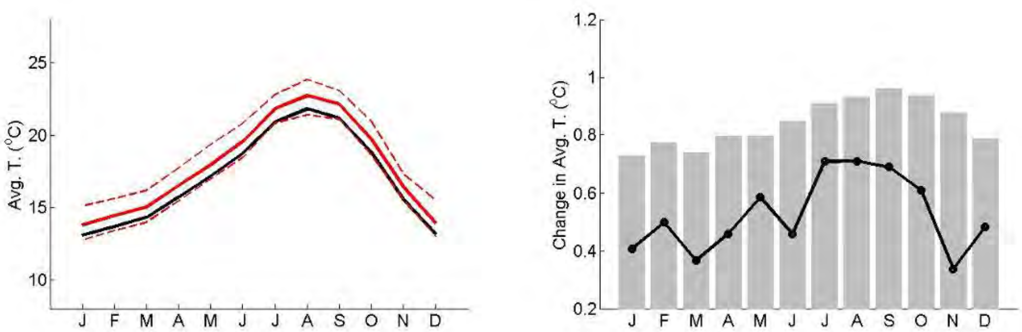
San Dieguito Water District



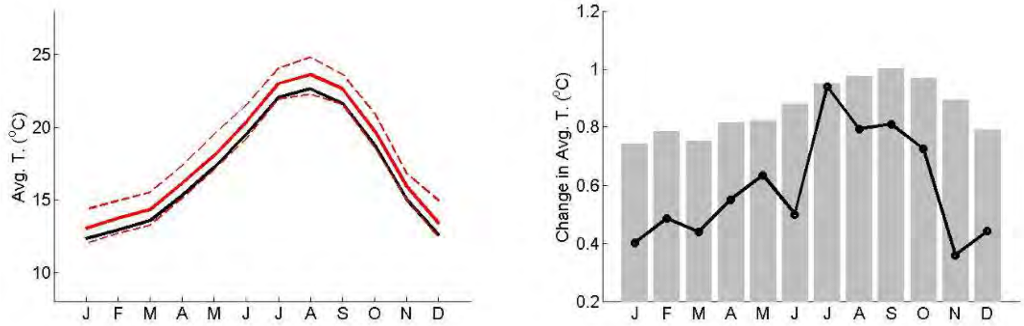
Santa Fe Irrigation District



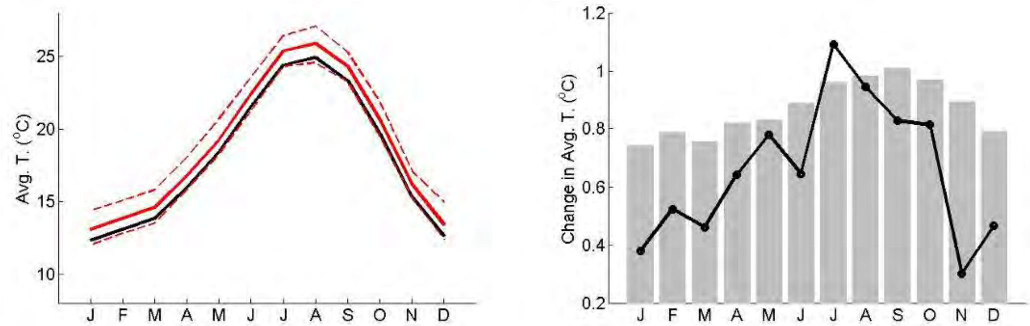
South Bay Irrigation District



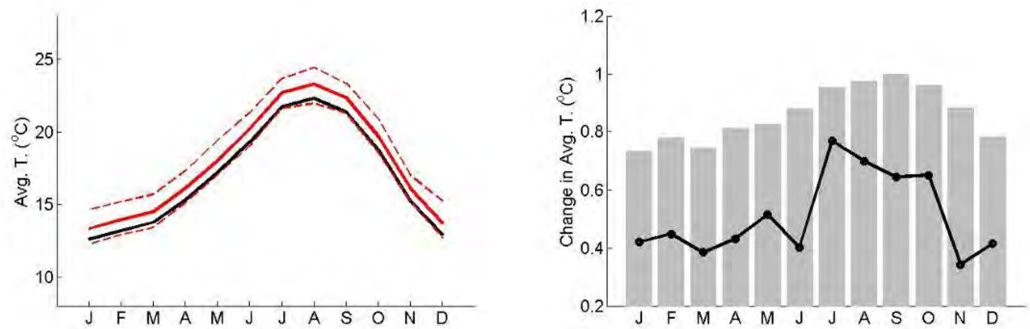
Vallecitos Water District



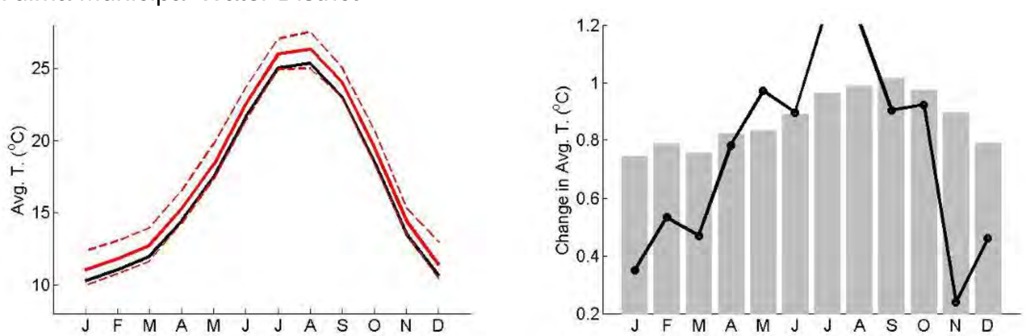
Valley Center Municipal Water District



Vista Irrigation District



Yuima Municipal Water District



Lakeside Water District

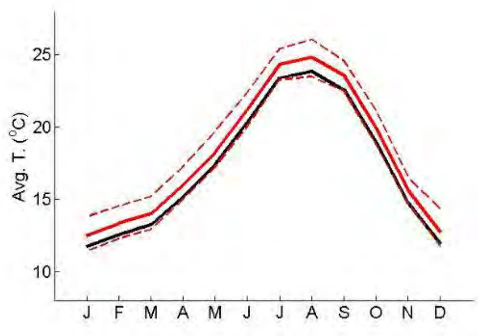


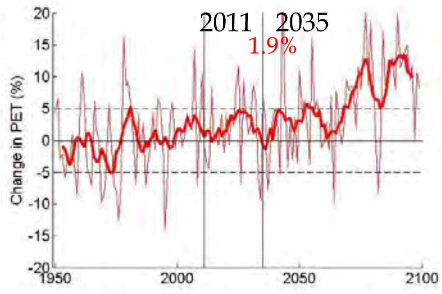
Table 2 below shows the projected changes in annual average PET. PET is computed using VIC hydrologic model as simulated by Constructed Analogues downscaled meteorologies from GFDL SRESA2. The percentage change is computed for the period 2011-2035 with respect to model simulated historical period 1971-2000.

Member Agency	%
CITY OF OCEANSIDE	1.1
CITY OF DEL MAR	1.0
CARLSBAD MUNI WATER DIST	1.4
CAMP PENDLETON MARINE CORPS BASE	0.7
CITY OF NATIONAL CITY	1.4
SOUTH BAY IRRIGATION	1.5
OLIVENHAIN MUNI WATER DIST	1.7
CITY OF SAN DIEGO	1.7
SAN DIEGUITO WATER DISTRICT	1.8
VISTA IRRIGATION DIST	1.4
SANTA FE IRRIGATION DIST	1.7
OTAY WATER DISTRICT (East)	1.9
YUIMA MUNI WATER DIST	2.1
CITY OF POWAY	2.3
HELIX WATER DISTRICT	2.2
VALLECITOS COUNTY WATER DISTRICT	1.9
RAINBOW MUNI WATER DISTRICT	1.8
FALLBROOK PUBLIC UTILITY	1.9
RINCON DEL DIABLO MUNI WATER DIST	2.2
VALLEY CENTER MUNI WATER DIST	2.0
CITY OF ESCONDIDO	2.4
PADRE DAM MUNI WATER DIST	2.6
RAMONA MUNI WATER DIST	2.5
LAKESIDE WATER DIST	2.7

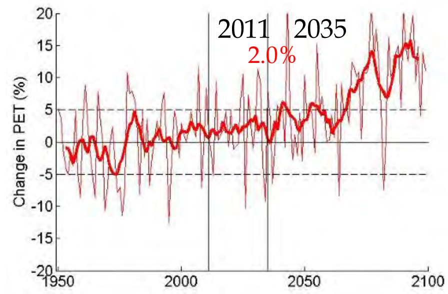
Coast	1.4
Inland	2.2

Figure 6 below shows the projected changes in annual average PET for some selected member agencies. Light color curves show the annual change. Thicker color curves show the 7 years moving averaged values. The change is computed for the period 2011-2035 with respect to model simulated historical period 1971-2000. Vertical lines bound the time period use for the Water Authority Master Plan. PET is computed using VIC hydrologic model as simulated by Constructed Analogues downscaled meteorologies from GFDL SRESA2. In the plots, average percentage change over the period 2011-2035 is indicated by red color numbers.

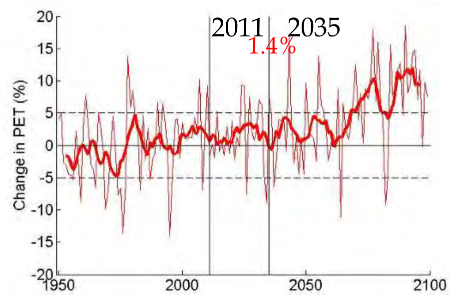
Otay Water District (East)



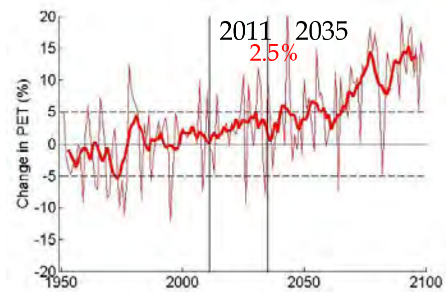
Valley Center Municipal Water District



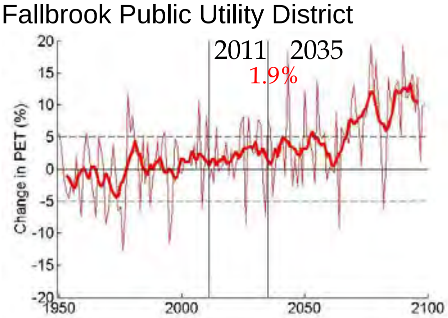
Carlsbad Municipal Water District



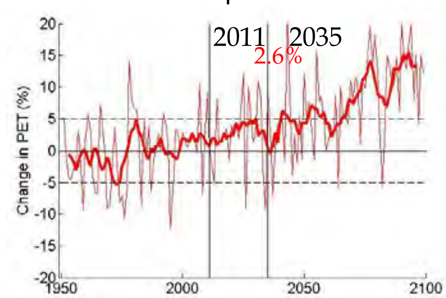
Ramona Municipal Water District



Fallbrook Public Utility District



Padre Dam Municipal Water District



City of San Diego

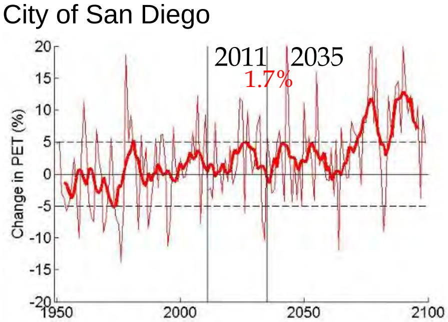


Table 3 below shows the changes in monthly PET. PET is computed using VIC hydrologic model as simulated by Constructed Analogues downscaled meteorologies from GFDL SRESA2. Percentage change in PET for the period 2011-2035 is computed from the climatologies computed over the period 1971 through 2000.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CITY OF OCEANSIDE	-4.3	-3.9	1.4	3.0	5.0	0.7	3.9	-1.4	2.0	2.6	-1.7	-5.6
CITY OF DEL MAR	-3.6	-2.9	2.1	3.2	5.1	1.0	3.6	-1.1	1.1	0.6	-2.3	-4.7
CARLSBAD MUNI WATER DIST	-3.3	-3.3	1.4	2.9	5.5	1.9	3.3	0.4	1.8	1.6	-1.4	-4.6
CAMP PENDLETON MARINE CORPS BASE	-4.1	-4.0	2.2	2.8	4.3	-0.1	3.7	-2.5	1.2	3.0	-1.7	-5.6
CITY OF NATIONAL CITY	-6.1	-2.0	3.3	6.0	5.3	0.1	3.1	-2.6	4.1	2.1	-0.7	-5.4
SOUTH BAY IRRIGATION	-6.6	-2.1	3.3	6.8	6.1	-0.3	3.3	-1.7	4.6	1.6	-1.3	-6.4
OLIVENHAIN MUNI WATER DIST	-2.2	-2.7	2.1	3.3	6.8	2.2	3.2	0.6	1.5	1.2	-1.8	-4.2
CITY OF SAN DIEGO	-5.6	-1.3	3.0	5.6	5.5	1.3	4.0	-1.4	2.7	2.0	-1.7	-4.7
SAN DIEGUITO WATER DISTRICT	-2.7	-2.0	2.4	3.5	6.3	2.3	3.6	0.6	1.8	1.0	-2.5	-4.1
VISTA IRRIGATION DIST	-4.7	-4.1	1.8	3.0	5.9	1.6	4.1	-1.0	2.2	2.5	-1.8	-6.1
SANTA FE IRRIGATION DIST	-2.2	-2.7	2.1	3.3	6.8	2.2	3.2	0.6	1.5	1.2	-1.8	-4.2
OTAY WATER DISTRICT (East)	-4.5	-1.1	3.4	4.5	6.4	1.2	3.2	-0.3	3.0	2.6	-0.6	-4.6
YUIMA MUNI WATER DIST	-2.2	-3.2	2.9	4.0	8.8	4.4	4.2	1.2	0.0	-2.8	-2.2	-7.1
CITY OF POWAY	-2.9	-1.5	2.5	4.4	7.8	3.0	3.2	1.9	2.1	1.3	-2.0	-4.5
HELIX WATER DISTRICT	-3.7	-1.1	2.9	4.6	6.8	2.2	3.1	1.2	2.7	2.5	-0.7	-4.3
VALLECITOS COUNTY WATER DISTRICT	-4.0	-3.3	2.3	3.8	7.2	2.3	4.0	0.3	2.7	1.9	-2.2	-5.7
RAINBOW MUNI WATER DISTRICT	-4.1	-3.6	2.4	3.4	7.3	2.3	4.0	-0.1	2.3	1.8	-1.5	-5.5
FALLBROOK PUBLIC UTILITY	-4.1	-2.6	2.8	3.8	8.4	2.6	2.9	1.3	1.4	1.8	-3.7	-6.5
RINCON DEL DIABLO MUNI WATER DIST	-3.0	-3.0	2.9	3.8	7.9	3.1	4.1	0.6	2.4	1.3	-2.0	-5.1
VALLEY CENTER MUNI WATER DIST	-2.9	-3.8	3.2	3.4	7.8	3.8	4.3	0.1	1.4	-0.3	-2.5	-6.1
CITY OF ESCONDIDO	-3.3	-2.3	2.9	4.5	8.8	3.3	3.3	1.6	1.4	1.8	-1.7	-5.2
PADRE DAM MUNI WATER DIST	-3.6	-1.9	3.9	5.3	9.0	4.7	3.0	1.2	1.4	0.9	-1.1	-5.9
RAMONA MUNI WATER DIST	-3.7	-2.2	3.0	5.1	9.5	3.5	3.2	2.5	0.8	1.1	-1.8	-6.0
LAKESIDE WATER DIST	-3.6	-1.6	3.1	5.5	9.0	3.8	3.3	2.0	1.6	1.7	-1.5	-5.0

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Coast	-4.1	-2.8	2.3	3.9	5.7	1.2	3.6	-0.9	2.2	1.7	-1.7	-5.1
Inland	-3.5	-2.4	2.9	4.3	8.1	3.1	3.5	1.0	1.8	1.2	-1.8	-5.5

Figure 7. Projected change in monthly PET. PET is computed using VIC hydrologic model as simulated by Constructed Analogues downscaled meteorologies from GFDL SRESA2. Percentage change in PET for the period 2011-2035 is computed from the climatologies computed over the period 1971 through 2000. Projected changes are spatially averaged for the member agencies categorizing the member agencies whether they are located at the coast or inland.

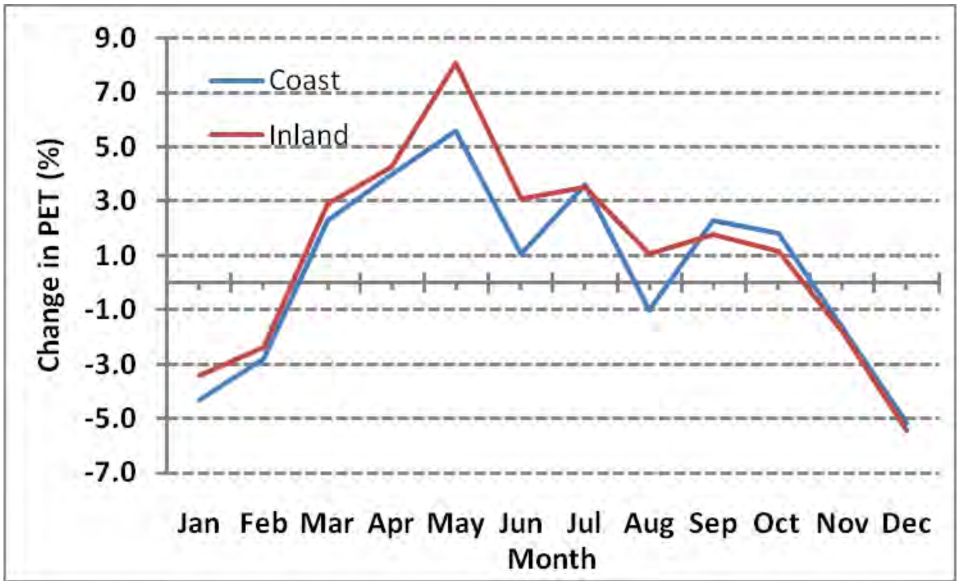
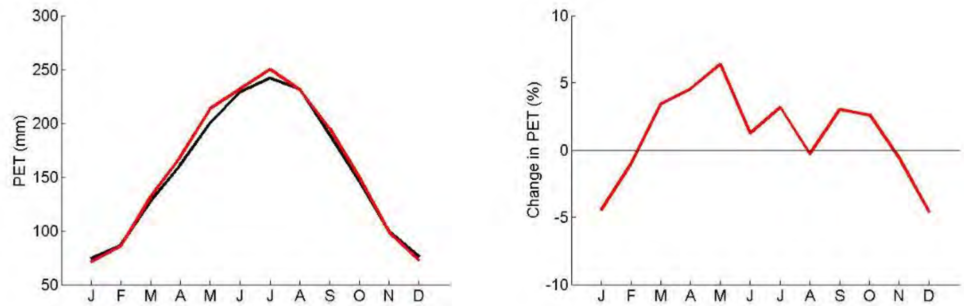
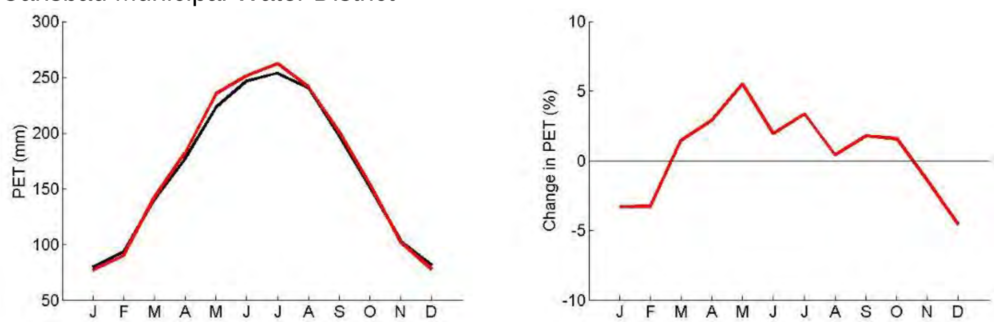


Figure 8 below shows the monthly climatology of PET (left panel) and change in PET (right panel) for some selected member agency in the Water Authority. PET is computed using VIC hydrologic model as simulated by Constructed Analogues downscaled meteorologies from GFDL SRESA2. Percentage change in PET for the period 2011-2035 is computed from the climatologies computed over the period 1971 through 2000.

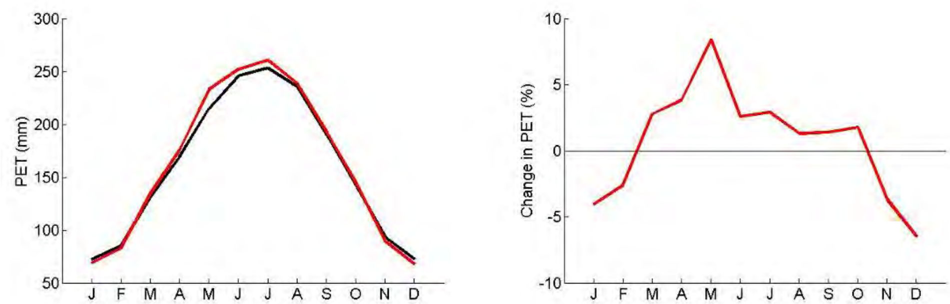
Otay Water District (East)



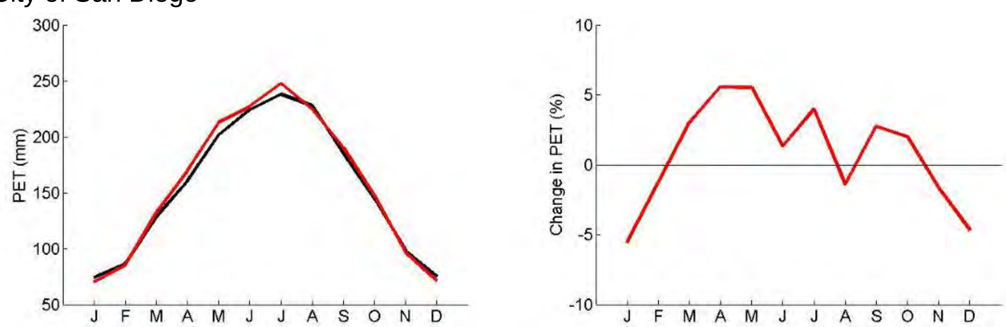
Carlsbad Municipal Water District



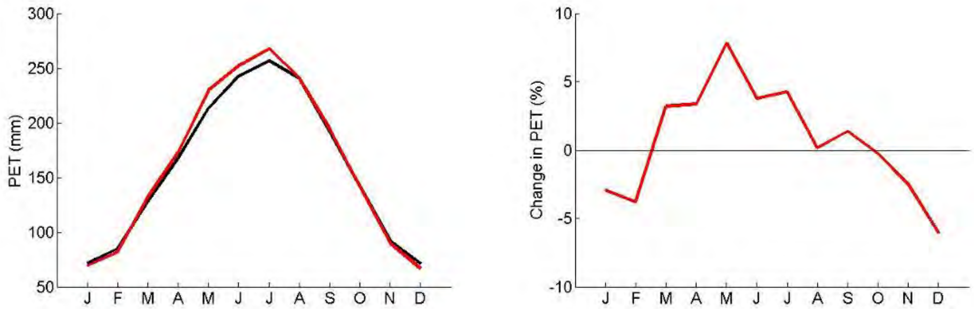
Fallbrook Public Utility District



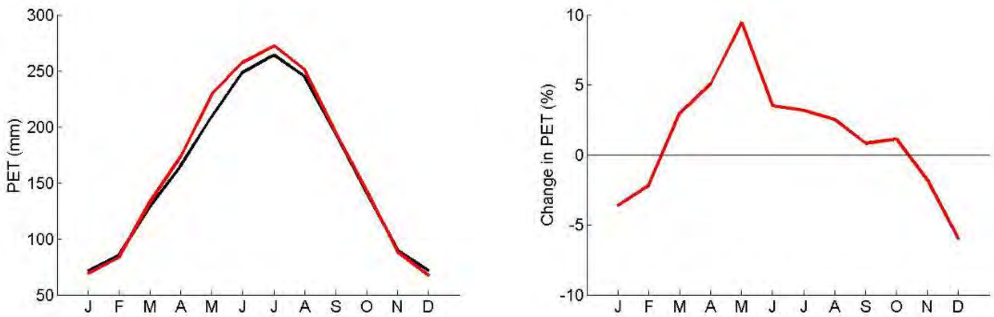
City of San Diego



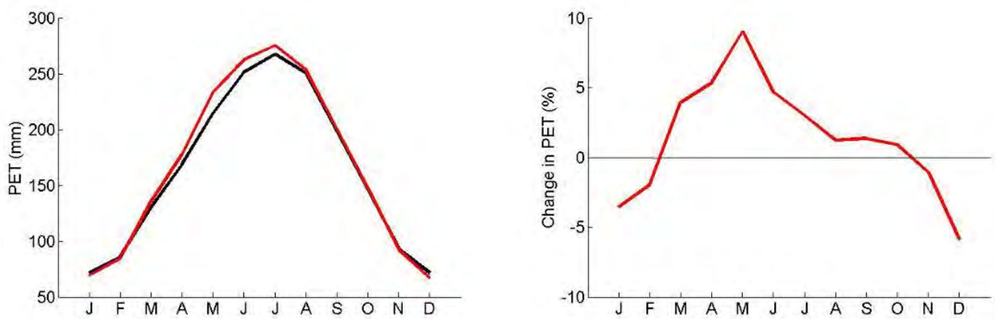
Valley Center Municipal Water District



Ramona Municipal Water District



Padre Dam Municipal Water District



Appendix F
San Diego Region Hydrology Extension

Introduction

Local San Diego Region surface water supply data is required to perform a long-term analysis of the Water Authority's integrated system. The availability and timing of the local surface water supplies influence demand on the Water Authority system and both member agency and Water Authority reservoir storage conditions. As part of previous long-range planning efforts, the Water Authority has compiled local surface water supply data at inflow locations to ten reservoirs for the period of 1888-1989. These flow data include observed or synthesized daily and monthly flow records.

As part of the 2013 Master Plan, the reservoir inflow data were extended from 1990 through 2011. The surface water hydrology extension was conducted using information from the Water Authority and member agencies and is focused on preparing inputs at the level needed to support regional modeling inputs. No changes to the 1888-1989 hydrology were made. A description of the methods and results is provided in this appendix.

Data and Methods

The extension of the inflow data for the major surface water reservoirs in the San Diego Region was prepared using monthly and daily reservoir information provided by the Water Authority and member agencies. The ten reservoirs included in Table F-1 were included in the hydrology extension to support the modeling needed for the Master Plan. These reservoirs represent nearly 80 percent of the total San Diego region's storage capacity and reflect the major storage facilities that influence Water Authority operations.

In general, reservoir elevations, deliveries, and releases were the type of information provided. In almost all cases, inflow to the reservoirs is not directly measured. In order to estimate inflow to reservoirs, the reservoir water balance must be developed and solved for inflow by utilizing measured or calculated values for storage change, evaporation and precipitation on the reservoir water surface, releases from the reservoir for delivery or spills, and any other losses.

The following steps describe the general methodology used in the hydrology extension:

1. From daily or monthly reservoir elevation data and reservoir elevation-area-capacity curves, compute the total monthly storage change and average monthly reservoir water surface area
2. Estimate the monthly evaporation from, and precipitation on, the reservoir water surface using historical climate data near the reservoir and the estimated surface area
3. Utilize historical information on deliveries from the reservoir or filling of reservoirs with non-native water (aqueduct deliveries)
4. Utilize historical information on reservoir spills or estimate spills from reservoir elevation and spillway crest elevation
5. From the information in steps 1-4, the reservoir mass balance can be solved for the inflow term.

These general steps were followed for each reservoir included in the assessment. However, since the provided data were in different formats, reporting frequencies, and levels of completeness, each reservoir inflow evaluation was somewhat unique. In some cases data gaps were required to be filled in order to develop continuous inflow records. In these cases, regressions were developed based on adjacent watershed flows and were utilized to fill the gaps. For short period data gaps, average monthly values were sometimes used.

Table F-1 indicates the information that was available for each of the reservoirs and the methods used to develop inflow estimates. Some general comments/notes regarding inflow estimates are provided below:

1. ***City of San Diego Reservoirs***. Monthly reservoir information was provided along with estimates of natural inflow. Independent verification of the reservoir balance calculations was performed. Recalculation of the inflow to El Capitan was performed to develop a "total" inflow value, rather than a City-specific inflow accounting. Some minor changes were made for San Vicente reservoir calculations to correct a formula inconsistency in some months.

2. ***Sweetwater Authority Reservoirs***. Due to the interconnected operations of the Loveland and Sweetwater Reservoirs, the total combined natural inflow to these reservoirs was first calculated. Natural inflow was then partitioned to the reservoirs individually based on long-term estimates.

3. ***Lake Wohlford.*** From the information provided, the assumption has been made that up to 60 cfs (canal capacity) of the river gain between Lake Henshaw and the Escondido Canal can be diverted into Lake Wohlford. The Escondido canal is operated to optimize Escondido's adjudicated water rights on the San Luis Rey during rainy periods then Vista's transfer of Henshaw water supplies. Vista's water only passes through Wohlford based on Vista's demand for water.

It should be noted that as a result of data noise, a negative inflow occasionally appears in the data set and the number is reset to zero. The level of noise is minor and does not influence the outcome of the modeling result.

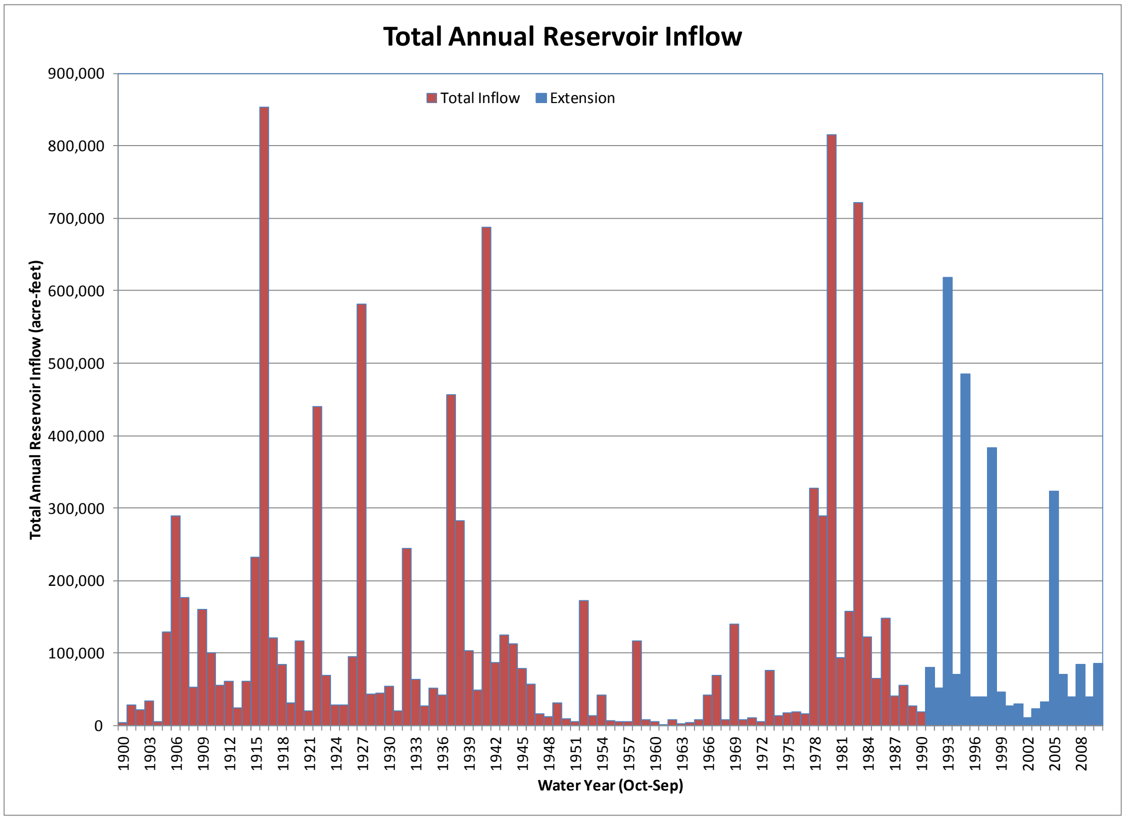
Results

The resulting total annual flows for all ten locations are shown in Figure F-1. The flows developed as part of the hydrology extension are shown in blue to the right of graph. The mean annual flow for the 1990-2010 period is approximately 124,000 acre-feet as compared to the 1956-1989 period mean annual flow of 102,000 acre-feet. The estimates of inflow are higher in the extension period, but reflect conditions observed in the 1980s and prior to the 1950s.

TABLE F-1
Summary of Reservoir Inflow Locations, Data Availability, and Method Notes

Reservoir	Agency	Reservoir Type in the Model	Inflow Data Availability from Confluence (Monthly)	Extension Data Availability	Method Notes
Dixon	City of Escondido	Forebay			Not developed
Wohlford	City of Escondido	Storage	1/1888-12/1994	1/1997-4/2011	Monthly average pattern applied for 1/1995-12/1996, 5/2011-12/2011
Jennings	Helix W.D.	Forebay			Not developed
Poway	City of Poway	Storage	N/A		Not developed
Ramona	Ramona M.W.D.	Storage	N/A		Not developed
Olivenhain – CWA	San Diego County Water Authority	Storage	N/A		Not developed
Barrett	City of San Diego	Storage	1/1888-12/1988	1/1989-12/2011	Computed from City data
El Capitan	City of San Diego	Storage	1/1888-12/1984	1/1989-12/2011	Recalculated from City data to estimate “total” inflow to El Cap
Hodges	City of San Diego	Storage	1/1888-12/1988	1/1989-12/2011	Computed from City data
Lower Otay	City of San Diego	Storage	1/1888-12/1988	1/1989-12/2011	Computed from City data
Miramar	City of San Diego	Forebay			Not developed
Morena	City of San Diego	Storage	1/1888-12/1988	1/1989-12/2011	Computed from City data
Murray	City of San Diego	Forebay			Computed from City data
San Vicente	City of San Diego	Storage	1/1888-12/1988	1/1989-12/2011	Computed from City data; corrected inconsistency for specific months
Sutherland	City of San Diego	Storage	1/1888-12/1988	1/1989-12/2011	Computed from City data
San Dieguito	San Dieguito W.D.	Forebay			Computed from City data
Loveland	Sweetwater Authority	Storage	1/1888-12/1998	1/1990-12/2010	Computed from total Sweetwater and Loveland inflow based on Sweetwater Authority data
Sweetwater	Sweetwater Authority	Storage	1/1888-12/1998	1/1990-12/2010	Computed from total Sweetwater and Loveland inflow based on Sweetwater Authority data
Henshaw	Vista I.D.	Storage	N/A		Not developed

FIGURE F-1
Estimated Total Annual Reservoir Inflow



The estimated natural inflows for each of the reservoirs are shown in Figure F-2. In general, the plots depict similar variability in annual flows in the most recent period as the preceding two decades and the period prior to 1950s. A period of lower mean annual flows and lower inter-annual variability exists during 1947-1977. This period represents conditions of lower than average precipitation and reduced annual precipitation variability as shown in Figure F-3. This precipitation mean and variability appear to be the driver in the overall reduction in annual runoff. However, the response during the intermittent wet years in this period appears to be significantly less than during other periods; particularly the most recent dry conditions in the 1990s and 2000s. It is recommended that further investigation be completed on this period (prior to the extension period) to determine whether this response is hydrologically consistent with other periods or whether data inconsistencies may be contributing to part of this result.

The results for the hydrology extension period are generally consistent across the locations. The period reflects a higher than average runoff conditions with high inter-annual variability, but lower maximum flows than during the previous two decades (1983 was an extreme wet year). However, the results for inflow to Lower Otay Reservoir and Lake Wohlford are different in the extension period. Results for Lower Otay inflow depict higher maximum flows during 1993 than in the early 1980s. In addition, inflow for Lake Wohlford is significantly higher in the extension period than in preceding decades. At this location, it is possible that differences in methodology to develop inflows for the extension period and prior periods may be partially contributing to these conditions.

FIGURE F-2
Annual Reservoir Inflow for 1900-2010 for Each of the Ten Locations

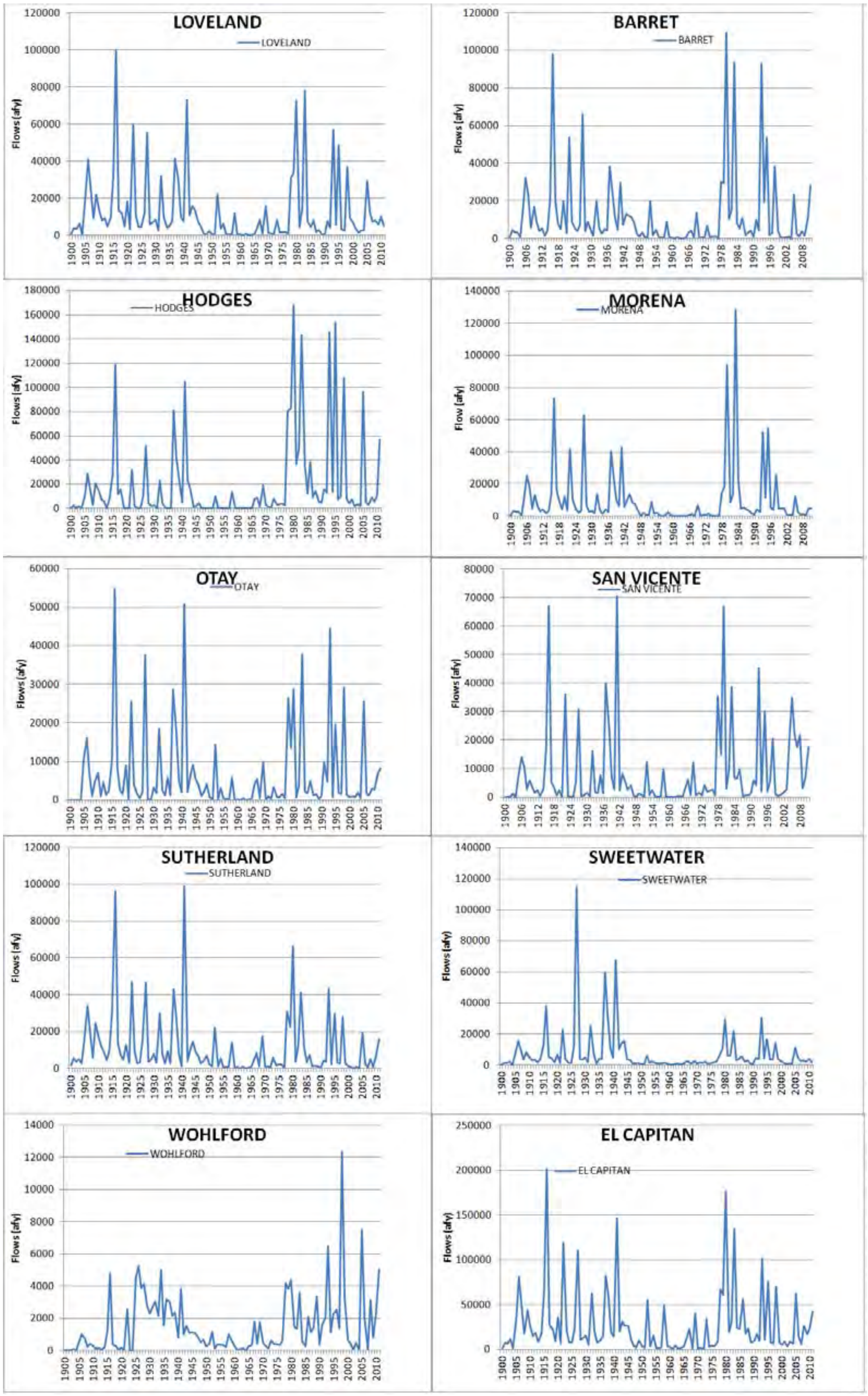
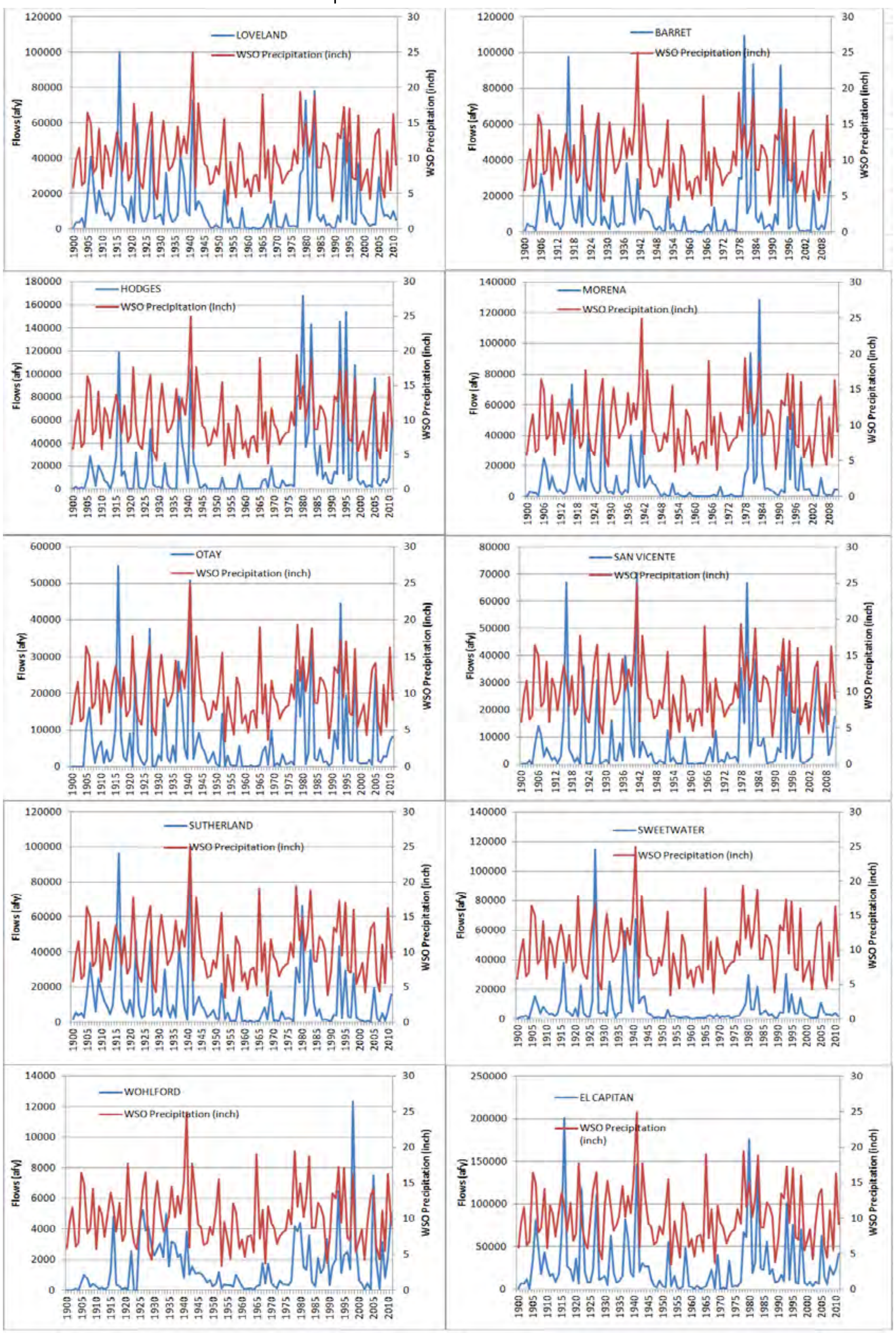


FIGURE F-3
Annual Reservoir Inflow and Annual Precipitation for 1900-2010 for Each of the Ten Locations



Limitations and Conclusions

The process of developing natural inflows to reservoirs for long-term water resources planning includes a number of uncertainties that contribute to uncertainty in the inflow results. First, the reservoir inflows are not directly measured and thus must be estimated based on observations and other measurements of the reservoir balance. Second, changes in reservoir bathymetry that commonly occurs as sediment fills the lower portions of reservoir storage, changes in watershed conditions and water use conditions, and changes in the methods to measure and report reservoir elevation and storage also contribute to the uncertainty in the results. Finally, since the methods applied in this assessment relied upon a number of different data sources from different member agencies, the approaches needed to be modified slightly and thus introduces some methodological differences.

The assessment include in this report reflects considerable data collection, synthesis, and calculation to develop the extended hydrology for 1990-2010 and presents important information related to the San Diego Region hydrologic variability associated with this most recent period that can be appended to previous work. Together, this extended hydrologic data set provides a longer, updated record for use in understanding the importance of local hydrologic variability on the operation and reliability of the Water Authority system.

Appendix G
Colorado River Conveyance Alternative Report

Contents

Appendix

Tables

Figures

Appendix G
Colorado River Conveyance Alternative Report

1.0 Background

1.1 Overview

The San Diego County Water Authority (Water Authority) is developing the 2013 Regional Water Facilities Optimization and Water Master Plan Update (Master Plan) to define facility needs to enable the Water Authority to maintain and enhance the reliability of the San Diego Region's water supply. One component of the future water supply mix could be Colorado River Conveyance Facilities (CRCF) to transport Colorado River Water to the San Vicente Reservoir. Through the Quantification Settlement Agreement (QSA), the Water Authority has water rights for Colorado River Water that is currently "wheeled" through Metropolitan Water District of Southern California (MWD) facilities to the Water Authority. Colorado River supply allocated to the Water Authority includes 200,000 acre-feet per year (AF/y) from the QSA plus 80,200 AF/y from the All American Canal (AAC) and Coachella Canal Lining projects, for a total of 280,200 AF/y. The CRCF could provide direct conveyance of Colorado River Water to the Water Authority from the Colorado River to San Vicente Reservoir. Several potential routes were analyzed beginning in 1996, with subsequent studies identifying two preferred routes to deliver Colorado River Water to the San Vicente Reservoir – Alignment Corridor 5A and 5C. These two preferred routes were analyzed as part of this report, which constitutes Appendix G to the Master Plan.

This report presents results of an evaluation of the preliminary criteria for potential facilities to convey Colorado River Water directly to San Vicente Reservoir including conveyance pipelines and tunnels and associated pumping systems. The conveyance facilities will begin at the AAC terminus at its junction with the Westside Canal. The pipeline termination point will be at the San Vicente Reservoir. Alignment Corridors 5A and 5C were reexamined to aid the Water Authority in identifying the requirements for the CRCF.

Figure 1-1 shows a project location map with the proposed starting and termination points for Alignment Corridors 5A and 5C from the original Imperial Irrigation District (IID) Water Transfer Feasibility Study in 1996 (1996 Water Transfer Study) . The plan view of Alignment Corridors 5A and 5C have been updated and included later in this Report (Figures 2-1 and 2-2). Figure 1-2 shows a schematic profile of Alignment Corridors 5A and 5C. Table 1-1 summarizes the proposed preliminary criteria for the CRCF.

TABLE 1-1
Pipeline Criteria

Parameter	Preliminary Criteria	Comment
Flow, Annual	280,200 AF/y	For the Imperial Valley Treatment Option, the lowest annual flow is 256,700 AF/y
Flow, Design	487 cfs	Includes 10% allowance for maintenance/emergency and 15% allowance to avoid “On-Peak” pumping energy charges
Pipe Diameter	96-inch	
Tunnel Diameter	12- to 15-foot diameter, excavated	10- to 14-foot diameter, finished
Pipe Material	Cement mortar lined and coated steel pipe (CMLC)	

1.2 Design Development Approach

The purpose of this report is to re-examine Alignment Corridors 5A and 5C for the CRCF including pipeline segments, tunnel segments, and associated pumping systems.

Using existing aerial topography, the area between the AAC and the San Vicente Reservoir was analyzed for alignment Corridors 5A and 5C. A field visit was conducted on May 22, 2012 with the Water Authority and project team members to drive the alignments. The purpose of the field visit was to identify potential favorable and unfavorable conditions and any changes in the land use since the original Colorado River Conveyance studies were conducted. Photos of key points of alignment Corridors 5A and 5C were taken as part of the field visit and are included in Appendix A.

An evaluation was conducted to re-examine the assumptions and analyses for Alignment Corridors 5A and 5C and determine potential changes or fatal flaws considering:

- Land Use
- Geological Characteristics
- Energy Management Strategy
- System Hydraulics
- Water Quality and Treatment
- Corridor Engineering Evaluations
- Electric Power Market Analysis
- Natural Gas Market Analysis
- Environmental Assessments
- Opinion of Probable Construction Costs
- Staging Opportunities
- Decision Analysis

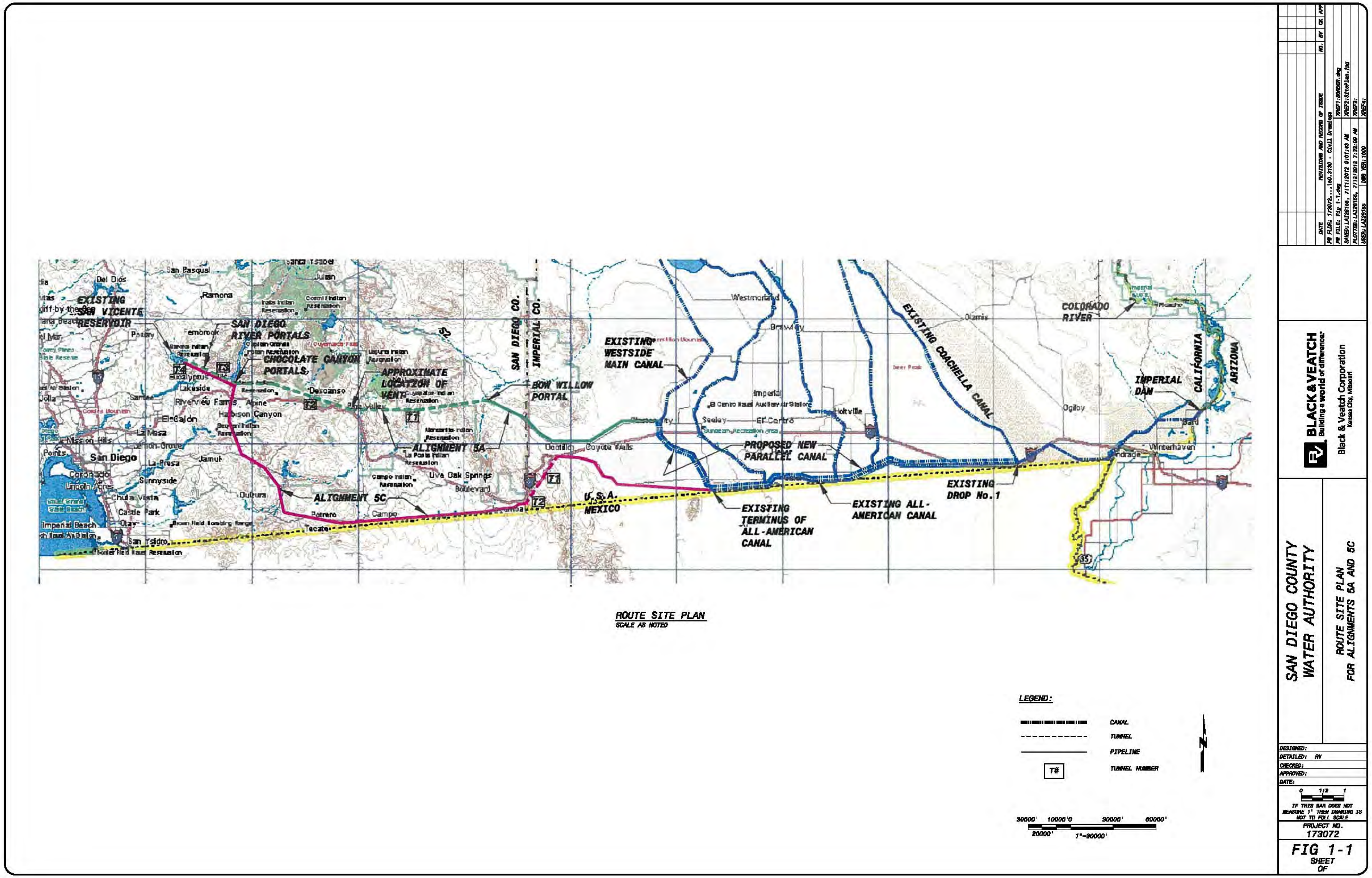


FIGURE 1-1
Route Site Plan for Alignments 5A and 5C

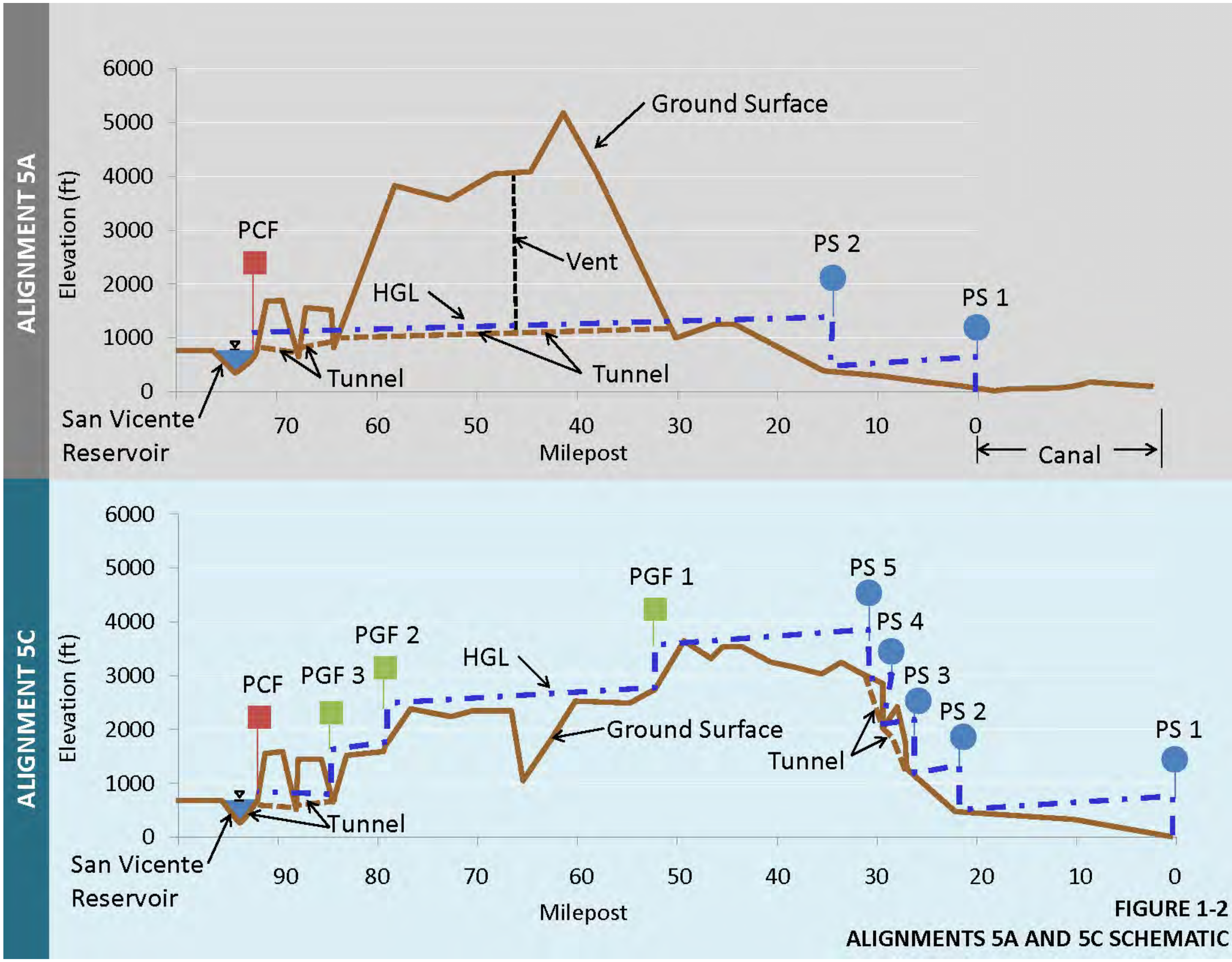


FIGURE 1-2
Alignments 5A and 5C Schematic

1.3 Background Information

Several Water Authority reports have been prepared analyzing various aspects of a Colorado River conveyance system from the Colorado River to San Diego and Mexico over the last 16 years. A summary of these reports and their focus is provided as background information.

1.3.1 1996 Water Transfer Study

The 1996 Water Transfer Study was prepared to analyze a conveyance system from the Colorado River to San Diego to ensure a reliable, high quality, supplemental water supply to meet the needs of the Water Authority's service area through the year 2100. It included an evaluation of five alternative corridors and three annual transfer volumes to develop a range of capital and operating costs to determine the economic feasibility of such a project. The feasibility study included land use assessment, geologic characterization, energy management strategy evaluation, water quality and treatment, corridor engineering evaluations, electric power market analysis, natural gas market analysis, environmental assessment, opinion of probable construction costs, staging analysis, and decision analysis. The estimated capital costs ranged from $1.4 billion for a 300,000 AF/y transfer volume to $2.3 billion for a 500,000 AF/y transfer volume in 1996 dollars (equivalent 2012 dollars is $2.3 to $3.8 billion). The estimated annual costs including Operation and Maintenance (O&M) costs, pumping power costs, water treatment, and energy recovery, ranged from $43 million for a 300,000 AF/y transfer volume to $92 million for a 500,000 AF/y transfer volume in 1996 dollars (equivalent 2012 dollars is $71 to $152 million per year).

1.3.2 2001 Geotechnical Data Report

The Geotechnical Data Report Northern Alignments Regional Colorado River Conveyance Feasibility Study, May 2001 (2001 Geotechnical Data) provided more detailed information of geologic conditions of Alignment Corridors 5A and 5C to better define tunnel requirements and cost. Geologic investigations included review of prior geologic data and geotechnical investigations, aerial photo interpretation, geologic mapping, geophysical seismic refraction and down hole surveys, hollow stem auger and rock core borings, packer hydraulic conductivity testing, and soil, rock, and groundwater laboratory testing.

1.3.3 2001 Geotechnical Interpretive Report

The Geotechnical Interpretive Report Northern Alignments Regional Colorado River Conveyance Feasibility Study, May 2001 (2001 Geotechnical Interpretive Report) provided the evaluation and interpretation of geotechnical data gathered by the 2001 Geotechnical Data Report. This report included engineering analysis of ground behavior, groundwater inflows, and construction considerations.

1.3.4 2001 Feasibility Study Cost Refinement

The Feasibility Study Cost Refinement of the Regional Colorado River Conveyance Alignments 5A and 5C North of the Mexico/US Border, June 2001 (2001 Feasibility Study Cost Refinement) purpose was to refine the cost information for Alignment Corridors 5A and 5C using new information from the 2001 Geotechnical Data Report and 2001

Geotechnical Interpretive Report. Other changes were also identified including additional tunnels for Alignment Corridor 5C along Interstate 8 near Bolder Creek and the San Diego/Imperial County Line, refined tunnel design criteria and costs, more detailed trench excavation criteria and costs, and updated schedule. The estimated capital costs ranged from $1.7 billion for a 300,000 AF/y transfer volume to $2.5 billion for a 500,000 AF/y transfer volume in 2001 dollars (equivalent 2012 dollars is $2.0 to $3.6 billion). The estimated annual costs including O&M costs, pumping power costs, water treatment, and energy recovery ranged from $47 million for a 300,000 AF/y transfer volume to $116 million for a 500,000 AF/y transfer volume in 2001 dollars (equivalent 2012 dollars is $68 to $169 million per year).

1.3.5 Feasibility Study for Water Conveyance from the Colorado River to the Tijuana, B.C. – San Diego, CA Region, February 2002

This report considered three primary alternative alignments (with several sub-alternative alignments) to deliver water from the Colorado River to the Tijuana/San Diego region. The study included alignment identification, geological characterization, land use analysis, environmental analysis, and energy use analysis. Three different storage reservoirs were analyzed as delivery points with the closest to San Diego being within Mexico near the border at Tecate.

1.3.6 2003 Environmental Issues Technical Memorandum

The Examination of Environmental Issues Related to the Bi-National Permitting Option, May 2003 (2003 Environmental Issues Technical Memorandum) evaluated the considerable permitting requirements of a Colorado River conveyance alternative from the Colorado River to the Tijuana/San Diego region. Responsible agencies, the scoping process, and environmental documentation requirements were identified for the Bi-National option under Mexico and United States laws.

1.3.7 2002 Feasibility Study

The Regional Colorado River Conveyance Feasibility Study, February 2002 (2002 Feasibility Study) identified, evaluated, and documented 10 alternative alignments to deliver water from the Colorado River to the Tijuana/San Diego region following adoption of the QSA. Transfer volumes of 300,000 AF/y for delivery to San Diego (San Vicente Reservoir) and either 100,000 to 200,000 AF/y to the Tijuana region were evaluated. The study included alignment evaluation, design criteria, water supply, water quality, environmental issues, geotechnical information, tunnel evaluation, storage analysis, cost analysis, finance options, system evaluations, and recommendations. The estimated capital costs for the United States' share of the costs corresponding to the transfer volume of 300,000 AF/y ranged from $1.3 to $2.0 billion in 2001 dollars (equivalent 2012 dollars is $1.8 to $2.9 billion). The estimated annual costs for the United States' share of the costs corresponding to the transfer volume of 300,000 AF/y including O&M costs, pumping power costs, water treatment, and energy recovery ranged from $86 to $122 million in 2001 dollars (equivalent 2012 dollars is $125 to $178 million per year).

1.4 Major Changes

Several major changes have occurred since the 1996 Water Transfer Study was prepared. Other studies provided updates and considered possible alignments to Mexico. These studies were also considered in documenting the major changes. Major changes are summarized here and detailed further in subsequent sections of this report.

1.4.1 Land Use

Over the course of the last 16 years since the 1996 Water Transfer Study was conducted, there have been some notable land use changes along Alignment Corridor 5A and 5C. These include:

- New San Diego Gas and Electric (SDG&E) Sunrise Powerlink Project right of way
- New residential developments and road extensions in El Cajon and Alpine
- Revised Bureau of Land Management (BLM) boundaries
- Revised Indian Reservation boundaries
- Revised Areas of Critical Environmental Concern (ACEC) boundary

1.4.2 San Vicente Dam Raise

As part of the Emergency Storage Project and carryover storage program (2003 Master Plan), the Water Authority has raised the San Vicente Dam to an elevation 117 feet higher than the existing dam. Both Alignment Corridors 5A and 5C deliver water to San Vicente Reservoir. Therefore, the hydraulics of the delivery point need to be adjusted to account for the higher elevation of San Vicente Dam. For both Alignment Corridor 5A and 5C, the pumping components can remain the same, but the last pressure control facility (PCF) will have less pressure head to break. Also, the tunnel portal location at San Vicente Reservoir will need to be coordinated with the new higher pool elevation of the San Vicente Reservoir.

1.4.3 San Vicente Pipeline/San Vicente Pump Station

The Water Authority completed the San Vicente Pipeline, a pipeline/tunnel segment from the Second San Diego Aqueduct near Mercy Road to the San Vicente Reservoir, and the San Vicente Pump Station. This system, termed the “Beeler Canyon System” in the 1996 Water Transfer Study, is now completed. Thus the overall pipeline length, pump station facilities, and costs for this system no longer apply and do not need to be included in the evaluation of Alignment Corridors 5A and 5C.

1.4.4 Water Treatment Plants

With the completion of the San Vicente Pipeline and San Vicente Pump Station, it is now possible to deliver water to several water treatment plants in San Diego County. The 1996 Water Transfer Study only considered untreated water deliveries to the City of San Diego’s Alvarado and Miramar Water Treatment Plants (WTP) and concluded treatment could occur downstream of these water treatment plants by adding reverse osmosis treatment with brine disposal via a dedicated brine disposal pipeline to the South Bay Ocean Outfall. Currently, untreated water deliveries can be made from the San Vicente Reservoir to five water treatment plants (Alvarado, Miramar, Levy, Otay, and Perdue WTPs). In addition, projects including the Camp Pendleton Desalination Plant and City of San Diego's Indirect Potable Reuse Project could blend with Colorado River Water to reduce salt loading.

1.4.5 All American Canal Relining

The Water Authority completed the AAC Relining Project which included construction of a new parallel canal system to the AAC in Imperial Valley. The project extended 23 miles from near Pilot Knob to Drop 3 adjacent to the existing AAC. This project allowed the Water Authority to reduce seepage of water through the old canal system and acquire the water rights to the reduced water seepage. The project ensures adequate capacity in the AAC to deliver flows to Imperial Valley for IID. Based on prior estimates of maximum discharges, available capacity in the AAC allows for an additional 300,000 AF/y for the Colorado River Conveyance Alternative. An agreement with IID would be required in any case for use of the existing AAC (from the Imperial Dam to any point along the canal to the terminus including the newly constructed canal segment) and for the ability to call on water demands from the Colorado River at the Imperial Dam take-off. For the purposes of this report, it was assumed that an agreement could be reached for the Water Authority's use of excess capacity in the AAC from the Imperial Dam to the terminus at the Westside Canal. The agreement would include provisions for use, ordering water, scheduling, and O&M costs (contribution to IID).

1.4.6 SDG&E Sunrise Powerlink Project

SDG&E recently completed construction of the Sunrise Powerlink Project from the Imperial Valley Substation near El Centro to the Sycamore Canyon Substation just south of Poway. The Sunrise Powerlink Project, which was put into service in mid-June 2012, is in proximity to several segments of Alignment Corridor 5C and the tunnel portal near El Capitan Reservoir for Alignment Corridors 5A and 5C. It is also near one pump station along Alignment Corridor 5A and all five of the proposed pump stations along Alignment Corridor 5C. The Sunrise Powerlink Project could potentially bring power to the proposed pump stations rather than requiring construction of new electric transmission lines from the Imperial Valley Substation. Power generation facilities along the pipeline could connect into the Sunrise Powerlink Project closer to the alignment.

1.4.7 Flow Rates

In the prior studies, flow rates of 300,000, 400,000, and 500,000 AF/y were considered. Since the QSA has been finalized and the AAC and Coachella Canal Lining Projects have been completed, the Colorado River water allocated to the Water Authority has been defined at 280,200 AF/y.

1.4.8 Costs

Since the 1996 Water Transfer Study was conducted, construction costs and O&M costs have escalated. Actual escalation costs from 1996 to 2012 are available specific to the southern California region; therefore, these new escalated costs were used in the reevaluation of the Colorado River Conveyance Alternative.

1.5 Organization of Report

For the CRCF, Alignment Corridor 5A and 5C were re-examined, along with associated pumping facilities. The report is organized into the following sections:

2.0 Description of Alignment Corridors
3.0 Land Use Assessment
4.0 Alignment Corridors Reevaluation
5.0 Project Risks
6.0 Project Costs
7.0 Implementation Schedule
Appendix A Field Visit Photos
Appendix B Cost Estimates
Appendix C Pipeline and Tunnel Construction Methods
Appendix D Energy Management Strategy Evaluation

1.6 Abbreviations and Acronyms

The following abbreviations and acronyms are utilized in this report.

AAC	All American Canal
ABDSP	Anza-Borrego Desert State Park
ACEC	Areas of Critical Environmental Concern
ACOE	Army Corps of Engineers
ACSR	aluminum conductor steel reinforced
AF	acre feet
AF/y	acre feet per year
B.C.	Baja California
BLM	Bureau of Land Management
BTU/kWh	British Thermal Unit per kilowatt hour
CCI	Construction Cost Index
CEC	California Energy Commission
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CMLC	cement mortar lined and coated
CRCF	Colorado River Conveyance Facilities
D/t	Diameter over thickness
EA	Environmental Assessment

EHS	extra high strength
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ENR	Engineering News Record
fps	feet per second
ft	feet
GIS	Geographic Information System
HGL	hydraulic grade line
IID	Imperial Irrigation District
IPR	Indirect potable reuse
ISO	International Organization for Standardization
ksi	kilopounds per square inch
kV	kilovolt
kWh	kilowatt hour
Master Plan	2012 Regional Water Facilities Optimization and Water Master Plan
MF	microfiltration
MF/RO	microfiltration/reverse osmosis
mg/L	milligrams per liter
mgd	million gallons per day
MMBtu	million metric British Thermal Units
MP	Milepost
MSL	Mean Sea Level
MW	megawatts
MWD	Metropolitan Water District of Southern California
N/A	Not applicable
NEPA	National Environmental Policy Act
No.	number
O&M	Operation and Maintenance
OD	outside diameter
PCF	pressure control facility

PGF	power generating facility
PS	pumping station
psi	pounds per square inch
QSA	Quantification Settlement Agreement
RMP	Resource Management Plan
RO	reverse osmosis
RWQCB	Regional Water Quality Control Board
SCH	Species Conservation Habitat
SDG&E	San Diego Gas and Electric
SDWA	Safe Drinking Water Act
TBM	tunnel boring machine
TDS	total dissolved solids
TOU	time of use
USFS	United States Forest Service
VFD	variable frequency drives
VRM	Visual Resource Management
Water Authority	San Diego County Water Authority
WMC	Westside Main Canal
WTP	water treatment plant

2.0 Description of Alignment Corridors

2.1 Overview

As shown on Figures 2-1 and 2-2, two primary corridors were evaluated in prior studies – Alignment Corridor 5A and 5C that would deliver Colorado River Water from the AAC to San Vicente Reservoir. Table 2-1 provides a summary of the alignment corridor key characteristics.

TABLE 2-1
Alignment Corridor Key Characteristics

Characteristic	Corridor 5A	Corridor 5C
Minimum Elevation, Feet Mean Sea Level (MSL)	-30	-30
Maximum Elevation, Feet (MSL)	1,150	4,050
Total Pumping Head, Feet	1,553	4,225
Total Hydro Head, Feet	0	2,350
Canal, Miles	12.0	0.0
Pipeline, Miles	30.3	81.2
Tunnel, Miles	41.4	10.6
Total Length, Miles	83.7	91.8
Pump Stations	2	5
Power Generating Facilities (PGF)	0	3
PCFs	1	1
Forebays/Storage Capacity	2 (40 acre feet [AF] each)	5 (40 AF each)
Afterbays/Storage Capacity	0	3 (40 AF each)
Electrical Transmission Lines, Miles	23.8	39.6
Electrical Substations	1	4
Water Treatment	Blending or WTP	Blending or WTP
Property Acquisition, Acres	1,100	1,650

2.2 Alignment Corridor 5A

Alignment Corridor 5A is primarily constructed in tunnels and is therefore known as the "Tunnel Alignment." This alignment is approximately 83.7 miles long comprised of approximately 12 miles of canal, 30.3 miles of pipeline, and 41.4 miles of tunnel. It includes the following reaches:

- Reach 1 – 12 miles of canal parallel to the Westside Canal
- Reach 2 – 15.3 miles of pipeline from the Westside Canal/Pump Station 1 to Pump Station 2
- Reach 3 – 14.5 miles of pipeline from Pump Station 2 to Bow Willow Portal

- Reach 4 – 34.3 miles of tunnel from Bow Willow Portal to El Capitan Portal
- Reach 5 – 7.1 miles of tunnel/0.5 miles of pipeline from El Capitan Portal to San Vicente Reservoir Portal/PCF

Alignment Corridor 5A also includes two pump stations, one PCF, and associated electrical transmission lines and substation. Two forebays provide operational storage and surge control for the pump stations.

2.3 Alignment Corridor 5C

Alignment Corridor 5C is primarily constructed as a pipeline and is therefore known as the "Pipeline Alignment." Corridor 5C is approximately 91.8 miles long comprised of approximately 81.2 miles of pipeline, and 10.6 miles of tunnel. It includes the following reaches:

- Reach 1 – 21.5 miles of pipeline from the AAC/Pump Station 1 to Pump Station 2
- Reach 2 – 3.5 miles of tunnel/4.6 miles of pipeline from Pump Station 2 to Pump Station 5. This reach includes four pump stations (Pump Stations 2, 3, 4, and 5).
- Reach 3 – 23.0 miles of pipeline from Pump Station 5 to PGF No. 1
- Reach 4 – 25.6 miles of pipeline from PGF No. 1 to PGF No. 2
- Reach 5 – 6.0 miles of pipeline from PGF No. 2 to El Capital Portal
- Reach 6 – 7.1 miles of tunnel/0.5 miles of pipeline from El Capitan Portal to San Vicente Reservoir Portal/PCF

This alignment also includes five pump stations, three PGFs, one PCF, and associated electrical transmission lines and substations. Five forebays provide operational storage and surge for the pump stations, and three afterbays provide operational storage for the PGFs.

2.4 Alignment Evaluation

As part of the alignment evaluation, an alignment analysis was performed to identify any portion of the alignment corridors that would present severe construction or operational challenges. Segments that were analyzed are discussed below. The alignment segments were also reviewed as part of the land use assessment discussed in Section 3.

Minor adjustment to these alignment segments of each alignment corridor could be made to optimize the alignment corridor during preliminary design. However, for the purposes of this report, only the changes at the AAC and the In-Ko-Pah Gorge area were made to the alignments for analyzing the alignment reevaluation, probable construction costs, and implementation schedule. No changes to the alignment of Corridor 5C in the Cleveland National Forest and Alpine Heights areas were made for the reasons stated below in Sections 2.4.3 and 2.4.4.

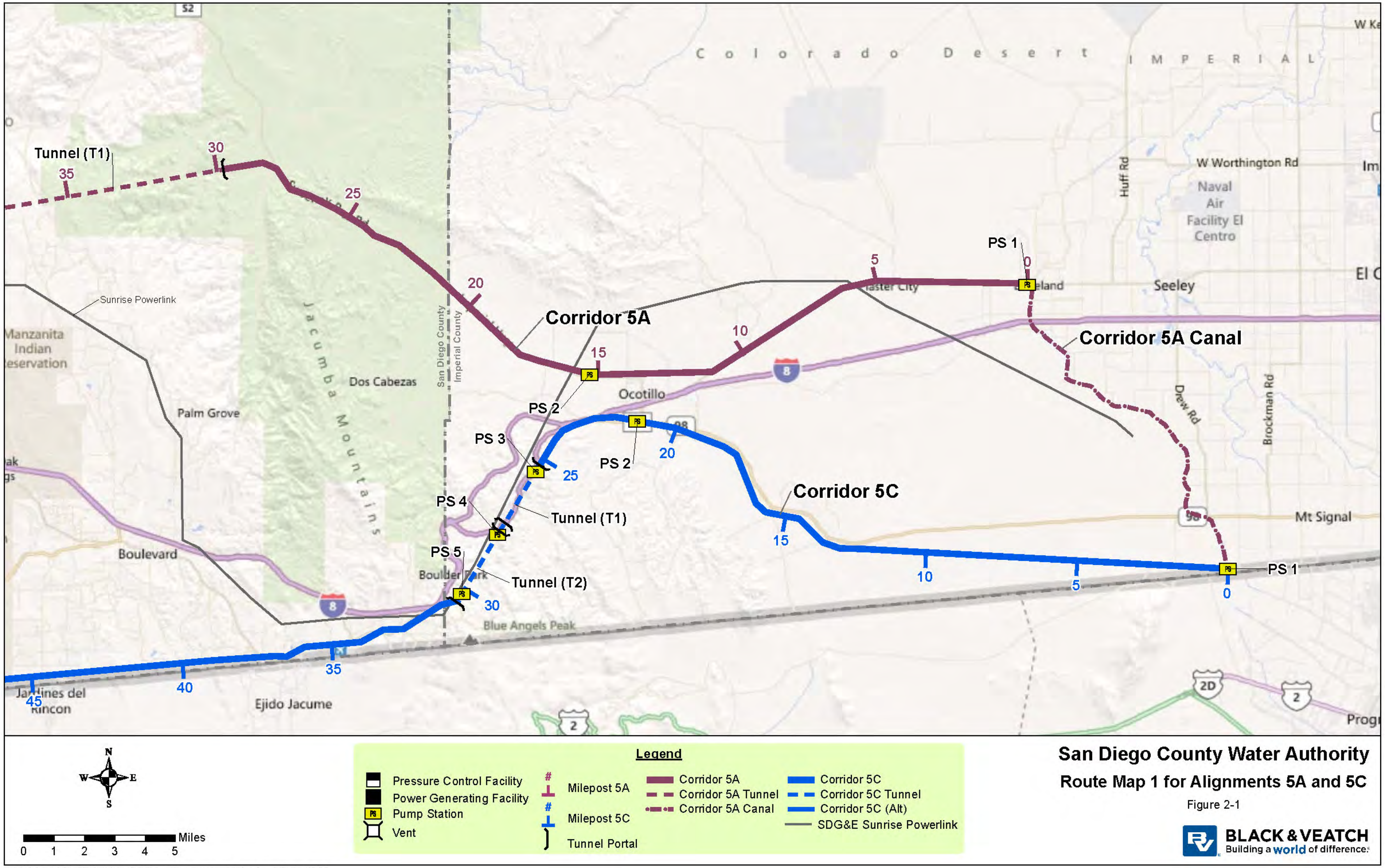
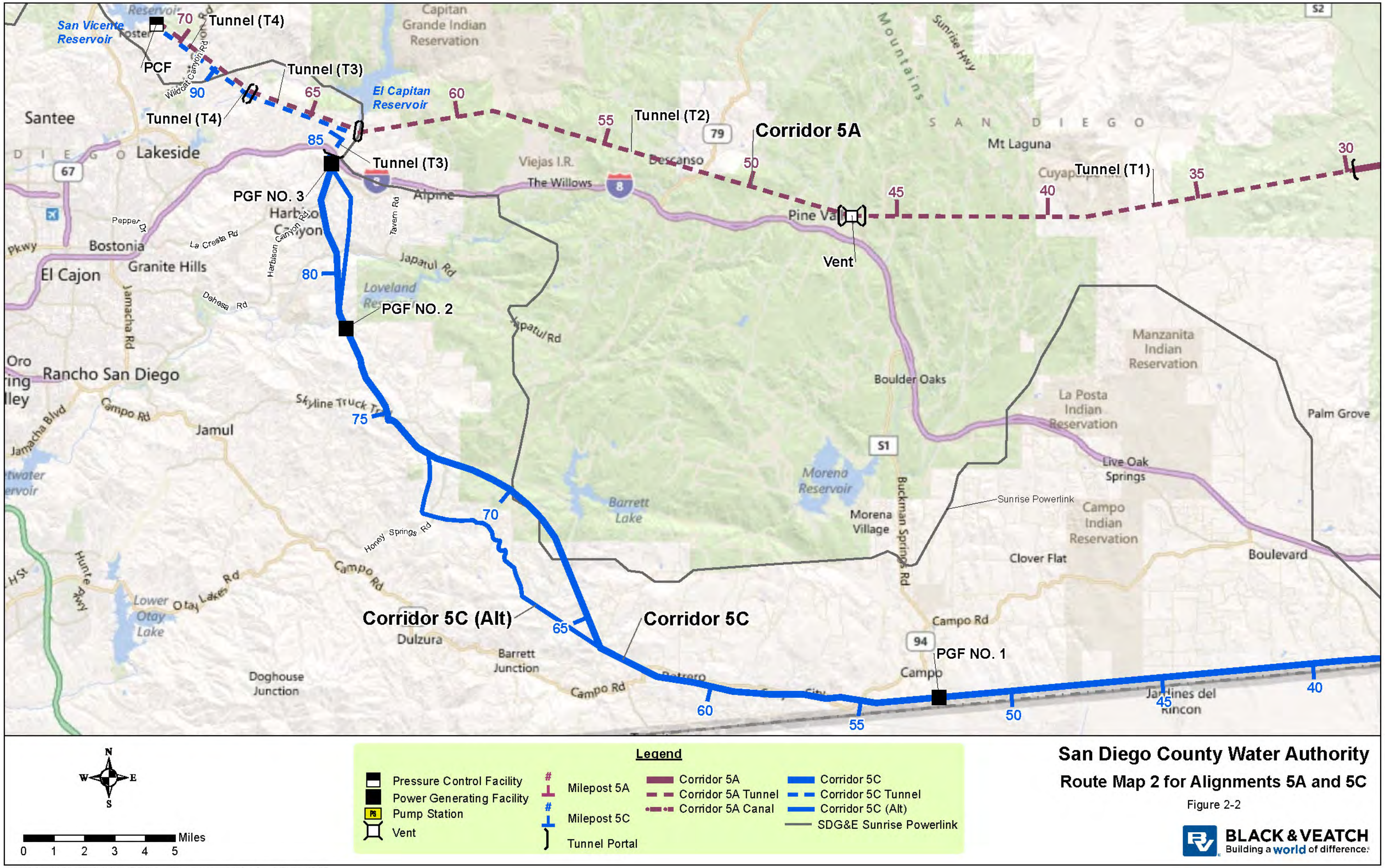


FIGURE 2-1
Route Map 1 for Alignments 5A and 5C



G:\Data\173072_SDCWA\ArcGIS\StreetMap.mxd A. Black July 10, 2012

FIGURE 2-2
Route Map 2 for Alignments 5A and 5C

The alignment lengths were verified using the latest U.S. Geologic Survey topographic maps, 2012 Quadrangle Mapping, 7.5-Minute Series (Quad Maps). The length of Alignment Corridor 5A was approximately 0.4 miles longer than indicated in prior studies. The length of Alignment Corridor 5C was approximately 1.7 miles shorter than indicated in prior studies.

A more detailed description of each alignment corridor is included in Section 4.6.

2.4.1 All American Canal

The AAC segment (Corridors 5A and 5C) was removed from both alignments based on the recent construction of the AAC Relining Project and available capacity in the existing AAC. This removed approximately 46 miles of canal from both Alignment Corridors 5A and 5C.

2.4.2 In-Ko-Pah Gorge Area (Corridor 5C)

This segment includes four pump stations (Pump Stations 2, 3, 4, and 5) and two tunnels (Tunnel T1 and T2). The segment proceeds adjacent to Highway 8 through Bolder Creek Canyon near Ocotilla to the Imperial/San Diego County border. During the site visit and document evaluation, it was determined to make minor modifications to the pump station locations and extend one of the tunnels to avoid extreme terrain that would present significant construction challenges.

2.4.3 Cleveland National Forest (Corridor 5C)

This 5-mile-long segment traverses through the Cleveland National Forest. The original alignment was selected due to topography. The hydraulic grade line and associated pipeline pressures and PGFs can be optimized by traversing this route. An alternate pipeline route was considered to avoid Cleveland National Forest and the associated agency coordination. The alternative route would follow Granite Creek to Bee Valley Road, then along Deerhorn Valley Road and Honey Springs Road. The alternative route was reviewed during the field visit (see Appendix A for photographs). However, the alternate pipeline route had several challenges including impacts to a rural residential development, increased pipeline length, and increased pipeline pressures or need to construct a portion in tunnel. For these reasons, it was determined to keep the original alignment.

2.4.4 Alpine Heights (Corridor 5C)

This 5-mile-long segment proceeds from near Loveland Reservoir and the Cleveland National Forest to Highway 8 through the community of Alpine Heights. The original alignment was selected due to topography. The hydraulic grade line and associated pipeline pressures and PGFs can be optimized by utilizing this route. The route also minimizes the difficulty of crossing the narrow Sweetwater River Canyon and Dehesa Road. An alternate pipeline route was considered to follow existing roadways in a more direct route through Alpine Heights. The alternative route would continue due north adjacent to the Cleveland National Forest, then follow Lilac Lane, Rockrest Road, South Grade Road, and Arnold Way to Highway 8. The alternative route was reviewed during the field visit (see Appendix A for photographs). However, the alternate pipeline route had several challenges including right of way width through rural residential development, grades of over 45 percent through Sweetwater River Canyon, and increased pipeline pressures or need to construct a portion in tunnel. For these reasons, it was determined to keep the original alignment.

3.0 Land Use Assessment

3.1 Overview

This section presents the land use assessment approach used for the evaluation of changes in land use along the proposed Corridor 5A and 5C.

Existing topographic maps, BLM data, and Thomas Bros. maps were analyzed between the AAC and San Vicente Reservoir to evaluate any land use changes since the original Colorado River Conveyance studies were conducted. A field visit was conducted on May 22, 2012, with Water Authority and project team staff to verify potential favorable and unfavorable conditions and any changes in the land use since the original Colorado River Conveyance evaluation.

The field visit helped to identify potential land use conflicts and the existing land condition along the proposed pipeline corridors. Various criteria were identified to evaluate whether there are any changes or fatal flaws for the pipeline corridors. Criteria included land use, geologic characterization, corridor engineering evaluations (including canals, pipelines, tunnels, storage reservoirs, pumping stations, PGFs, PCFs, electric transmission lines, and water treatment facilities), environmental assessments, and staging opportunities.

3.2 Description of Land Uses

There are various types of land uses within the vicinity of Alignment Corridors 5A and 5C. Critical land uses were evaluated including: BLM land designations, ABDSP, Cleveland National Forest, SDG&E Sunrise Powerlink right-of-way, Native American Reservations, areas requiring Caltrans coordination, railroads, commercial land use, and private land use. Figures 3-1 and 3-2 show current land use designations based on the research performed for this study.

3.2.1 BLM Land

The BLM is responsible for extensive land use planning to balance resource protection with proposed use for public lands. Through collaboration with participating agencies and stakeholders, BLM produces Resource Management Plans (RMP) that serve as a framework for approved land use. Alignment Corridors 5A and 5C traverse areas of Imperial County and San Diego County that are managed by the El Centro and Palm Springs/South Coast field offices within the California Desert District. The most recent RMP for each area was used as reference for this study.

BLM provides ACEC designation to critical areas. ACECs are defined as public lands where special management and direction is needed to protect human life from natural hazards and prevent irreparable damage to wildlife resources, natural systems, and important historic, cultural, and scenic values. ACEC designation indicates that BLM recognizes the land as a sensitive area and will implement management to protect and enhance the resource values.

As shown on Figures 3-1 and 3-2, the majority of Alignment Corridors 5A and 5C crosses BLM land, as well as areas designated as state parks or national forest. The BLM land use designations from the 1996 Water Transfer Study are still applicable, with the following key exceptions described in Tables 3-1 and 3-2.

TABLE 3-1
Alignment Corridor 5A BLM Land Use Changes since 1996 Water Transfer Study

Approximate Milepost (MP)	1996 Water Transfer Study Description	Current Description/Impact
MP 21.50 to MP 30	Primarily traveled along border between state park and BLM wilderness, as well as crossed BLM wilderness.	State park boundary has expanded, thus the alignment traverses more state park and no longer crosses BLM wilderness. Additional coordination with the State park would be required.
MP 38 to MP 42	Not designated as reservation land.	Alignment crosses underneath area designated as Cuyapaipe Indian Reservation land. This could present additional permitting challenges.
MP 68	Area not designated as BLM land.	Area is designated as BLM land. Additional coordination with BLM would be required.

TABLE 3-2
Alignment Corridor 5C BLM Land Use Changes since 1996 Water Transfer Study

Approximate Milepost	1996 Water Transfer Study Description	Current Description/Impact
MP 0 to MP 20	Land designated as BLM wilderness.	Land designated as Yuha Basin ACEC. This will likely present additional permitting challenges.
MP 46.5 to MP 50.5	Land designated as Campo Indian Reservation.	Campo Indian Reservation limits have been revised resulting in the alignment traversing less reservation land. This lessens permitting requirements for this area.
MP 89.5	Land not designated as BLM land.	Area designated as BLM land. Additional coordination with BLM would be required.

The BLM has also identified land in Ocotillo that will be utilized for a wind farm to supply utility customers with electricity. Construction has started on an array of 112 wind turbines, with an anticipated completion date of mid-2013. The new wind farm will tie into the Sunrise Powerlink electrical transmission line. Alignment Corridor 5A will cross through the proposed wind farm from approximately MP 15 to MP 17.5. Alignment Corridor 5C will cross through the proposed wind farm near MP 22. Coordination with the wind project developer(s) will be required to avoid conflicts.

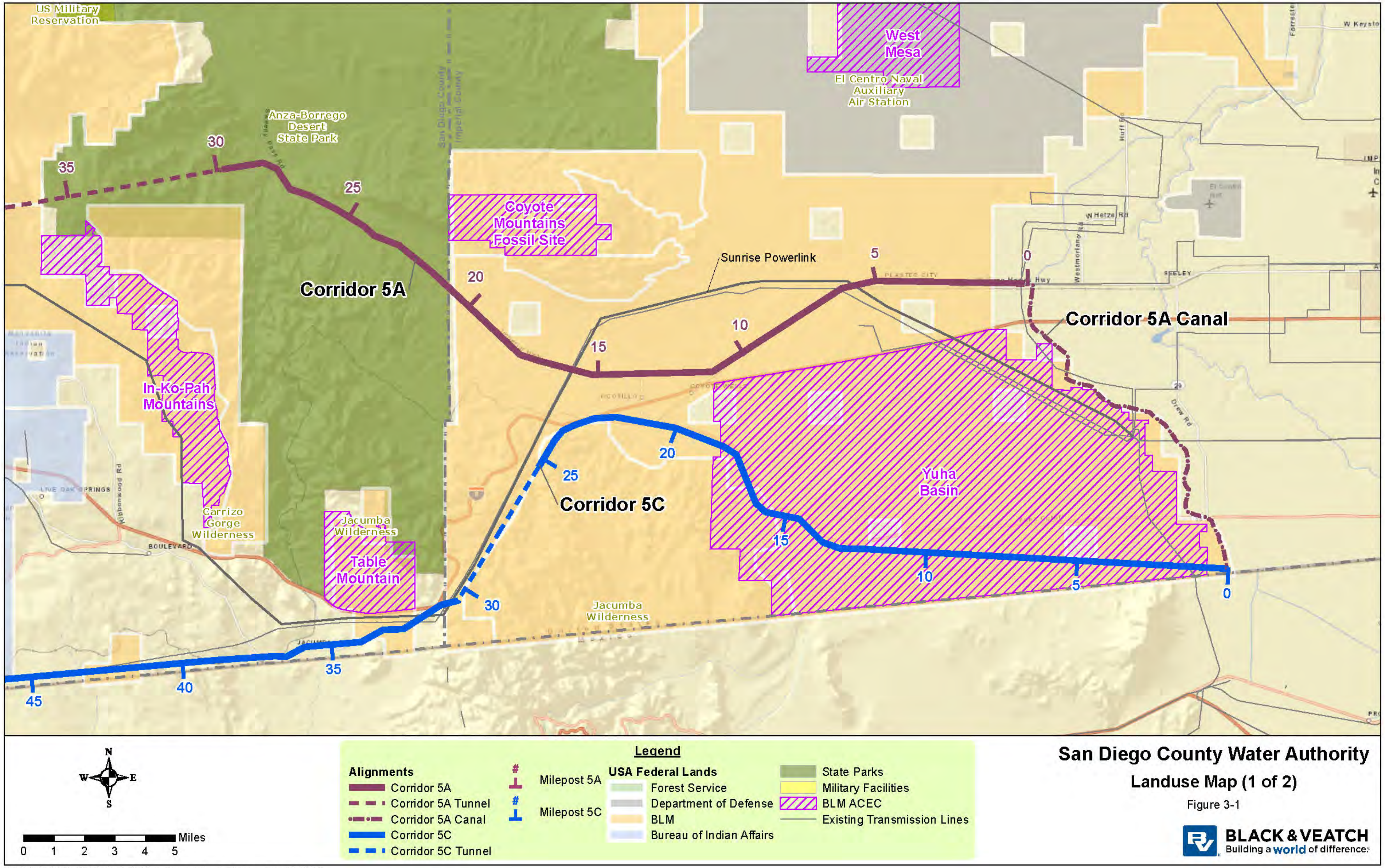


FIGURE 3-1
Landuse Map (1 of 2)

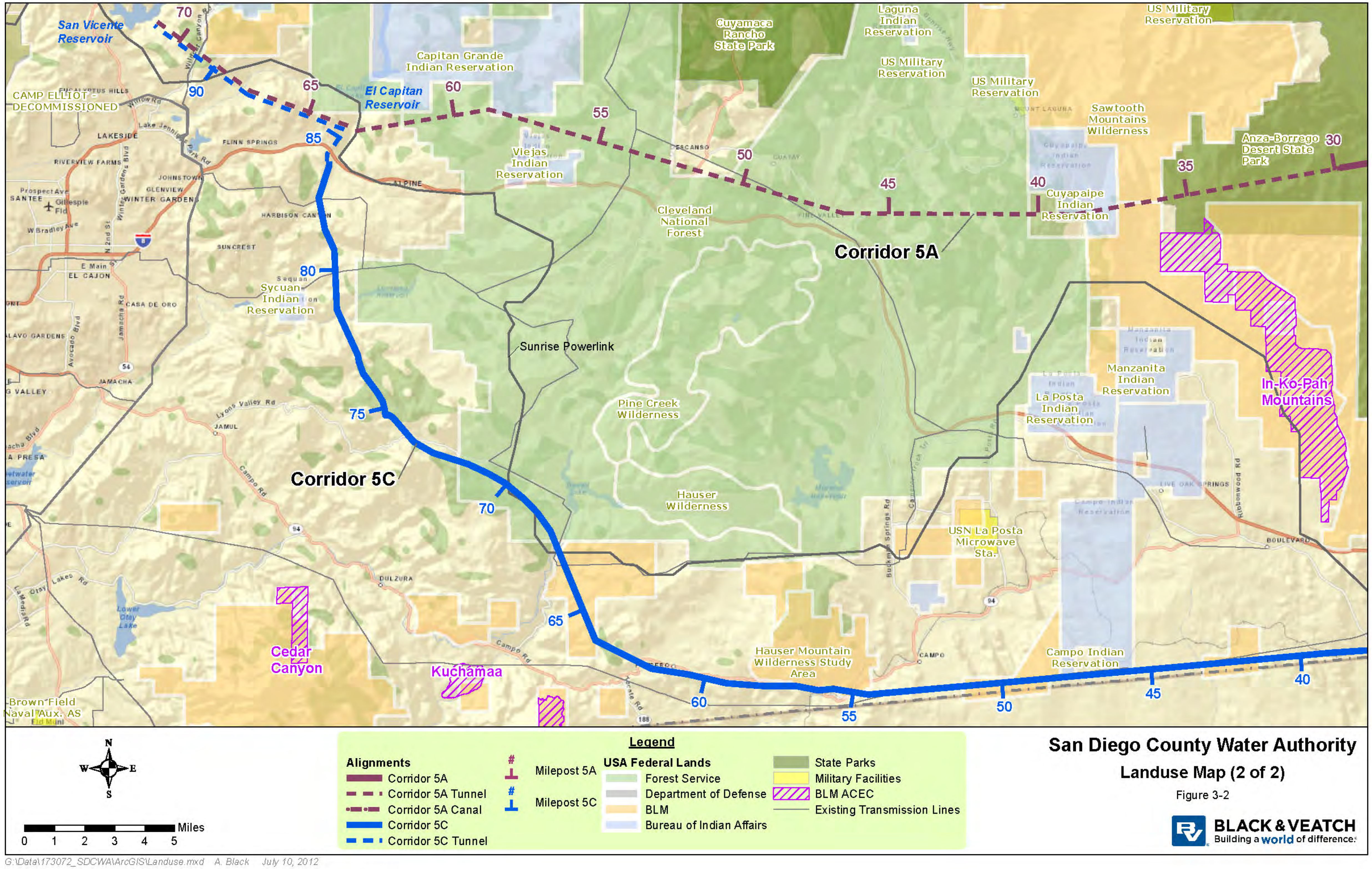


FIGURE 3-2
Landuse Map (2 of 2)

Other land use designations and potential concerns are discussed in the 1996 Water Transfer Study. The land use changes summarized in the descriptions and tables above are not anticipated to have a major impact on the project, with the exception of the ACEC designation for the beginning part of Alignment Corridor 5C.

The Yuha Basin is home to the threatened species of flat tail horned lizard, as well as the rare crucifixion thorn. In addition to protecting these species, several other unique attractions contribute to the ACEC designation, including the Juan Bautista de Anza National Historic Trail, geoglyphs created by Native Americans, oyster shell beds, and the Yuha well. Although currently used for recreation, the Yuha Basin ACEC is a BLM limited use area and may pose challenges for open trench pipeline construction.

3.2.2 Anza-Borrego Desert State Park

The ABDSP was designated in 1974 as a national Natural Landmark and is recognized as an internationally significant conservation area. The ABDSP is home to a wide variety of species and may present unique challenges for pipeline construction. Alignment Corridor 5A traverses a portion of the ABDSP from approximately MP 20 to MP 38. Although classified entirely as a state park, a large portion of the park is designated by the subunit classification of State Wilderness. State Wilderness has a higher level of preservation measures in place to protect the natural habitat. The alignment crosses both state park and state wilderness. This stretch of the alignment is also where the open trench pipeline construction transitions to a tunnel, thus creating the need for the tunnel portal.

3.2.3 Cleveland National Forest

The Cleveland National Forest is the southernmost national forest in California and is administered by the United States Forest Service (USFS). Alignment Corridor 5A proposes to tunnel beneath the forest from approximately MP 40.5 to MP 62. Alignment Corridor 5C crosses through the forest from approximately MP 67.5 to MP 72 via open cut trench. As indicated in the 2002 Feasibility Study, it is anticipated that National Environmental Policy Act (NEPA) documentation, such as an Environmental Assessment (EA) or Environmental Impact Statement (EIS), would be required as well as special use permits for drilling, construction, and tunneling

3.2.4 SDG&E Sunrise Powerlink

The Sunrise Powerlink is a 150-mile transmission line project. SDG&E recently completed construction of the Sunrise Powerlink Project from the Imperial Valley Substation near El Centro to the Sycamore Canyon Substation just south of Poway. This project, which was put into service in mid-June 2012, provides SDG&E another electric transmission corridor into San Diego. The Sunrise Powerlink Project is in proximity in several segments of Alignment Corridor 5C and the tunnel portal near El Capitan Reservoir for Alignment Corridors 5A and 5C. New utility power line crossings, right of way acquisition, and parallel right of way will need to be considered that will affect costs for the CRCF. However, no major shifting of the pipeline alignment for Alignment Corridor 5A or 5C is expected due to the Sunrise Powerlink Project. The Sunrise Powerlink is also near one pump station along Alignment Corridor 5A (Pump Station 2) and all five of the proposed pump stations along Alignment Corridor 5C (Pump Stations 1, 2, 3, 4, and 5). This may allow use of the new electric transmission system to provide power to the proposed pump stations in lieu of construction of a new electric transmission system that was considered in the 1996 Water Transfer Study that would reduce costs for the CRCF. Power generation facilities along Alignment Corridor 5C (PGF 1, 2, and 3) could connect into the Sunrise Powerlink Project closer to the alignment reducing the transmission line length and costs for the CRCF.

3.2.5 Native American Reservations

Southern San Diego County contains various Native American reservations that represent cultural and historical significance. Tables 3-1 and 3-2 summarize any new reservation conflicts that have arisen since the 1996 Water Transfer Study. The alignment corridors were originally selected to avoid crossing reservation land; however, some reservation boundaries have changed.

3.2.6 Caltrans

Caltrans is the governing agency for impacts related to transportation and has required criteria for crossing of expressways, freeways, and conventional highways. While criteria vary based on highway classification, main applicable criteria include the following:

- With the exception of special cases, new utilities will not be permitted to be installed longitudinally within highway right-of-way.
- Highway crossings should be normal (90 degrees) to the highway alignment where practical, although skews up to 30 degrees from normal may be allowed.
- Underground facilities should be encased between highway right-of-way lines.
- The utility should be located so that it can be serviced, maintained, and operated from outside the highway right-of-way.

An encroachment permit will need to be obtained from Caltrans for any proposed highway crossings. Table 3-3 summarizes the proposed highway crossings for the two corridor alignments. Each crossing will require a separate permit.

TABLE 3-3
Highway Crossing Summary

Highway/ State Route	Number of Crossings for Alignment Corridor 5A	Approximate Milepost for Alignment Corridor 5A	Number of Crossings for Alignment Corridor 5C	Approximate Milepost for Alignment Corridor 5C
8	0	--	3	23.5, 28, and 83
S2	1	28.5	0	--
80	0	--	2	35 and 36.5
79	1	52.5	0	--
94	0	--	3	54, 55, and 61

3.2.7 Railroads

There are specific requirements for submittal of proposed pipeline crossings of railroads. Design of pipeline crossings of railroads is generally determined by the utility agency with review by the railroad, but typically require jack and bore crossings to minimize service interruption and compliance with standards of practice. Alignment 5C has three railroad crossings near MP 36, MP 37.5, and MP 55. All crossings are along the Desert Line of the San Diego and Arizona Eastern Railway, operated by Carrizo Gorge Railway. The section of railroad is utilized for freight operations.

3.2.8 Commercial Land

No new specific commercial land impacts have been identified since the 1996 Water Transfer Study. Renewable energy projects have the potential to be considered commercial businesses, but will primarily be located on BLM and private land.

3.2.9 Private Land

A 1998 Thomas Bros. map was compared to a 2008 Thomas Bros. map to identify any new roads that have been constructed since the 1996 Water Transfer Study. The new or revised roads were verified by reviewing aerial maps and confirming during the field visit. Table 3-4 summarizes the changes and the potential impact on the alignment corridors.

TABLE 3-4
Updated Road Conditions

Approximate Alignment Corridor 5A MP	Approximate Alignment Corridor 5C MP	Current Road Conditions	Potential Impact on Alignment Corridor
N/A	MP 80 to 81	New paved roads off of Alpine Trail Road have been constructed with housing and areas cleared for potential future roads and housing. New roads include Michelle Rene Way, Kevin Court, Sheri Place, and Alicia Way.	New road crossings for open cut trench pipeline alignments. The addition of homes in this area could also present additional challenges with open cut trench.
MP 66	MP 88	A new road, Espinoza Road, has been constructed with housing.	New road crossing along tunnel portion of alignment. The addition of homes in this area could present additional tunnel easement challenges.
MP 67	MP 89	Quail Canyon Road was extended and connects to Broad Oaks Road. Housing is present in this area.	New road crossing along tunnel portion of alignment. The addition of homes in this area could present additional tunnel easement challenges.

Areas that are suitable for green energy facilities could potentially be another source of private land use. As renewable energy becomes a more viable energy source, wind and solar projects are becoming more prevalent in Imperial County. One such example noted during the field visit is near the junction of the AAC and Westside Canal, or MP 0 for Alignment Corridor 5C.

4.0 Alignment Corridors Reevaluation

4.1 Overview

This section presents the reevaluation of the Alignment Corridors 5A and 5C considering geological characteristics, energy management strategy, system hydraulics, water quality and treatment, corridor engineering evaluations, electric power market analysis, natural gas market analysis, and environmental assessments.

4.2 Geological Characteristics

In 2001, the Water Authority conducted feasibility-level geologic and geotechnical investigations for the alignment corridors. For purposes of this evaluation, it was assumed that the geological characteristics of the corridors have remained largely unchanged. General characteristics and geologic and geotechnical conditions are summarized below.

4.2.1 General Characteristics

The pipeline reaches for both corridors cross the Elsinore fault and within the Salton Trough will encounter soft alluvial and lake bed sediments that are easily excavated and are generally above the groundwater table. Within the Peninsular Ranges, the 5C pipeline will encounter both weathered and decomposed rock, and blasting will be required for areas of unweathered rock. Steep topography encountered within the 5C corridor in the Peninsular Ranges will require tunnel construction instead of open cut. Due to residential development along Reach 6 (MP 82.5 and MP 83), existing grades may have changed, and the material to be excavated could change compared to original evaluations. The 5A tunnels will utilize tunnel boring machines (TBM) to construct the project in a reasonable time frame through a wide range of hard, granitic, and metasedimentary rocks below the groundwater table. The tunnels will cross several fracture zones, but no active faults. High volume and high pressure groundwater inflows may occur, and aggressive groundwater control measures will be required. The 34-mile-long tunnel will be the most challenging aspect of Corridor 5A and will be constructed from two separate headings, two separate approximately 17-mile-long drives at depths up to 4,900 ft. During design, additional shaft locations can be evaluated, which may speed construction and save money. Recently, the MWD Arrowhead Tunnels, which are part of the Inland Feeder Project, were constructed under similar conditions as the proposed tunnels.

4.2.2 Geologic Issues

Key geologic issues that impact the cost and construction schedule of this long tunnel include:

- Potentially high rock temperatures due to the earth's natural geothermal gradient
- High in situ stresses requiring additional ground support
- Several significant lineaments (fault zones) which must be crossed, requiring probe drilling, pre-excavation grouting, and support

- Potentially high pressure/high volume groundwater inflows, requiring pre-excavation grouting to reduce flows for mitigating impacts to the groundwater resources and for construction purposes

Groundwater within the project vicinity serves commercial and residential purposes as well as the U.S. Forest Service, BLM, and ABDSP lands. The deep 34-mile-long 5A tunnel can be constructed without adversely affecting the groundwater resources. A water-tight lining will be required during and after construction for the shorter, shallow western 5A tunnel sections to prevent impacts to the groundwater table. To ensure groundwater control, aggressive measures will be required during tunnel construction including maintaining probe holes in advance of the TBM, performing formation grouting, and installing a water-tight lining system.

4.2.3 Geotechnical Considerations

Key geotechnical considerations include:

- The amount of blasting required in hard rock areas to excavate the trench to specific depths
- The need to perform dewatering near the Westside Main Canal (WMC) and across major drainages
- Special fault crossing designs for crossing the active Elsinore fault zone
- The degree and length of ground improvement or special foundation design in areas subject to liquefaction or scour
- The difficult construction and access in the steep slope areas between Potrero Peak and Alpine

4.2.4 Geologic Formations

General descriptions of the various geologic units are listed below:

Alluvium Formations

Qal – Alluvium (silt, sand, and gravel)

Qc – Colluvium, Debris Flow (sand, silt, and rock fragments) and Canebrake Formation (pebble to bolder conglomerate; marginal equivalent to Palm Springs Formation)

Qp – Palm Springs Formation – fine to coarse-grained arkosic arenite (sandstone) alternating with discontinuous lensing mud and siltstones of various colors; early Plesitocene

Qm – Mesa Conglomerate – massive or torrentially bedded coarse conglomerate near mountain front; poorly bedded sandstone and conglomerate alluvial outwash deposits

Ql – Lake beds (sediments of ancient Lake Cahuilla)

Qfg – Very young alluvial fan deposits

Igneous Rock Formations

Tal – Alverson Andesite (basaltic and andesitic flows, breccia, and intercalated volcaniclastic rocks including interbedded tuff, breccias, and nonmarine sediments; Miocene)

Ka – Tonalite of Alpine (biltite-pyroxene-hornblende tonalite)

Klp – La Posta Pluton (tonalite)

Klb – Tonalite of Las Bancas (pyroxene-blotite tonalite)

Kc – Cuyamaca Gabbro (Peridotite, olivine gabbro, horneblende gabbro)

Kcm – Granite of Corte Madera (hornblende-biotite leucogranite and leucogranodiorite)

Kgm – Granite Mountain (tonolite)

Kjv – Tonalite of Japatul Valley (biotite-hornblende tonalite and hornblende-biotite granodiorite

Kcp – Granite of Chiquito Peak (hornblende-biltite granite and granodiorite

Metamorphic Rock Formations

TRm (or Jm) – Metasedimentary rocks (mica-quartz-feldspar semischist; micaceous feldspathic metaquartzite; calc-silicicate rock; lesser mica-quartz schist, amphibolites and metaconglomerate) and marble (metamorphosed limestone and dolomite)

4.3 Energy Management Strategy

This section presents the results of tradeoff analyses comparing the capital and annual costs associated with alternate energy management strategies for the transfer of 280,200 AF/y for Corridors 5A and 5C. These strategies were reevaluated due to the change in the price of energy and capital costs of infrastructure based on the transfer of 280,200 AF/y. The analysis included the development of capital costs associated with each alignment corridor as well as the annual pumping costs based on alternate energy management strategies. Purchased power rates are typically higher during on-peak electric use periods compared to off-peak periods; therefore, alternate operating scenarios were evaluated to coincide with periods of on-peak and off-peak electrical usage.

Four alternate operating scenarios were carried forward to this evaluation:

- Uniform Annual Pumping – Pump at a constant rate throughout the year
- Avoid On-peak Pumping – Pump only during semi-peak and off-peak use periods during both summer and winter
- Off-Peak and Summer Semi-Peak Pumping – Pump during off-peak periods of summer and winter seasons, and semi-peak periods of summer only
- Off-Peak Only – Pump only during off-peak use periods

Pumping at a uniform rate throughout the year would result in a transfer system with minimum hydraulic capacity and, therefore, minimum capital costs. However, since pumping would occur during on-peak electrical usage periods as well as off-peak periods, pumping at a uniform rate would also result in maximum annual pumping costs. Alternatively, pumping only during off-peak energy usage periods would minimize annual pumping costs at the expense of higher capital costs associated with the greater hydraulic capacity of the transfer system.

4.3.1 Time-of-Use Periods and Energy Rates

Each alternative management strategy utilizes specific time periods and associated rates for energy usage. The time periods and energy rates vary by regional utility. The proposed facilities are located within the IID and SDG&E service areas. The pumping facilities are located near the IID/SDG&E service area boundary (at the Imperial/San Diego County boundary). The pumping facilities are within IID's service area; however, SDG&E owns and operates the Imperial Valley Substation and transmission lines within Imperial County near the pumping facilities. Due to the proximity of SDG&E's facilities and verification with IID, SDG&E was assumed to be the electric service provider. The generating facilities are located within SDG&E's service area and the Water Authority would be considered and Energy Service Provider to SDG&E. For purposes of this evaluation, the current SDG&E time-of-use rate schedule for large customers (Schedule AL-TOU Primary) was used to define on-peak, semi-peak, and off peak periods during summer and winter seasons and associated energy rates. Summer is defined as the 5-month period from May through September. Winter is the 7-month period from October through April. Daily time periods are defined as follows:

- On-Peak – 11:00 a.m. to 6:00 p.m. summer weekdays and 5:00 p.m. to 8:00 p.m. winter weekdays except holidays
- Semi-peak – 6:00 a.m. to 11:00 a.m. and 6:00 p.m. to 10:00 p.m. summer weekdays and 6:00 a.m. to 5:00 p.m. and 8:00 p.m. to 10:00 p.m. winter weekdays, except holidays
- Off-Peak – All other hours

Eight holidays are observed throughout the year. The breakdown of hours by use period is shown on Table 4-1.

TABLE 4-1
SDG&E Time-of-Use Periods

Use Period	Summer	Winter	Total
On-Peak Hours	742	441	1,183
Semi-Peak Hours	954	1,911	2,865
Off-Peak Hours	1,952	2,760	4,712
Totals	3,648	5,112	8,760

Demand and energy rates associated with each of the above time-of-use periods are indicated in Table 4-2. For energy generation, only the community portion of the Energy Charge was considered for cost recovery (see Appendix D).

TABLE 4-2
SDG&E Rate Schedule (July 2012 Rates)

Item	Summer	Winter
Demand Charges		
Basic Service ($/Mth)	233	233
Non-Coincident ($/kW each Mth)	13.26	13.26
On-Peak ($/kW each Mth)	7.95	4.81
Energy Charges ($/kWh)		
On-Peak	0.10038	0.09486
Semi-Peak	0.08218	0.08711
Off-Peak	0.06228	0.6743

The design hydraulic capacity of the transfer system was determined for each strategy based on an annual transfer volume of 280,200 AF and the number of available pumping hours associated with each strategy. Available pumping hours were considered equal to the total pumping hours associated with each strategy divided by 1.10, representing an availability factor of approximately 0.91. This approach results in a design hydraulic capacity that is 10 percent greater than the required average hydraulic capacity for each management strategy. The characteristics of the alternate energy management strategies are provided in Table 4-3.

TABLE 4-3
Alternate Energy Management Strategies

Strategy	Available Summer Hours	Available Winter Hours	Total Available Hours	Design Hydraulic Capacity (cfs)
Uniform Annual	3,320	4,652	7,972	422
Avoid On-Peak	2,644	4,251	6,895	487
Off-Peak and Summer Semi-Peak	2,644	2,512	5,156	652
Off-Peak Only	1,776	2,512	4,288	784

4.3.2 Comparative Capital Costs

For each corridor, comparative capital costs were estimated for the major system components whose capital costs would be significantly impacted by the alternate energy management strategies. The use of comparative costs for each corridor provided a means to evaluate differential capital costs associated with each energy management strategy considered. Capital costs were based on 2012 dollars escalated to the mid-point of construction.

For purposes of the tradeoff analyses, unit costs were estimated based on escalated costs and recent cost estimates for similar projects. All comparative costs included engineering and administration costs. Comparative capital costs were estimated for the following system components:

- Canals
- Pipelines
- Tunnels
- Pumping plants
- PGFs/PCFs
- Electrical transmission lines

The Water Authority has raised the San Vicente Dam to provide an additional 152,000 AF of usable storage. Therefore, the capital costs associated with storage reservoirs were not included in the evaluation. Corridors 5A and 5C both require operational storage that will be provided at the enlarged San Vicente Reservoir.

The basis for development of comparative capital costs for each component utilized the "Avoid On-Peak" energy management strategy as the base cost and factored costs for other energy management strategies based on comparative flow rates. Unit costs were developed from the cost estimates described in Section 6.

Canals. The design hydraulic capacity of canals was considered equal to the system hydraulic capacity for each energy management strategy to eliminate the need for seasonal storage facilities located with the IID system. A unit cost of $1,091,000 per mile was used for canals. Costs for canal structures, including turnouts, were included in these unit costs.

Pipelines. An 8-foot-diameter pipeline was used for the pumping rate of 487 cfs based on an allowable maximum velocity of 10 feet per second (fps). Pipeline diameters for the other hydraulic capacities considered were selected using the maximum 10 fps velocity criterion. Table 4-4 provides the pipeline diameters used in the tradeoff analyses.

TABLE 4-4
Pipeline Diameters

Design Hydraulic Capacity (cfs)	Pipeline Diameter (ft)
422	7.5
487	8
652	9
784	9.5

Tunnels. Tunnels were also sized based on construction methods with a 10 fps maximum allowable velocity. Tunnels were sized with a minimum finished diameter of 10 feet. For Alignment Corridor 5A, some tunnel segments with minimal lining requirement have a finished diameter of 14 feet. Table 4-5 provides the tunnel diameters used in the tradeoff analyses.

TABLE 4-5
Tunnel Diameters

Design Hydraulic Capacity (cfs)	Finished Tunnel Diameter (ft)
422	10-14
487	10-14
652	10-14
784	10-14

Pumping Plants. Power requirements for pumping plants were determined based on the total dynamic head for each corridor and the design hydraulic capacity associated with each energy management strategy.

Power Generating/Pressure Control Facilities. Installed generating capacity was determined based on the total available net head for each corridor and the design hydraulic capacity associated with each energy management strategy.

Electrical Transmission Lines. SDG&E owns and operates the Imperial Valley/Miguel 500 kilovolt (kV) transmission line and recently completed construction of the Sunrise Powerlink 500 kV transmission line near the project vicinity. As part of the 1996 Water Transfer Study it was assumed sufficient capacity did not exist on the Imperial Valley/Miguel transmission line and a new dedicated transmission line was required for the project pumping stations. Based on the construction of the new Sunrise Powerlink transmission line and the ability to receive power through the line, a new dedicated transmission line from the Imperial Valley may not be required. A new substation adjacent to one of the proposed project pump stations would still be required to step down the voltage to 230 kV and a shorter 230 kV transmission line to transmit power to each pump station. Due to the unknowns associated with receiving power through the Sunrise Powerlink, it was assumed for purposes of the energy management strategy that new dedicated 230 kV transmission lines and a substation supplying power to the pumping stations would be required. Depending on the nature of the agreement with SDG&E for power delivery, the capital costs of electrical transmission lines and substations may be paid for by the electrical entity with cost recovery through annual demand and energy costs. However, for the purposes of this study, it was assumed the capital costs would be included in the CRCF costs. The transmission lines carrying power away from the PGFs were assumed to have a voltage of 69 kV.

4.3.3 Comparative Annual Costs

Comparative annual costs for pumping energy and annual cost savings resulting from installation of energy recovery (hydroelectric) facilities were estimated for each corridor and energy management strategy.

Annual Pumping Costs. Annual pumping costs, consisting of demand and energy costs, were determined based on the pumping periods associated with each energy management strategy and the SDG&E time-of-use rate schedule. Annual costs based on a total dynamic head of 800 feet and annual transfer volume of 280,200 AF are summarized in Table 4-6 for each alignment corridor.

The annual pumping costs were then evaluated for each energy management strategy with the results presented in Appendix D.

TABLE 4-6
Annual Pumping Costs (Avoid On-Peak Strategy)

Item	Per Pump Station	Alignment Corridor 5A "Tunnel"	Alignment Corridor 5C "Pipeline"
Number of Pump Stations		2	5
Demand Costs			
Basic Service	$2,800	$5,600	$14,000
Non-Coincident	$6,561,000	$13,122,000	$32,805,000
On-Peak	$0	$0	$0
Energy Costs			
On-Peak	$0	$0	$0
Semi-Peak	$9,187,000	$18,374,000	$45,935,000
Off-Peak	$11,544,000	$23,088,000	$57,720,000
Total Annual Energy Cost	$27,295,000	$54,590,000	$136,474,000

Overall costs per kilowatt hour ($/kWh), termed "busbar costs," for each energy management strategy were determined by dividing the total annual pumping cost by the annual pumping energy requirement. A large differential cost is the key energy cost parameter in evaluating different energy management strategies. A large differential favors low energy cost options; while a low differential favors low capital cost options.

Annual Energy Recover Savings. For purposes of the tradeoff analyses, recovered energy was considered to offset a portion of the transfer system pumping power requirements. Annual costs recovered were determined based on the operating (pumping) periods associated with each energy management strategy and the SDG&E rate schedule. Since recovered energy was considered to be used solely within the transfer system, no capacity benefit would be realized. Annual recovered costs based on a net head of 800 feet and annual transfer volume of 280,200 AF are summarized in Table 4-7 for each alignment corridor.

TABLE 4-7
Annual Energy Recovery Savings (Avoid On-Peak Strategy)

Item	Per PGF	Alignment Corridor 5A "Tunnel"	Alignment Corridor 5C "Pipeline"
Number of PGFs		0	3
Energy Recovery			
On-Peak	$0	$0	$0
Semi-Peak	$4,667,000	$0	$14,001,000
Off-Peak	$5,606,000	$0	$16,818,000
Total Annual Energy Savings	$10,273,000	$0	$30,819,000

The annual energy savings were then evaluated for each energy management strategy with the results presented in Appendix D.

4.3.4 Total Comparative Costs

Total comparative costs for the four energy management strategies for each corridor are summarized in Table 4-8 (see also Appendix D). Total comparative capital costs for each energy management strategy equals the sum of comparative capital costs estimated for each major system component. Total comparative annual energy costs equal the sum of the annual pumping demand and energy less the energy recovery cost reduction. All estimated costs are in 2012 dollars.

TABLE 4-8
Energy Management Strategy Summary

	Energy Management Strategy			
Item	**Uniform Annual**	**Avoid On-Peak**	**Off-Peak and Summer Semi-Peak**	**Off-Peak Only**
Design Flow (cfs)	422	487	652	784
Alignment Corridor 5A				
Total Capital Cost ($2012)	$1,648,321,000	$1,680,581,000	$1,769,242,000	$1,817,738,000
Present Worth (15-year Cash Flow)	$1,543,001,000	$1,573,200,000	$1,656,196,000	$1,701,593,000
Present Worth of Annual Costs	$374,641,000	$340,757,000	$351,426,000	$363,493,000
Comparative Project Costs	$1,917,642,000	$1,913,957,000	$2,007,622,000	$2,065,086,000
Differential Costs	+0.2%	Low Cost	+4.7%	+7.3%
Alignment Corridor 5C				
Total Capital Cost ($2012)	$1,839,553,000	$1,956,243,000	$2,277,488,000	$2,451,814,000
Present Worth (15-year Cash Flow)	$1,722,015,000	$1,831,248,000	$2,131,968,000	$2,295,155,000
Present Worth of Annual Costs	$734,156,000	$659,506,000	$621,248,000	$599,391,000
Comparative Project Costs	$2,456,171,000	$2,490,754,000	$2,753,216,000	$2,894,546,000
Differential Costs	Low Cost%	+1.4%	+10.8%	+15.1%

The present worth of total comparative capital and annual energy costs was determined using a cash flow analysis based on an escalation rate of 4 percent and discount rate of 5 percent.

Project cash flow was determined based on a 15-year design/permit/construction period (2012 through 2027), followed by a 30-year period of operation (2028 through 2057). The total comparative capital costs were escalated to the midpoint of construction (2023) and then discounted back to June 2012 using the economic parameters described above. Total comparative annual costs were escalated from 2012 through the period 2028-2057 and then discounted back to June 2012. The sum of the present worth of capital and annual costs determined for each corridor equals the present worth of total comparative project costs for each management strategy.

4.3.5 Selected Energy Management Strategy

As shown in the 1996 Water Transfer Study and confirmed through this analysis, the present worth of comparative capital costs for each energy management strategy was found to increase with an increase in system hydraulic capacity. For each corridor, minimum comparative capital cost resulted from the “Uniform Annual” strategy. However, for each corridor, maximum comparative annual energy costs resulted from the “Uniform Annual” strategy. Overall, the present worth of total comparative project costs was found to vary by less than 15 percent for the various energy management strategies considered for each alignment corridor.

The variation in total comparative project costs resulted in part from comparative annual energy costs based on SDG&E time-of-use rate schedules. Busbar costs for pumping energy ranged from an annual average value of approximately 10 cents/kWh to 11 cents/kWh.

Because total comparative project costs do not vary significantly with the alternate management strategies considered for either alignment corridor, the range of costs for transferred water will not be particularly sensitive to selection of one energy management strategy over another. However, a variation of 5 percent is equivalent to approximately $100 million. It is therefore confirmed to recommend that the “Avoid On-Peak” strategy be selected for use in the feasibility-level evaluations because this strategy results in facilities with the lowest overall cost considering capital and annual energy costs.

4.4 System Hydraulics

Corridors 5A and 5C will convey 280,200 AF of water from the terminus of the AAC to the San Vicente Reservoir. The system hydraulics has remained largely unchanged from the 1996 Water Transfer Study, but has been carried forward to this evaluation. Due to the proposed increase in water surface elevation at the San Vicente Reservoir as part of the Water Authority’s Emergency Storage Project, the downstream water surface elevation will reduce the amount of excess energy to be dissipated at the San Vicente Reservoir. A downstream pressure reducing facility will still be required at the end of each corridor to dissipate the excess head. Figure 4-1 shows a profile of Alignment Corridors 5A and 5C.

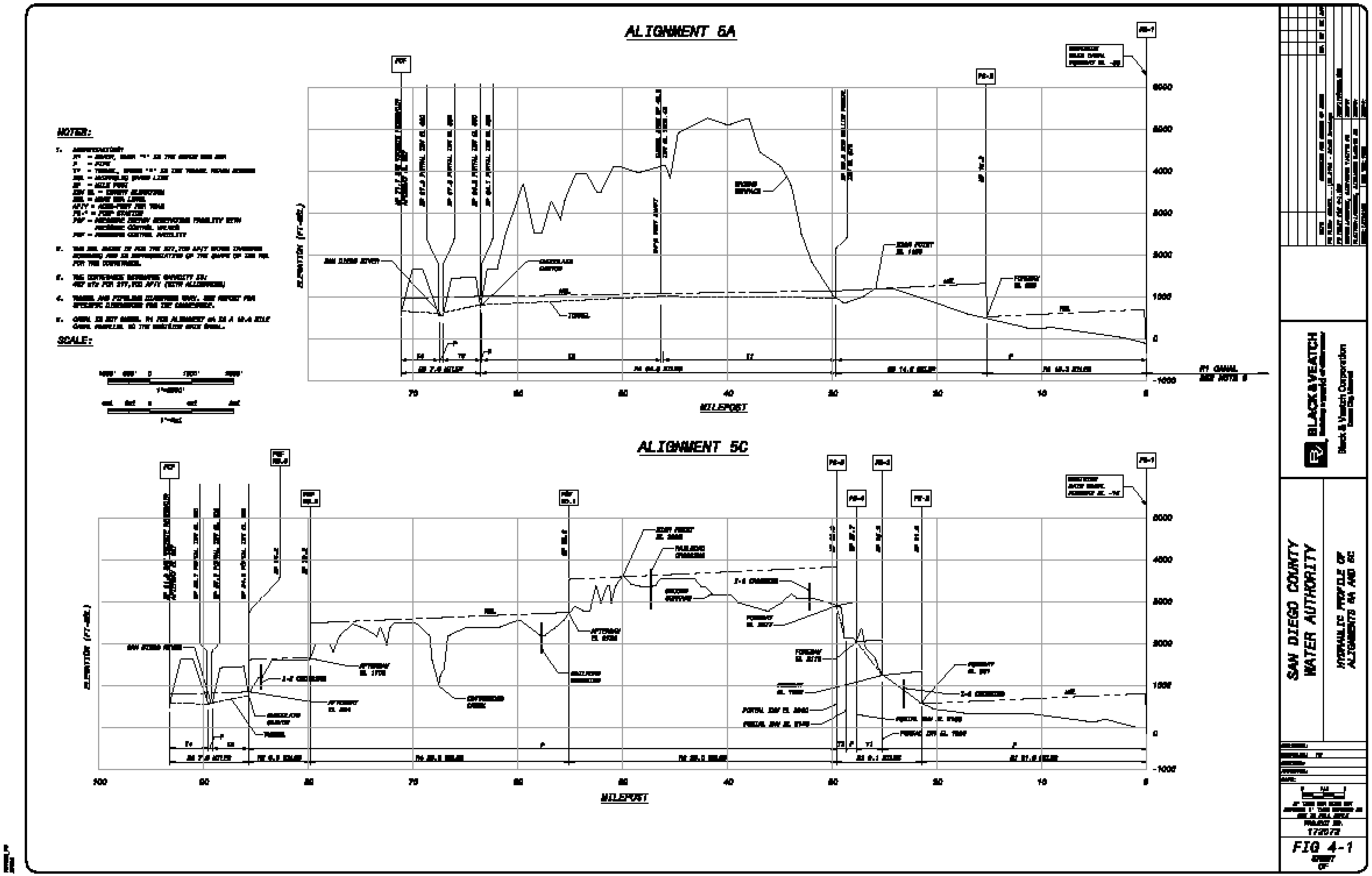


FIGURE 4-1
Hydraulic Profile of Alignments 5A and 5C

4.4.1 Hydraulic Criteria

Design. The required hydraulic capacity was increased by 10 percent to establish the design pumping and flow rates in the canals, pipelines, and tunnels. The 10 percent factor was originally selected to provide approximately 1 month for annual maintenance and emergency outages and was utilized for this evaluation. Based on the energy management analysis presented in Section 4.3, the hydraulic capacity was increased by an additional 15 percent to account for avoiding On-Peak pumping. Table 4-9 presents the annual transfer volume, design flow rates, and required pipeline and tunnel finished internal diameters to the nearest 6 inches. A maximum velocity of approximately 10 fps was used as an additional criterion for selecting the pipe and tunnel diameters.

TABLE 4-9
Conveyance Criteria

Annual Conveyance (acre-feet/year)	Design Flow Rate (cfs)	Pipeline Diameter (inches)	Fully Lined Tunnel Diameter (inches)
280,200	487	96	120

Headloss. Utilizing Manning's equation and an "n" value of 0.012, a headloss of 10 feet per mile of pipeline was used.

Maximum Pressure. Based on a maximum allowable pumping lift of 800 feet per pumping station and 96-inch-diameter pipe, a maximum wall thickness of approximately 1¼-inch and steel yield strength of 36 kilopounds per square inch (ksi) will be required for all new pipelines and tunnels. A minimum diameter over thickness (D/t) ratio was used for this study.

Surge Protection. Transient conditions will occur along each corridor from normal mechanical system operations and emergency shutdown operations. These conditions will be controlled by forebays, afterbays, flywheels on pumps, and valve operation to minimize the surges in the system. For purposes of this study, a maximum anticipated surge of 1.4 times normal operating pressure was used at the pumping plants.

Pumping. Evaluations for pumping flow rates consider use of pumping plants on a seasonal basis with allowance for annual maintenance, outages, and avoiding On-Peak pumping. Pumping operation would occur approximately nine months at full flow (3 pump operation = 487 cfs) and three months at reduced flow (2 pump operation = 325 cfs) with no pumping during On-Peak hours (10:00 a.m. to 6 p.m. summer weekdays and 5:00 p.m. to 8:00 p.m. winter weekdays except holidays).

4.4.2 Capacity of Existing Facilities

The existing AAC conveys water from the Imperial Dam on the Colorado River to a point along the Mexican border south of State Highway 98. Recently, the Water Authority completed the AAC Relining Project, which included construction of a new parallel canal system from Pilot Knob to Drop 3 (approximately 23 miles in length). The project ensures adequate capacity in the AAC to deliver flows to Imperial Valley for IID (capacity of 10,155 cfs in Reach 1, 7,600 cfs in Reach 2, and 7,600 cfs in Reach 3). Based on prior estimates of maximum discharges, there is available capacity in the AAC (both the new canal system and the existing) for an additional 280,200 AF/y for the Colorado River Conveyance Alternative. The original alignment corridors 5A and 5C included approximately 10 miles between Drops 3 and 1 of the new canal system and the remaining unimproved 36 miles of the AAC. Based on the assumption that the proposed alignment corridors will utilize portions of the new canal system and the remaining unimproved AAC, these alignment reaches were removed from the cost evaluation. Alignment corridor 5A conveys water from the terminus of the AAC along the WMC. However, based on previous studies, the WMC does not have sufficient capacity for the additional 280,200 AF/y and a new parallel canal would be required. The design criteria for the proposed canal paralleling the WMC are provided in Section 4.6.2.

4.5 Water Quality and Treatment

This section describes general Colorado River water quality considerations, summarizes 1996 Water Transfer Study Alternatives, develops two options, and selects a basis for this report.

4.5.1 Colorado River Water Quality Considerations

In the 1996 Water Transfer Study, a water quality and treatment analysis was performed to define potential alternatives and costs to produce water quality from the Colorado River comparable to MWD untreated water supply or consistent with Safe Drinking Water Act (SDWA) standards.

The salinity of the Colorado River is subject to wide variation due to ongoing hydrologic conditions. In 1975, the Colorado River Basin Salinity Control Forum established water quality standards for three locations along the Colorado River using the flow-weighted average annual salinity. Table 4-10 shows the salinity levels from 1993 in comparison to the established salinity standards. The recent 2011 Review Water Quality Standards for Salinity Colorado River System (October 2011 Colorado River Basin Salinity Control Forum) confirmed the salinity standards listed in Table 4-10.

TABLE 4-10
1993 Colorado River Salinity Levels

Sample Location along Colorado River	Observed Salinity (milligrams per liter) (mg/L)	Flow-Weighted Average Annual Salinity (mg/L)	Established Salinity Standards (mg/L)
Below Hoover Dam	660	720	723
Below Parker Dam	631	747	747
At Imperial Dam	784	864	879

As part of the 1996 Water Transfer Study, various IID water quality reports were reviewed to help establish the basis of design for waters transferred from the AAC in Imperial County. Table 4-11 presents data on general mineral, physical, and trace metals in the Colorado River supply for two different locations. Samples were taken in the early 1990s.

TABLE 4-11
General Mineral, Physical, Trace Metals Analyses of Colorado River Aqueduct Water Supplies

Constituent	Symbols and Units	IID AAC Drop 4	Lake Havasu Pumping Plant Intake	IID AAC Design Feedwater
Silica	SiO_2 mg/L	NM	8.5	<24
Calcium	Ca mg/L	90	73	90
Magnesium	MG mg/L	37	29	40
Sodium	Na mg/L	114	95	130
Potassium	K mg/L	4.9	4.5	5
Carbonate	CO_3 mg/L	<1.0	0	--
Bicarbonate	HCO_3 mg/L	179	160	188
Sulfate	SO_4 mg/L	312	254	350
Chloride	Cl mg/L	116	83	135
Nitrate	NO_3 mg/L	<1.0	0.85	<1.0
Fluoride	F mg/L	0.5	0.34	NM
Boron	B mg/L	NM	0.16	NM
Total Dissolved Solids (TDS)	TDS mg/L	762	628	879
Total Hardness as $CaCO_3$		360	302	380
Total Alkalinity as $CaCO_3$		146	132	150
Free Carbon Dioxide	CO_2 mg/L	NM	1.9	NM
H+ Concentration	pH mg/L	8.4	8.16	8.3
Specific Conductance	µmho/cm	1220	1015	NM
Color Units	CU	29	NM	NM
Turbidity	NTU	NM	4.1	<25
Temperature	ºC	168	20	25
Bromide	Br mg/L	ND	0.08	NM
Aluminum	Al µg/L	<5	29	160
Antimony	AN µg/L	141	ND	NM
Arsenic	Ar µg/L	ND	2.3	NM
Barium	Ba µg/L	ND	141	140
Beryllium	Be µg/L	ND	ND	NM
Cadmium	Cd µg/L	ND	ND	NM
Chromium	Cr µg/L	ND	ND	NM
Copper	Cu µg/L	ND	ND	NM
Iron	Fe µg/L	132	ND	100
Lead	Ph µg/L	ND	ND	NM
Lithium	Li µg/L	ND	44	NM

TABLE 4-11
General Mineral, Physical, Trace Metals Analyses of Colorado River Aqueduct Water Supplies

Constituent	Symbols and Units	IID AAC Drop 4	Lake Havasu Pumping Plant Intake	IID AAC Design Feedwater
Manganese	Mn µg/L	ND	ND	30
Mercury	Hg µg/L	ND	ND	NM
Molybdenum	Mb µg/L	ND	ND	NM
Nickel	Ni µg/L	ND	ND	NM
Selenium	Se µg/L	ND	ND	NM
Silver	Ag µg/L	ND	ND	NM
Strontium	Sr µg/L	ND	1000	1.0
Thallium	Th µg/L	ND	ND	NM
Zinc	An µg/L	ND	ND	NM

ND = Not Detected
NM = Not Measured

4.5.2 Water Transfer Study Treatment Options

As shown in the Table 4-10 above, Colorado River Water has an estimated long-term maximum average of 879 mg/L TDS (salinity standard) at Imperial Dam used to feed the CRCF, while MWD untreated water supply below Hoover Dam is 723 mg/L TDS. The SDWA drinking water secondary standard is 500 mg/L TDS. Microfiltration/reverse osmosis (MF/RO) treatment plants were considered to treat the water either in Imperial Valley by a centralized treatment plant or in San Diego after water blended in San Vicente Reservoir was delivered to the Alvarado and Miramar WTPs in the 1996 Water Transfer Study. Several brine disposal options were considered including evaporation ponds or conveyance and disposal to a water body. A summary of the 1996 Water Transfer Study alternatives is presented in Table 4-12.

TABLE 4-12
1996 Water Transfer Study Water Treatment Options

Alt.	TDS Quality	Treatment	Treatment Site	Brine Waste	Brine Disposal	Capital Cost (1996$)	Annual Cost (1996$)
1 East	710 mg/L	MF/RO	Imperial	7.2%	Salton Sea	$386/AF	$37/AF
1 West	710 mg/L	RO	San Diego	6.0%	South Bay Outfall	$430/AF	$34/AF
2 East	500 mg/L	MF/RO	Imperial	17.5%	Salton Sea	$870/AF	$78/AF
2 West*	500 mg/L	RO	San Diego	13.3%	South Bay Outfall	$759/AF	$70/AF

*Alternative 2W was selected for purposes of cost estimating in the 1996 Water Transfer Study

The 1996 Water Transfer Study determined pretreatment was necessary for the eastern alternatives with a centralized treatment plant in Imperial Valley, but not necessary for the western alternatives since demineralization facilities would be located downstream of the existing Alvarado and Miramar WTPs. However, the prior studies did not consider the extent of delivery to additional WTPs after completion of the San Vicente Pipeline and Moreno Lakeside Pipeline. Currently, untreated water deliveries can be made from the San Vicente Reservoir to five water treatment plants (Alvarado, Miramar, Levy, Otay, and Perdue WTPs). The Alternative 2W that was selected in prior studies is now complicated by the need to add RO treatment facilities to five WTPs.

For the San Diego alternatives (1West and 2West), three possible brine disposal options were considered:

- Discharge to local sewers
- Dedicated brine disposal pipeline to the South Bay Ocean Outfall
- Dedicated brine disposal via piping to the San Diego River

Discharge to local sewers with disposal to the Point Loma WWTP was determined to have extremely high discharge fees and, therefore, was deemed economically infeasible. In addition, the existing sewer capacity and outfall capacity at the Point Loma WWTP are not sufficient to accommodate the required flows. A preliminary review of the existing sewer capacity near Miramar and Alvarado indicated that construction of new gravity sewers and a pump lift station would be required to discharge to the South Bay Outfall. The environmental and permitting challenges associated with discharges to the San Diego River are complex and may preclude this option. The 2002 Feasibility Study considered discharge to the South Bay Outfall via a new brine line to be the preferred option for brine disposal. It should be noted, that with the additional WTPs, addition of brine lines would be needed at Levy, Otay, and Perdue WTPs.

For the Imperial Valley alternatives (1East and 2East), four possible brine disposal options were considered:

- Evaporation ponds
- Conveyance via canal/pipeline to Yuma Desalter Drain
- Conveyance via canal/pipeline to Gulf of California
- Discharge to Salton Sea via the New or Alamo River

The brine disposal options for the Imperial Valley alternatives considered disposal of 3,000 mg/L brine to the Salton Sea consistent with current agricultural irrigation discharge TDS; however, regulatory requirements were considered uncertain. Conveyance to the Yuma Desalter Drain or Gulf of California was considered in the 1996 Water Transfer Study, but had more uncertainty due to environmental, regulatory, and international issues. Evaporation ponds were also considered as a brine disposal method with an estimated 3,000 acres of ponds with a cost of $400 million (in 1996 Dollars per the 1996 Water Transfer Study). Evaporation ponds were examined in more detail as part of this report and would require approximately 3,700 acres with a cost of approximately $860 million (2012 dollars).

It appears the most effective disposal of brine for the Imperial Valley alternatives is to the Salton Sea with a brine disposal pipeline and coordination with regulatory agencies to address any environmental mitigation. The 2002 Feasibility Study also considered brine disposal to the Salton Sea to be the leading option for concentrate disposal for the Imperial Valley alternatives. The study suggested that the concentrate would be conveyed by a new drainage canal from the treatment plant to the New River and, ultimately, the Salton Sea. While the TDS of the concentrate is higher than that typically allowed for discharge, it would be considered to be relatively fresh water compared to the extremely high TDS of the Salton Sea. The salinity of the Salton Sea has been continuously increasing while the water level has been lowering, thus leading to a steady decline in the overall water quality that threatens the habitat. The California Department of Water Resources issued the draft EIS/EIR, dated August 2011, for the Salton Sea Species Conservation Habitat (Salton Sea SCH) Project, which seeks to identify alternatives for restoration of the Salton Sea habitat. According to the report, the Salton Sea is currently a hypersaline ecosystem with a TDS of approximately 51,000 mg/L. Without restoration, the declining inflows and increasing salinity will result in a collapse of the ecosystem and other water quality stresses. The restoration project proposes a shallow saline habitat that would be created by mixing seawater with drain water to provide salinity between 20,000 to 60,000 mg/L. The preferred alternative identified 62,000 acres of ponds to form a saline habitat complex. Each pond in the complex would be approximately 1,000 acres in size, with salinity ranging from 20,000 mg/L to 200,000 mg/L. The future of this restoration project is key for evaluating future brine disposal opportunities. Feeding the concentrate inflow to the Salton Sea could help maintain the sea's water levels and provide a beneficial environmental enhancement.

The prior studies did not consider the reduced capital and operating costs of delivering less volume through the conveyance system if the treatment site were located in Imperial Valley. This report did consider these reduced costs.

4.5.3 Water Blending/Treatment Options

Over the last several years, MF/RO treatment process and recovery rates have improved. For alternatives which use RO or MF/RO (with MF recycle), the brine waste could be lowered to approximately 7.5 percent for the TDS reduction from 879 mg/L to 500 mg/L.

For the purposes of this report, two options to address the Colorado River water quality considerations were evaluated; San Vicente Reservoir Blending and Imperial Valley Water Treatment.

San Vicente Reservoir Blending Option

This option would include all flow from the Colorado River transferred to San Vicente Reservoir and blended with local rainfall runoff, indirect potable reuse (IPR) water from the City, and other raw water supplies entering San Vicente Reservoir. Figure 4-2 illustrates the San Vicente Reservoir blending alternative.

Key characteristics of the San Vicente Reservoir Blending Option are listed below:

- Total Annual Average Flow from Colorado River = 280,200 AF/y (384 cfs)
- Colorado Conveyance Facilities sized for 487 cfs
- Colorado River water blended in San Vicente Reservoir with no treatment
- Total Annual Average Water Supply to Water Authority = 280,200 AF/y (384 cfs)

This option has the lowest cost since no water treatment facilities are needed. The concern is the long-term TDS balance in San Vicente Reservoir. TDS is a Secondary Standard for drinking water that affects taste, odor, and appearance. Higher TDS does not have health effects at regulated levels, but higher TDS may impact irrigated plants. Although the recommended TDS is 500 mg/L, the upper limit is 1,000 mg/L for drinking water delivered to customers. Water quality objectives based on the Basin Plan, San Diego Regional Water Quality Control Board, 1994 have set the TDS goal for San Vicente Reservoir at 300 mg/L. TDS goals also apply to groundwater basins and hydrologic units that supply the reservoir to protect its beneficial uses. However, transfer of imported water from one water body to another water body should be permitted. If not, a water treatment plant with brine disposal would be required prior to delivery to San Vicente Reservoir. The low water quality objective for San Vicente Reservoir is impractical since many reservoirs receive imported water with TDS higher than 500 mg/L and inflow from streams with TDS as high as 1,300 mg/L. Water quality objectives for waters in the state must conform to State Board Resolution No. 68-16, Statement of Policy with Respect to Maintaining High Quality of Waters in California. Resolution No. 68-16 establishes a general principle of nondegradation, with flexibility to allow some changes in water quality which is in the best interests of the State. Changes in water quality are allowed where it is in the public interest and beneficial uses are not unreasonably affected. It may be possible to change the water quality objectives in the Basin Plan to set a TDS goal for San Vicente Reservoir at 500 mg/L or higher.

Imperial Valley Water Treatment Option

This option would include flow from the Colorado River treated in Imperial Valley at the canal/pipeline junction point before being pumped to San Vicente Reservoir. Treatment includes microfiltration (MF) with recirculation of all the flow, and reverse osmosis (RO) of about 50 percent of the flow to get a blended water with 500 mg/L TDS for delivery to San Vicente Reservoir. A uniform flow rate was used for this option to optimize treatment and reduce costs for treatment and brine disposal associated with higher flow rates of the "Avoid On-Peak Pumping" energy management strategy. Figure 4-3 illustrates the treatment processes, brine waste, and overall recovery rate of the Imperial Valley Water Treatment Option. Brine waste from the RO process would be addressed using evaporation ponds at the water treatment location or disposal by a brine pipeline to the Salton Sea. Key characteristics of this option are listed below:

- Total Annual Average Flow from Colorado River = 280,200 AF/y (387 cfs)
- Colorado Conveyance Facilities sized for 433 cfs uniform flow (based on highest expected product water flow rate from the water treatment plant with the lowest TDS = 600 mg/L from the Colorado River)
- Water Treatment Plant influent flow sized for 422 cfs (272.8 mgd) uniform flow. MF sized for 439 cfs (283.7 mgd). RO sized for 212 cfs (137.3 mgd). Product water = 390 cfs uniform flow.
- Brine Disposal = 31.9 cfs (20.6 mgd) using evaporation ponds or brine pipeline to the Salton Sea.
- Evaporation ponds sized for 31.9 cfs = 3,692 acres at 80 inches per year evaporation rate in El Centro.
- Total Annual Average Water Supply to Water Authority = 259,000 AF/year (358 cfs)

Since water would be treated with brine disposed prior to conveyance to San Vicente Reservoir, the design flow rates and corresponding design criteria were adjusted. This also resulted in a change in the estimated capital and annual costs for conveyance facilities; however, the additional cost of water treatment would offset the reduced costs for conveyance facilities.

This alternative would result in less water supply since brine would be disposed rather than blended. This is very important for a water supply project with the loss of 7.6 percent of water supply or approximately 21,000 AF/y. For this reason, the Imperial Valley Treatment Plant Option was considered the highest cost option.

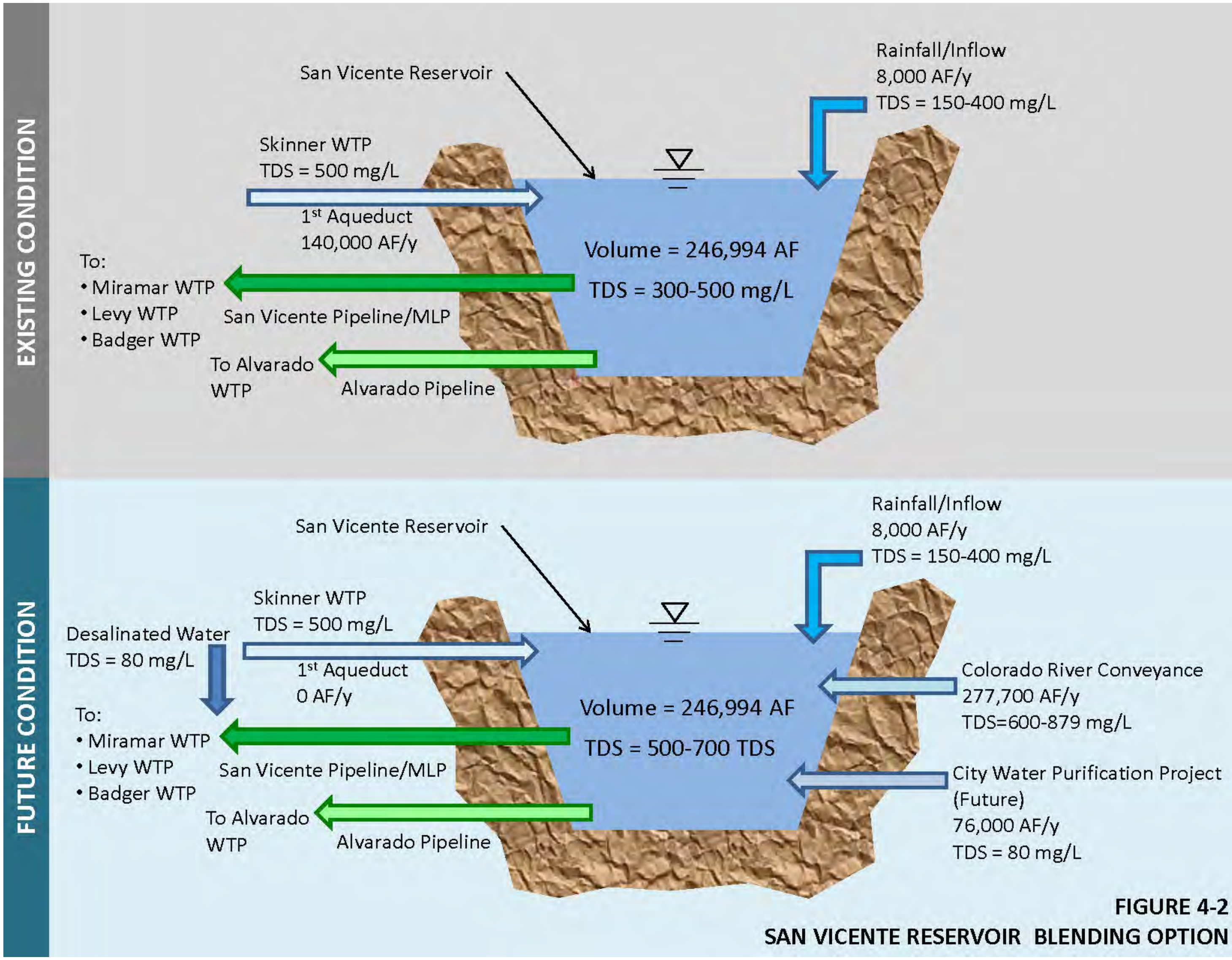


FIGURE 4-2
San Vicente Reservoir Blending Option

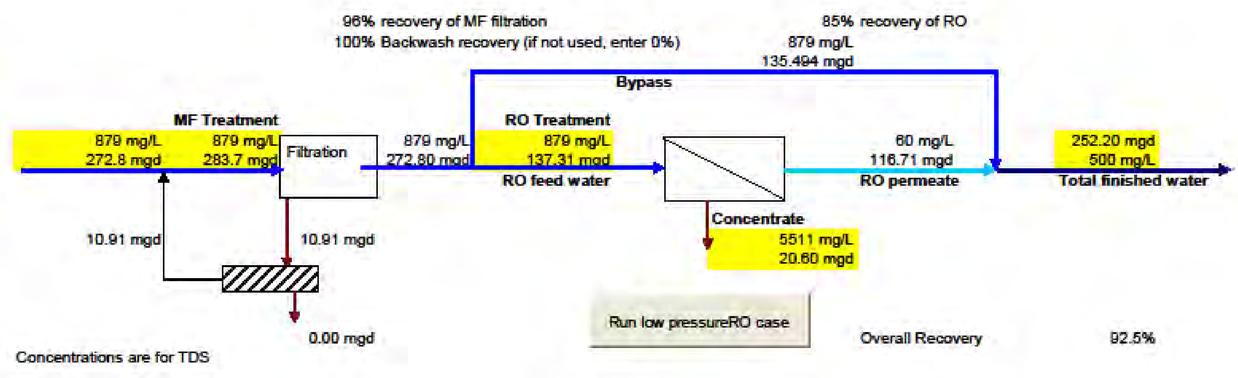


FIGURE 4-3
Imperial Valley Water Treatment Option

4.5.4 Water Quality Option Costs

The San Vicente Reservoir Blending Option is reflected in the cost estimate with no significant cost and represents the low range of costs to address water quality.

The upper range of costs to address water quality was estimated using the Imperial Valley Treatment Options with evaporation ponds. If the Imperial Valley Treatment Option were selected, it would add approximately $1.7 billion in capital costs and $22 million in annual costs.

4.6 Corridor Engineering Evaluations

This section describes the feasibility level engineering evaluations performed for Corridor 5A and 5C. The evaluation includes a general description of each alignment, canal construction, construction methods, tunneling methods, storage reservoirs, pumping plants, PGFs/PCFs, and electrical transmission lines required for each corridor. See Section 2.0 for maps of the alignments and Appendix C for pipeline and tunnel construction methods.

4.6.1 Transfer System Description

Corridors 5A and 5C remain largely unchanged from the alignment corridors described in previous reports, but brief descriptions are provided for clarity.

Corridor 5A. Corridor 5A is summarized in Table 4-13 and requires two pumping stations.

TABLE 4-13
Corridor 5A Reach Characteristics

Reach	Length (miles)	From	To	Soil Type[1]	Excavation Type	System
1	12	Terminus of AAC	Paralleling WMC, Dixieland, PS No. 1	Ql, Qal	Open Cut	Canal
2	15.3	Dixieland, PS No. 1 (MP 0)	PS No. 2, North of Ocotillo (MP 15.3)	Ql, Qal, Qc, Qp	Open Cut	Pipe
3	14.5	PS No. 2, North of Ocotillo (MP 15.3)	Base of Pinyon Canyon Ridge just south of Culp Canyon (MP 29.8)	Qal, Qc, Qp, Tal, Jm, Qm	Open Cut	Pipe
4	34.3	Base of Pinyon Canyon Ridge just south of Culp Canyon (MP 29.8)	Chocolate Canyon south of El Capitan (MP 64.1)		TBM	Tunnel
5	7.6	Chocolate Canyon south of El Capitan (MP 64.1)	San Vicente Reservoir, pressure reducing facility (MP 71.7)		Open Cut/TBM	Pipe/Tunnel
Total	83.7					

[1]Soil Types: Ql, Qal, Qc, Qp, Qm = Alluvium formations; Tal = Igneous rock formations, Jm = Metamorphic rock formations (see Section 4.3 for soil descriptions)

Corridor 5C. Corridor 5C is summarized in Table 4-14 and requires five pumping stations and two PGFs.

TABLE 4-14
Corridor 5C Reach Characteristics

Reach	Length (miles)	From	To	Soil Type[1]	Excavation Type	System
1	21.5	Terminus of AAC, PS No. 1 (MP 0)	PS No. 2, parallels Highway 98, south of Ocotillo (MP 21.5)	Ql, Qal, Qc, Qp	Open Cut	Pipe
2	8.1 (3.5 miles of tunnels)	PS No. 2, south of Ocotillo (MP 21.5)	Parallels I-8, Sunrise Powerlink, PS No. 5 Boulder Park (MP 29.6)	Qal, Qfg, Klp, TRm	Drill and Blast	Pipe/Tunnel
3	23.0	PS No. 5, Boulder Park (MP 29.6)	PGF No. 1, South of Canyon City (MP 52.6)	Qal, Qfg, Klp, TRm	Open Cut	Pipe
4	25.6	PGF No. 1, South of Canyon City (MP 52.6)	PGF No. 2, south of Loveland Reservoir (MP 78.2)	Qal, Klp, Klb, Kc, Kcm, Ka	Open Cut	Pipe
5	6.0	PGF No. 2, south of Loveland Reservoir (MP 78.2)	Chocolate Canyon (MP 84.2)	Klb, Kgm, Kjv, Qal, Kcp, Kcm	Open Cut	Pipe
6	7.6 (7.1 miles of tunnels)	Chocolate Canyon (MP 84.2)	San Vicente Reservoir, pressure reducing facility (MP 91.8)		Open Cut/TBM	Pipe/Tunnel
Total	91.8					

[1]Soil Types: Ql, Qal, Qc, Qp, Qfg = Alluvium formations ; Klp, Klpd, Klb, Kc, Kcm, Ka, Kgm, Kjv, Kcp = Igneous rock formations; TRm = Metamorphic rock formations (see Section 4.3 for soil descriptions)

4.6.2 Canal Construction

The proposed gravity flow aqueduct system aligned generally parallel and adjacent to the existing WMC would have the design parameters listed in Table 4-15.

TABLE 4-15
Design Parameters for a Concrete-Lined Canal

Parameter Description	Criteria
Design Discharge Rate	487 cfs
Canal Bottom Width	12 feet
Side Slopes (H:V)	1.5:1
Invert Slope	0.0006
Design Water Depth	4.50 feet
Height of Lining	6.0 feet
Design Flow Velocity	5.4 fps
Right of Way Width	100 feet

4.6.3 Pipeline Construction Methods

The trench conditions remain unchanged from previous reports, requiring two types of trenches, open cut and shored. The majority of the pipelines will be open cut trenches to limit construction costs, but shored trenches will be utilized at stream crossing to minimize environmental impacts and alluvium excavations. Tunnel construction will be required for all interstate crossings, heavily traveled roads, and railroad crossings. A summary of key criteria for pipeline construction is provided in Table 4-16.

TABLE 4-16
Pipeline Trench Conditions

Item	Criteria
Depth of Cover (unrestricted areas within Right of Way)	7 ft
Unshored slopes	1:1, 1/2:1
Minimum trench widths (shored)	Pipe outside diameter (OD) plus 4 feet
Minimum trench width (unshored)	35 feet
Minimum ROW Required	91 feet
Right of Way Width	100 feet

Water Authority standards require CMLC pipe with tape wrap. An alternative to the tape wrap with cement mortar coating that is becoming more readily accepted and installed throughout California is polyurethane coating. Utilization of this material could result in significant materials cost savings and increased rate of production in the field during construction, due to the lighter weight, while maintaining the integrity of the pipe.

Trench backfill shall be per Water Authority design guidelines. It is anticipated that a portion of the excavated trench material can be utilized as backfill within the trench zone, and any excess will be hauled offsite or used elsewhere. Due to the various construction techniques required for the corridor construction, it is anticipated that multiple construction crews with varying equipment (small and large backhoes, cranes, dewatering equipment, vibratory compactor, etc.) will be required. Construction access roads will be required and anticipated to be via major highways and the right-of-way secured for the project. Temporary construction easements will be obtained for the contractor's staging areas.

River and stream crossings will include special design and construction techniques, specifically shored trench construction or bore and jack construction. Construction will be limited within these areas to minimize environmental impacts. When shored trench construction is utilized, the excavation will be deep enough to provide 6 feet of rock above the pipe and the pipe encased. If sandy soils are encountered and deeper excavation is required, tunneling methods will be utilized.

Interstate crossings will require Caltrans encroachment permits. Additional coordination may be required with municipalities for street crossings. Tunnel and bore and jack construction methods will be utilized for interstate and railroad crossings.

4.6.4 Tunneling Considerations

Geologic conditions directly affect the design and constructability of tunnels. The tunneling considerations outlined in the 1996 Water Transfer Study were carried forward to this evaluation. Additional description of geologic conditions in the project vicinity is provided in Section 4.2.

All corridor tunnel sections are anticipated to be located within hard rock and will require excavation using drill-and-blast techniques or a hard rock TBM. Careful consideration will be required when a tunnel alignment crosses a fault, including crossing a fault at a high angle rather than parallel, monitoring groundwater inflow for personnel safety, slower advance rates, changing the tunnel method at the fault crossing, and encountering clayey gouge. The ground stabilization initial support system will be selected based upon the method of tunnel excavation and groundwater inflow control requirements and modified as necessary when conditions change. Construction water during tunnel excavation will include groundwater inflows and minor construction flows at the tunnel head. Coordination will be required for disposal of the water with the Regional Water Quality Control board (RWQCB), and treatment of the water is expected. A summary of key criteria for pipeline tunnel construction is provided in Table 4-17.

TABLE 4-17
Design Parameters for Tunnels

Item	Tunnel Diameter/Method	Lining Type
Alignment Corridor 5A		
T1 (Bow Willow Portal to Vent)	14 feet/TBM	Steel at Portals Steel Sets at Fracture/Shear Zones Shotcrete at Other Locations
T2 (Vent to El Capitan Reservoir)	14 feet/TBM	Steel at Portals Steel Sets at Fracture/Shear Zones Shotcrete at Other Locations
T3 (El Capitan to El Monte)	15.17 feet/TBM	Precast Concrete Segments with Cast-in-Place Lining (10 feet)
T4 (El Monte to San Vicente)	15.17 feet/TBM	Precast Concrete Segments with Cast-in-Place Lining (10 feet)
Alignment Corridor 5C		
T1 (In-Ko-Pah Gorge PS3 to PS4)	12 feet (Horseshoe)/ Drill and Blast	Steel-lined (10 feet)
T2 (In-Ko-Pah Gorge PS4 to PS5)	12 feet (Horseshoe)/ Drill and Blast	Steel-lined (10 feet)
T3 (El Capitan to El Monte)	15.17 feet/TBM	Precast Concrete Segments with Cast-in-Place Lining (10 feet)
T4 (El Monte to San Vicente)	15.17 feet/TBM	Precast Concrete Segments with Cast-in-Place Lining (10 feet)
Right of Way Width	40 feet	+10 acres per Portal or Vent for Staging Areas

4.6.5 Storage Reservoirs

The Water Authority has raised the San Vicente Dam through their Emergency Storage Project, which will provide an additional 152,000 acre-feet of storage capacity. Both alignment Corridors 5A and 5C will deliver water to San Vicente Reservoir. No additional active storage will be required due to the reservoir expansion.

Some conditions identified in the water supply modeling conducted as part of the 2012 Master Plan require Colorado River water supply be reduced to match demands. This condition occurs during wet winter months with increased watershed inflow into San Vicente Reservoir and reduced water demands. However, addition of a storage reservoir was not considered in this analysis. Should the Water Authority desire to capture additional Colorado River water during low demand years, additional seasonal storage or underground aquifer storage should be considered as a separate project.

4.6.6 Pumping Plants

This section provides the operating criteria and facility descriptions for the pumping plants and forebays proposed for Corridors 5A and 5C. For purposes of this evaluation, it was assumed that pumping will occur throughout the year and the pumping capacity will be increased by 10 percent to account for maintenance and pumping outages. Pumping equipment was sized so that a single layout facility could be provided for each pumping plant within an alignment corridor. Table 4-18 provides the design criteria for pumping stations.

TABLE 4-18
Pump Station Design Criteria

Item	Criteria
Number of Pumps	3 duty, 1 standby
Pump Type	Vertical turbine, single stage, constant speed
Rated Discharge	162 cfs
Rated total head	800 ft
Motor Type	Vertical, synchronous
Maximum Pipeline Wall Thickness	1¼ inch
Property Acquisition	10 acres/Pumping Plant & Forebay combination

The pump type is based on the recommendation of previous studies, but it may be beneficial for the Water Authority to evaluate the use of horizontal split case pumps (currently utilized at the San Vicente Pump Station) in lieu of the vertical turbine pumps. Horizontal split case pumps have a horizontal shaft with the motor mounted next to the pump. The pumps require less overhead clearance and are mounted on the pump station floor. Excavation would not be required for pump cans below the pump station floor and could be a potential cost savings when excavating in rock. Horizontal split case pumps can include addition of a flywheel to dampen surges. The major advantages include less wearing parts, lower cost, excellent pumping efficiency, convenient access for maintenance, lower reverse runaway speed, ability to use a flywheel, and a higher rotative moment of inertia, which helps reduce transients upon loss of pumping power. Horizontal split case pumps would, however, require more floor space with a larger building footprint, and the weight of the pump and motor would be supported by guide bearings. Both pump types are common in the water industry, and each has certain characteristics related to the way the pump is constructed.

Previous studies recommended constant speed pumps. It may be beneficial for the Water Authority to evaluate the addition of variable frequency drives (VFDs) and soft starters at each pumping plant. The VFDs will allow additional flexibility in the pumping plant when the hydraulic design point cannot be maintained upstream. Soft starters will reduce the required energy draw to start the pumping plant.

The pumping units and auxiliary electrical, mechanical, and control equipment will be enclosed within a reinforced concrete structure with a steel framed superstructure and metal wall panels. Each pumping unit would have a separate intake with trashrack and stoplog slots. A 35-ton traveling bridge crane and 10-ton gantry crane would be provided for lifting. Typical auxiliary electrical and mechanical systems would be provided for a pump station of this size and per Water Authority design standards.

A substation would be provided at a location adjacent to the pumping structure and would consist of the main step-up transformers, circuit breakers, and a takeoff tower.

A forebay would be provided at each pumping plant for normal startup and shutdown of the pumping plant and for unscheduled outages of one or more pumps or pumping plants. Forebay storage would also help balance operational differences in pumping plant discharge of individual pumping plants in series. Table 4-19 presents the forebay design criteria.

TABLE 4-19
Forebay Design Criteria

Item	Criteria
Operational Storage	60 minutes at 100 percent discharge
Operational Storage required for 300,000 ac-ft transfer	40 ac-ft
Reservoir Surface Area	4.0 acres
Type	Earthen with plastic liner (if topography allows)

4.6.7 Power Generating/Pressure Reducing Facilities

This section provides the operating criteria and facility descriptions for the PGFs/PCFs and afterbays proposed for Corridors 5A and 5C. For purposes of this evaluation, it was assumed that energy generation will occur throughout the year and that based on the 10 percent increased pumping capacity for maintenance and pumping outages and 15 percent increase to avoid On-Peak pumping, the design hydraulic capacity will be 487 cfs. Power generating equipment was sized so that a single layout facility could be provided for each PGF within an alignment corridor. Corridor 5A does not have sufficient head to generate power. Corridor 5C has a total net power generating head of approximately 2,350 feet. Table 4-20 provides the design criteria for PGFs.

TABLE 4-20
Power Generating Facility Design Criteria

Item	Criteria
Number of Generating Units	1
Turbine Type	Vertical, Pelton, four nozzles
Rated Discharge	487 cfs
Rated total head	800 ft
Generator Type	Vertical, synchronous
Number of Sleeve Valves (bypass capability and energy dissipation during generating unit outage)	3
Sleeve Valve Discharge Capacity	244 cfs
Property Acquisition	10 acres/Facility & Afterbay combination

A final pressure reducing facility will be provided at San Vicente Reservoir to dissipate excess head within each corridor. Due to the proposed higher pool elevation at San Vicente Reservoir, there will be less pressure head to break. Energy generation is not anticipated at this facility.

The power generating units and auxiliary electrical, mechanical, and control equipment will be enclosed within a reinforced concrete structure with a steel framed superstructure and metal wall panels. Shutoff valves will be provided at the turbine inlet and upstream of each sleeve valve to accommodate system shutdown during emergency situations. A 95-ton traveling bridge crane would be provided for lifting. Typical auxiliary electrical and mechanical systems will be provided for a PGF of this size and per Water Authority design standards.

A substation would be provided at a location adjacent to the power generating/pressure control structure and would consist of the main step-up transformer, circuit breakers, and a takeoff tower.

An afterbay would be provided at each PGF for normal startup and shutdown of the PGF and for unscheduled outages of one or more of the PGFs. Afterbay storage would also help balance operational differences in total PGF discharges of individual PGFs in series. Table 4-21 provides the afterbay design criteria.

TABLE 4-21
Afterbay Design Criteria

Item	Criteria
Operational Storage	60 minutes at 100 percent discharge
Operational Storage required for 300,000 ac-ft transfer	40 ac-ft
Reservoir Surface Area	4.0 acres
Type	Earthen with plastic liner (if topography allows)

4.6.8 Electrical Transmission Lines

This section provides the design criteria for the 230 kV transmission lines supplying power to the pumping plants located along Corridors 5A and 5C. For purposes of this evaluation and as described further in other sections, it is anticipated that a dedicated electrical transmission line would be required in lieu of utilizing the SDG&E Sunrise Powerlink or the Imperial Valley/Miguel 500 kV transmission lines that are located adjacent to the pumping plants. However, the PGF would be connected to the new SDG&E Sunrise Powerlink to significantly reduce transmission line lengths.

Dedicated transmission lines would be required to carry away power from the PGFs and would have a voltage of 69 kV. A new substation would be required to step up the power to the main transmission line.

Table 4-22 provides the lengths of the proposed transmission lines.

TABLE 4-22
Transmission Line Lengths

Corridor	Pumping Plant (230 kV Transmission Lines)	PGFs (69 kV Transmission Lines)
5A	23.8 miles	0 miles
5C	29.6 miles	10 miles
Right of Way (Width)	100 feet	60 feet

The following criteria apply to the proposed 230 kV and 69 kV transmission lines:

- Single circuit transmission line, supported on galvanized single shaft poles and davit arms
- I-string insulators attached at ends of arms for tangent and small angle structures
- 2, 954 kcmil aluminum conductor steel reinforced (ACSR) Cardinal conductor for the 230 kV line
- 1, 954 kcmil ACSR Cardinal conductor for the 69 kV line
- 1 3/8 inch extra high strength (EHS) shield wire
- 1,000 ft max wind span for 230 kV line
- 600 ft max wind span for 69 kV line
- Drilled pier foundations

The following equipment would be required for interconnection to the Imperial Valley Substation for the pumping plant transmission lines:

- Two 500 kV circuit breakers
- Two stepdown transformers
- A 230 kV switchyard consisting of four breakers in a ring-bus configuration

The PGFs would require interconnection to the SDG&E substations located near the proposed facilities. Connection to an existing substation would require the following:

- Installation of an additional 69 kV bus location
- 69 kV circuit breaker and switches
- Extension of the existing 69 kV bus
- Protective relaying and controls meeting SDG&E requirements
- Associated line attachment hardware

4.7 Electric Power Market Analysis

The 1996 Water Transfer Study evaluated the electrical transmission facilities within the project vicinity and identified additional facilities required for the project. The study indicated that, though the existing SDG&E Imperial Valley/Miguel 500 kV transmission line passed near the proposed project pumping plants, new 230 kV transmission lines would be required to transmit power to each pumping plant. In addition, a new substation adjacent to one of the proposed project pumping plants would still be required to step down the voltage to 230 kV and a shorter 230 kV transmission line to transmit power to each pump station. SDG&E recently completed construction of the Sunrise Powerlink 500 kV transmission line near the project vicinity. There may be the potential of receiving power through the Sunrise Powerlink, but, due to the associated unknowns, it was assumed for this evaluation that the new dedicated 230 kV transmission lines and a substation supplying power to the pumping stations would be required. The proposed pumping electrical loads for each corridor remain the same from previous evaluations as are provided in Table 4-23.

TABLE 4-23
Proposed Pumping Electrical Loads

Corridor	Number of Pump Stations	Electrical Load (MW)
5A	2	90
5C	5	220

Current electrical rates are in the range of 4 cents/kWh to 10 cents/kWh. Based on these prices and the required loads, it would be beneficial for the Water Authority to continue to evaluate the potential for developing a dedicated combustion turbine facility to power the pumping plants.

Some of the alternatives examined in the 1996 Water Transfer Study and 2001 Feasibility Cost Refinement are no longer viable. In addition, the maximum power generation of 220 megawatts (MW) significantly limits the number of generation options available. The following three combined cycle power generating options can be considered for this application:

- 1x1 7EA (General Electric)
- 2X1 LMS 100 PB (General Electric)
- 1x1 MHI 501D (Mitsubishi)

Table 4-24 presents the net plant output and net plant heat rate of the three generating options.

TABLE 4-24
Dedicated Generating Facilities (2012 to 2032)

	Combined Cycle Technology		
Item	1x1 7EA	2x1 LMS100PB	1x1 MHI501D
Capacity, Net Plant Output, International Organization for Standardization (ISO) Condition (MW)	130	230	167
Net Plant Heat Rate, ISO Condition (British Thermal Unit [BTU]/kWh)	6,800	6,540	6,635

A dedicated power facility could produce electricity at a competitive energy cost to power supplied by an electric utility (IID or SDG&E). Based on the current market and projected rates, the Water Authority should continue to evaluate the use of a dedicated combined cycle combustion turbine facility.

4.8 Natural Gas Market Analysis

The 1996 Water Transfer Study examined published forecasts of gas reserves, production, and demand to assess whether adequate supplies would be available to support the water transfer project without placing significant upward pressure on prices. The study indicated that the proven reserves from the four gas supply basins would be more than adequate to satisfy the future gas requirements of southern California and the CRCF project. In addition, the available capacity of the pipeline transmission facilities would likely be sufficient to meet the fuel requirements of the project. The analysis indicated that the delivered cost of natural gas in 2016 for the project location in Brawley, California, was likely to range from highs of $6.93/MMBtu to lows of $3.68/MMBtu.

The 2001 Northern Alignment Cost Refinement Study confirmed many of the assumptions of the 1996 Water Transfer Study, including the availability of the natural gas resources relative to the current and projected demands in California. However, the 2001 study noted that pipeline capacity was strained and that additional pipeline capacity was expected to be needed and constructed in the next two decades. The market conditions were accelerating the need for many expansion projects and the expectation was that these expansions would occur as needed. The average spot market price for natural gas delivered to southern California in 2001 was $15.91/MMBtu, which was approximately $9.00/MMBtu over the Henry Hub price. This was expected to drop as more supplies become available to around $3/MMBtu.

A review of the 2011 CEC Natural Gas Market Assessment provides a current look at the natural gas market outlook. Over the past decade, United States and California residential and commercial gas demand has remained constant despite continued population growth. As part of the current recession, the industrial sector has exhibited a long term declining demand. However, the power generation sector gas demand is increasing. Recent improvements in technological improvements have improved the knowledge of what reserves exist underground, thus increasing potential reserves. Access to underground reserves has improved based on the use of horizontal direction drilling particularly in shale formations. Well completion and hydraulic fracturing has improved the effectiveness of extraction and lowered the cost of producing natural gas from shale formation. Between the years 2000 and 2008, significant spikes in gas prices (up to $18/MMBtu at its highest) occurred due to extreme winter periods (increased demand) and hurricanes (reduced natural gas production). Since 2008, natural gas prices have trended lower, due to reduced demands (economic recession) and improved technology for extraction. The current California rates are in the range of $4.50/MMBtu to $5.50/MMBtu and are forecasted to level out through 2030 at a price near $6.50/MMBtu. Due to recent concerns related to pipeline safety (San Bruno pipeline explosion), an ongoing inspection program could reveal the need for significant capital investments in pipeline repair or replacement. These costs would ultimately be paid by the ratepayers but would not be significant, in the range of a

4 percent increase to the transportation rate that is rolled into the overall cost of the natural gas. The transportation rate is typically 4 percent of the overall cost.

4.9 Environmental Assessments

The 1996 Water Transfer Study outlines the following major environmental permitting areas:

- Project effects on biological resources and related permitting requirements. Biological resources include sensitive plants, sensitive wildlife species, sensitive wildlife use areas, substantial wetlands, and/or waters that would be affected by the corridor.
- Project effects on cultural resources and related permitting requirements. Cultural resources include archaeological and historic sites, structures, buildings, features and districts, and areas or features of spiritual or religious significance to an ethnic group. Cultural resource site types include trails, lithic scatters, cleared circles, rock alignments, geoglyphs, rock rings, habitation sites, quarry sites, cairns, and petroglyphs.
- NEPA and California Environmental Quality Act (CEQA) compliance requirements. In general, use of each corridor would require a Grant of Right-of-Way from BLM and a Special Use Permit from the USFS. Crossings of streams, rivers, and wetlands will require a Section 404 permit from the United States Army Corps of Engineers (ACOE). Based on the potential for significant impacts, an EIS would need to be prepared. For CEQA compliance, an Environmental Impact Report (EIR) would also need to be prepared, possibly as a joint document with the EIS.
- Other permitting requirements, including brine discharge permitting and air quality permitting.

In April 2003, a technical memorandum was prepared that summarizing environmental issues for the Regional Colorado River Conveyance System, including bi-national pipeline alignment alternatives. This document identifies agencies responsible for review of environmental issues, describes the scoping process for each agency, and describes the documentation required for agency approval. As much of the report focuses on environmental impact assessment under Mexico law and requirements of bi-lateral agreements with the United States, the report findings are not directly applicable to this study.

The 2002 Feasibility Study provides an update to the environmental screening performed for the 1996 Water Transfer Study. Environmental conditions are viewed largely as unchanged from the 1996 Water Transfer Study and 2002 Feasibility Study. As part of the evaluation for this report, additional research was performed to identify any additional environmentally sensitive areas. A review of previous studies, such as the Sunrise Powerlink EIR and the 2008 Eastern San Diego County Resource Management Plan, yielded the following sensitive areas within the proposed corridor alignments:

- Pacific Crest National Scenic Trail – Alignment Corridor 5A has one tunnel crossing along this historic trail, while Alignment Corridor 5C crosses it via open cut trench.

- Peninsular bighorn sheep critical habitat – Alignment Corridor 5A traverses this area via open cut trench, as well as when it transitions into tunnel. Alignment Corridor 5C crosses it via open cut trench.
- Quino checkerspot butterfly critical habitat – Alignment Corridor 5C traverses this area via open cut trench.
- Wilderness Study Area – this area is classified as Visual Resource Management (VRM) Class I. For this class, the level of change to the characteristic landscape should be very low and must not attract attention. Alignment Corridor 5C crosses this area via open cut trench.
- Sawtooth Mountains Wilderness – this area is classified as VRM Class III. This class allows moderate changes to the landscape, although every attempt should be made to minimize the impact of the activities. Alignment Corridor 5A crosses through a small part of this area via tunnel.
- Yuha Basin ACEC – as previously discussed in Section 3.2.1, this area is home to sensitive species, including the flat-tailed horned lizard and the rare crucifixion thorn.

These areas will need to be further investigated as the project progresses. However, it is not anticipated that they will present significant additional challenges. The environmental permitting process will be extensive for both alignment corridors. Table 4-25 summarizes the anticipated permits required for the alignment corridors.

TABLE 4-25
Anticipated Environmental Permits

Regulatory Agency	Permit or Approval
Federal	
BLM	Grant of Right-of-Way NEPA Compliance (EIS) Temporary Use Permit Issuance of Noncompetitive Sales of Mineral Material Contracts (pipeline bedding material) Assurance of Compliance with Certain Applicable Federal Laws, Orders, and Regulations, including: Endangered Species Act of 1973 Executive Order 11593 (Protection and Enhancement of the Cultural Environment) and the Historic Preservation Act of 1996 (as amended), Section 106 Executive Order 11988, Floodplain Management
USFS	Special Use Permit NEPA Compliance (EIS)
US Fish and Wildlife Service	Endangered Species Act Compliance (includes endangered species surveys, biological assessment, mitigation agreement) Fish and Wildlife Coordination Act
US Department of the Interior, Advisory Council on Historic Preservation	National Historic Preservation Act (NHPA), Section 106 Compliance (including site testing, excluding mitigation)
US Department of Defense, ACOE	Section 404 Permits (Stream and River Crossings)

TABLE 4-25
Anticipated Environmental Permits

Regulatory Agency	Permit or Approval
State (California)	
Department of Parks and Recreation	Special Use Permit
Department of Fish and Game	Compliance with California Endangered Species Act Stream Alteration Agreement
Caltrans	Encroachment Permits (crossings of state highways)
State Water Resources Control Board (SWRCB), Regional Board	National Pollutant Discharge Elimination System (NPDES) Permit/Report of Waste Discharge (hydrostatic test water discharges and tunnel dewatering)
SWRCB, Division of Water Rights	Temporary Permit to Appropriate Water (hydrostatic test water)
Local	
Water Authority	CEQA Compliance
Other	Combined local permitting (encroachment, grading, road crossings, zoning)

4.10 Staging Opportunities

The 1996 Water Transfer Study evaluated possible strategies to stage construction of alternative alignment alternatives by initially constructing facilities with less capacity in an effort to defer capital costs. The current evaluation considers an alternative to deliver 280,200 AF/y. It was determined in the prior studies that staging construction of a mostly pipeline alignment (Alignment Corridor 5C) using two smaller pipelines would likely cause a significant increase in the capital cost due to additional trenching, installation, and appurtenance costs for two pipelines. This is still true for the 280,200 AF/y alternative. There is no opportunity for staging tunnel sections of the alignment since a minimum excavated diameter is required for constructability reasons (TBM sizing, mucking and removal of material, air equipment during construction, etc.). The one type of facility that provides a good opportunity for staging is pumping plants. The pumping plant building can be designed for the ultimate capacity with the ability to add pumps as delivery capacity increases.

4.10.1 Decision Analysis

In the 1996 Water Transfer Study, a decision analysis was performed to provide a statistical interpretation of cost risk associated with construction and operation of the water transfer system from the Colorado River to San Diego. The reason was to identify the risk characteristics and determine how to manage potential risks. The approach used was a deterministic model with elements of a probabilistic model. It was noted that the tunnels represent the largest portion of cost uncertainty due to geotechnical variability. In the 1996 Water Transfer Study, the decision analysis showed the cost variability presented as a probability of the cost not exceeding a certain value. These values were then compared with the estimated capital and operation costs presented in the study. It was concluded that the capital and annual costs were considered reasonable and appropriate with the capital costs falling on the upper portion of the percentile curve and the annual costs at approximately the 70 percentile.

For purposes of the reevaluation of costs for the Colorado River Alternative for the 2013 Master Plan, the decision analysis was not performed. Instead, costs were prepared using the Water Authority's Cost Estimating Guidelines for this level of estimate, Class 4 Estimate–Feasibility Study or Screening. A scope and market allowance contingency of 30 percent was applied, as well as an allowance of 25 percent for soft costs.. The expected accuracy range for a Class 4 Estimate is from -30 percent to +50 percent of the estimate. With this approach, the actual cost of the project is expected to fall within the range of 30 percent less than the cost estimate to 50 percent more than the cost estimate.

5.0 Project Risks

5.1 Overview

This section discusses risk analysis criteria and then briefly describes specific risks associated with Corridors 5A and 5C. As part of the alignment corridor reevaluation, a risk analysis was performed to identify any area of the alignment that would present severe construction or operational challenges or fatal flaws. Each of the alignment characteristics reevaluated in Section 4 was analyzed for potential project risks or fatal flaws.

5.2 Risk Criteria

Criteria that would constitute a major project risk or fatal flaw include the major land use conflicts, extreme terrain that would make the alignment unconstructable, unknown geologic conditions for tunnel construction, environmental considerations, agency coordination and interagency agreements, and public acceptance. These are described in more detail below.

- Land Use – The majority of the alignment corridors are within open country or tunnels. Several jurisdictional areas would require significant agency coordination for land acquisition. Some segments of the alignments traverse commercial and residential areas which may require a significant land acquisition effort. Generally, these can be address with Eminent Domain.

- Extreme Terrain – Construction methods and adequate right-of-way space must be allocated to provide a constructable alignment. Generally, difficult construction areas can be addressed with the use of appropriate construction equipment and adequate construction space at a higher cost.

- Unknown Geological Conditions – Preliminary geotechnical investigation was conducted for the alignment corridors in 2001. Geologic conditions are defined by general mapping and detailed investigation at specific points along the alignment. However, the geology is estimated through interpolation between data points and can be different as found in the field during construction. This is particularly critical for tunnel segments with geologic conditions defining the type of TBM, tunneling methods, and lining methods used. Changed geologic conditions must be defined in the Contract Documents with risk defined for the Owner or Contractor.

- Environmental Considerations– The construction of the facilities for the Colorado River Conveyance project will impact the environment including sensitive habitats and species. The significance and mitigation of these impacts will be determined in the EIR/EIS. Project risks occur when significant impacts cannot be mitigated. Generally minor re-alignments and purchase of mitigation land can address these impacts.

- Agency Coordination and Interagency Agreements – The Colorado River Conveyance project will involve multiple agencies with a significant coordination effort. Coordination with agencies includes risk of schedule delays and lack of agreement on key issues. Interagency agreements will be required with several agencies including:

SDG&E for power supply and delivery, IID for use of the existing AAC, and BLM/Forest Service for land acquisition.

- Public Acceptance – With any large project, public acceptance is a key issue and risk to obtain the necessary regulatory and political approvals. Implementing an effective public outreach program and informing the public early in the design process are essential to obtaining public acceptance.

5.3 Preliminary Comparison of Risks for Corridors 5A and 5C

Relative risks for Corridors 5A and 5C are summarized in Table 5-1.

TABLE 5-1
Relative Risks for Corridors 5A and 5C

Risk Factor	Corridor 5A	Corridor 5C
Land Use	Less Risk	More Risk
Extreme Terrain	Less Risk	More Risk
Unknown Geological Conditions	More Risk	Less Risk
Environmental Considerations	Less Risk	More Risk
Agency Coordination	Equal	Equal
Public Acceptance	Less Risk	More Risk

5.3.1 Corridor 5A

Alignment Corridor 5A has less risk for land use due to its shorter alignment and more tunnel segments requiring less right of way width. Alignment Corridor 5A has less risk for extreme terrain since much of the alignment is tunneled and the pipeline segments have relatively flat topography. Alignment Corridor 5A has more risk associated with geologic conditions for the tunnel segments. Alignment Corridor 5A has less risk for environmental issues due to its shorter pipeline length and use of tunnels. Both alignments have equal risks associated with agency coordination and interagency agreements. Alignment Corridor 5A will likely have less risk for public acceptance due to the extent of tunneling.

5.3.2 Corridor 5C

Alignment Corridor 5C has more risk for land use due to its longer alignment and more pipeline segment requiring more right of way width. Alignment Corridor 5C has more risk for extreme terrain since much of the alignment is pipeline with more segments with steep topography. Alignment Corridor 5C has less risk associated with geologic conditions due to its shorter tunnel segments. Alignment Corridor 5C has more risk for environmental issues due to its longer pipeline length. Both alignments have equal risks associated with agency coordination and interagency agreements. Alignment Corridor 5C will likely have more risk for public acceptance due to the extent of pipeline.

6.0 Project Costs

6.1 Overview

Capital and annual costs were developed for the CRCF alternatives based on information gathered from prior reports. Unit costs from the 1996 Water Transfer Study and 2001 Feasibility Study Cost Refinement were escalated based on actual cost escalation in the southern California region from 1996 to 2012. New unit costs were developed for new project items based on recent estimates for similar projects and escalation factors. Adjustments and refinements were made to quantities based on the reevaluation of this report. A scope and market allowance contingency of 30 percent was applied, as well as an allowance of 25 percent for soft costs. In accordance with the purpose of this study, the costs provided define an estimated range of costs to transfer Colorado River water to San Vicente Reservoir. The costs are considered to be feasibility level costs equivalent to a Class 4 Estimate using the Water Authority's Cost Estimating Guidelines (2008). As such, the cost estimates have a range of +50 percent to -30 percent accuracy.

Updated estimated capital and annual costs are summarized in Tables 6-1 and 6-2 for Alignment Corridors 5A and 5C. Both alternatives consider an annual transfer volume of 280,200 AF/y from the AAC terminus at its junction with the WMC to the San Vicente Reservoir. Detailed estimated costs are provided in Appendix B.

TABLE 6-1
Estimated Capital Costs[1]

Item	Corridor 5A "Tunnel" Alignment	Corridor 5C "Pipeline" Alignment
Canals	$10.3 million	$1.8 million
Pipelines	$205.8 million	$758.2 million
Tunnels	$967.9 million	$369.8 million
Pumping Plants	$85.2 million	$213.1 million
PGFs/PCFs	$26.3 million	$150.6 million
Electric Transmission Lines	$33.9 million	$46.0 million
Water Treatment (Blending)	$0	$0
Environmental Permitting/Mitigation	$12.8 million	$22.6 million
SUBTOTAL	**$1,342.2 million**	**$1,562.1 million**
Admin/Engr./Constr. Management (25%)	$335.6 million	$390.5 million
Contingency (30%)	$402.7 million	$468.6 million
TOTAL (2012 Dollars)	**$2,080.5 million**	**$2,421.2 million**
Escalation to Midpoint of Construction (5A: Feb. 2026; 5C: June 2019)	$665.9 million	$775.0 million
TOTAL CAPITAL COSTS	**$2,746.4 million**	**$3,196.2 million**

[1] Costs include 30% contingency and 25% implementation allowance. Expected accuracy range for a Class 4 Estimate is from -30 percent to +50 percent of the estimate.

TABLE 6-2
Estimated Annual Costs[1]

Item	Corridor 5A "Tunnel" Alignment	Corridor 5C "Pipeline" Alignment
Pumping Energy/Demand	$54.6 million	$136.5 million
O&M and Replacement	$11.6 million	$18.6 million
Water Treatment (Blending)	$0 million	$0 million
Energy Recovery	$0 million	($30.8 million)
TOTAL ANNUAL COSTS (2012 Dollars)	**$66.2 million**	**$124.3 million**

[1] Costs include 30% contingency. Expected accuracy range for a Class 4 Estimate is from -30 percent to +50 percent of the estimate.

The costs presented in Table 6-2 consider the San Vicente Reservoir Blending Option for Water Treatment. Costs were also developed for the Imperial Valley Treatment Option to provide estimated costs at the high end of the range of costs (see Appendix B, Tables B-8 and B-10). Estimated costs to implement the Imperial Valley Treatment Option would add approximately $1.7 billion in capital costs (2012 dollars) and $22 million per year in annual costs for either Alignment Corridor 5A or 5C.

Estimated costs on a cost per acre-foot basis were developed and are summarized in Table 6-3. Capital cost expenditures were amortized based on a 30-year loan at 5 percent interest rate. Annual costs in 2012 dollars were considered. The cost per acre-foot was then calculated based on the total annual cost divided by annual flow volume of Colorado River Water delivered to San Vicente Reservoir.

TABLE 6-3
Estimated Cost per Acre-Foot[1]

Item	Corridor 5A "Tunnel" Alignment	Corridor 5C "Pipeline" Alignment
San Vicente Blending Option		
Amortized Annual Capital Costs	$232.5 million	$208.3 million
Annual Costs	$66.2 million	$124.3 million
Total Annual Costs	$298.6 million	$332.6 million
Transfer Volume, AF/y	280,200	280,200
Cost Per Acre-Foot (2012 dollars)	$1,075	$1,198

[1] Expected accuracy range for a Class 4 Estimate is from -30 percent to +50 percent of the estimate.

6.2 Canals

The AAC has sufficient capacity for the addition of 280,200 AF/y flow and would be used for the Colorado River Conveyance project instead of construction of a new AAC parallel canal. A new parallel canal would be constructed adjacent to the Westside Main Canal from the terminus of the AAC to the connection point of the pipeline alignment for Alignment Corridor 5A. The existing WMC does not have sufficient capacity for the addition of 280,200 AF/y flow for the Colorado River Conveyance project.

The new parallel canal to the WMC would be constructed as a concrete-line canal with a trapezoidal shape. Design criteria for canal construction are presented in Section 4.6.2. Unit costs from the 2001 Feasibility Study Cost Refinement were escalated based on actual cost escalation in the southern California region from 2001 to 2012. Quantities and cost items were adjusted to reflect the construction of the canal parallel to the WMC only. Annual costs for O&M were added considering costs equivalent to 1 percent of capital costs. Capital and annual costs for canals are summarized in Table B-2 of Appendix B.

6.3 Pipelines

Pipelines would be constructed along both Alignment Corridors 5A and 5C for various segments of the Colorado River Conveyance project. Detailed pipeline wall thicknesses for the pipeline alignments were developed in the 2001 Feasibility Study Cost Refinement, based on design pressures from the hydraulic profile and pipeline invert elevation which were used for this report. Pipeline construction methods included open cut, shored, and short tunnels for highway or railroad crossings. Detailed trench construction types were developed in the 2001 Feasibility Study Cost Refinement that was used for this report. Four types of open trench construction were used with various levels of trench side slopes, blasting, and use of excavated material as backfill. Separate trench construction methods were identified for shored excavation and completely blasted open cut trench. Accessories, crossings, and specials were developed in the 2001 Feasibility Study Cost Refinement including appurtenances, highway crossings, railroad crossings, river crossings, surface/utilities, and the San Vicente Outfall Structure that were used for this report.

The pipeline will be 96-inch-diameter steel pipe. Design criteria for pipelines are presented in Section 4.6.3. Unit costs from the 2001 Feasibility Study Cost Refinement were escalated based on actual cost escalation in the southern California region from 2001 to 2012. Quantities and cost items were adjusted to reflect the adjusted pipeline segment lengths developed in this report. Annual costs for O&M were updated considering costs equivalent to 1 percent of capital costs. Capital and annual costs for pipelines are summarized in Table B-3 of Appendix B.

6.4 Tunnels

Alignment Corridors 5A and 5C each have four defined tunnel segments (T1, T2, T3, and T4). For Alignment Corridor 5A, tunnel segments T1 and T2 total 3.5 miles through the In-Ko-Pah Gorge area. For Alignment Corridor 5C, tunnel segments T1 and T2 total 34.3 miles from the Bow Willow Portal to El Capitan Reservoir. Both Alignment Corridors 5A and 5C have a common segment for tunnels T3 and T4 from El Capitan Reservoir to San Vicente Reservoir totaling 7.6 miles (7.1 miles of tunnel and 0.5 miles of pipeline). Detailed tunnel parameters, construction methods, and costs were developed in the 2001 Feasibility Study Cost Refinement based on geologic evaluations from the geotechnical studies completed in 2001. This detailed basis for tunnel construction was used for this report.

Alignment Corridor 5A tunnel segments T1 and T2 would be constructed using a TBM and have an excavated diameter of 14 feet with lining varying from steel lining at the portals, steel sets at the fracture/shear zones, and shotcrete lining at other locations. Alignment Corridor 5C tunnel segments T1 and T2 would be constructed using drill and blast methods with an excavated diameter of 12 feet (horseshoe shaped) with a steel-lined finished diameter of 10 feet. The tunnel segments T3 and T4 common to both alignments would be constructed using a TBM and have an excavated diameter of 15.17 feet with an initial lining of precast concrete segments with bolted and gasketed joints and final lining of cast-in-place concrete with a finished diameter of 10 feet. Design criteria for tunnels are presented in Section 4.6.4. Unit costs from the 2001 Feasibility Study Cost Refinement were escalated based on actual cost escalation in the southern California region from 2001 to 2012. Quantities and cost items were adjusted to reflect the adjusted tunnel segment lengths developed in this report. Annual costs for O&M were added considering costs equivalent to 0.5 percent of capital costs. Capital and annual costs for tunnels are summarized in Table B-4 of Appendix B.

6.5 Pumping Plants

Pumping plants are necessary on both Alignment Corridors 5A and 5C to overcome the elevation difference for transfer of Colorado River water from Imperial Valley to the San Vicente Reservoir. Two pump stations are needed for Alignment Corridor 5A with approximately 800 feet of pumping head each to overcome approximately 1,180 feet of elevation difference and dynamic losses. Five pump stations are needed for Alignment Corridor 5C with approximately 800 feet of pumping head each to overcome approximately 4,080 feet of elevation difference and dynamic losses. Detailed costs for pumping plants were developed in the 1996 Water Transfer Study and updated in the 2001 Feasibility Study Cost Refinement that will continue to be used for this report. Pumping plant costs include civil, structural, mechanical, and electrical costs along with the associated costs of the forebay.

Pumping plants are designed for 800 feet of pumping head with a 3+1 (3 duty + 1 standby) pump configuration with each pump sized for 162 cfs to convey the planned 280,200 AF/y of the Colorado River Conveyance project. Design criteria for pumping plants are presented in Section 4.6.6. Unit costs from the 2001 Feasibility Study Cost Refinement were escalated based on actual cost escalation in the southern California region from 2001 to 2012. Quantities from the 2001 Feasibility Study Cost Refinement were utilized. Annual costs for O&M and equipment replacement were escalated based on actual cost escalation and updated power costs. Capital and annual costs for pumping plants are summarized in Table B-5 of Appendix B.

6.6 Power Generating/Pressure Control Facilities

PGFs located on Alignment Corridor 5C would be capable of recovering energy and reducing the pressure within the pipeline as the alignment transitions from higher elevations crossing the mountain range to lower elevations approaching El Capitan Reservoir. Three PGFs on Alignment Corridor 5C would each reduce approximately 800 feet of pressure head to reduce the overall 2,350 feet of pressure head. A PCF is needed on both

Alignment Corridors 5A and 5C to reduce pressure in the pipeline at the San Vicente Reservoir Outfall Structure.

PGFs are designed for 800 feet of head at 487 cfs with vertical Pelton type turbines. PCFs are designed for the specific pressure reduction required for each alignment and include pressure reducing sleeve valves. Design criteria for PGFs/PCFs are presented in Section 4.6.7. Unit costs from the 2001 Feasibility Study Cost Refinement were escalated based on actual cost escalation in the southern California region from 2001 to 2012. Quantities from the 2001 Feasibility Study Cost Refinement were utilized. Annual costs for O&M and equipment replacement were escalated based on actual cost escalation and updated power costs. Capital and annual costs for pumping plants are summarized in Table B-6 of Appendix B.

6.7 Electric Transmission Lines

Electric transmission lines and substations are necessary to provide power to pumping plants and transmit power from PGFs. With the recent construction of the SDG&E Sunrise Powerlink Project, transmission lines and substation locations have been adjusted. One large 230 kV Substation and 230 kV transmission lines are needed to provide power to each pumping plant. A separate 230 kV transmission line was assumed to be required to connect to the existing Imperial Valley Substation since transmission of power to pumping plants from SDG&E's Sunrise Powerlink Project may not be feasible. One 69 kV Substation and 69 kV transmission lines are needed to transmit power from each PGF. Delivery of power to SDG&E's Powerlink Project was assumed to be acceptable since several solar and wind project are also providing power to SDG&E's project along its route.

Design criteria for electric transmission are presented in Section 4.6.8. Unit costs from the 2001 Feasibility Study Cost Refinement were escalated based on actual cost escalation in the southern California region from 2001 to 2012. Quantities and cost items were adjusted to reflect the adjusted transmission line lengths developed in this report. Annual costs for O&M were included with pumping plant and PGFs/PCFs annual costs. Capital and annual costs for electric transmission are summarized in Table B-7 of Appendix B.

6.8 Water Treatment

Based on the analysis conducted, the San Vicente Reservoir Blending Option was used for the lowest cost option for the water treatment for the CRCF. This option was not considered in prior studies. Blending Colorado River water in San Vicente Reservoir to address TDS and water quality would have no significant cost.

Costs were also developed for the Imperial Valley Treatment Option to provide estimated costs at the high end of the range of costs (see Appendix B, Tables B-8 and B-10). Estimated costs to implement the Imperial Valley Treatment Option would add approximately $1.7 billion in capital costs (2012 dollars) and $22 million per year in annual costs for either Alignment Corridor 5A or 5C.

6.9 Environmental Permitting

Environmental permitting is required for regulatory approval of the Colorado River Conveyance project including environmental mitigation. Both alignments will require environmental permitting and mitigation; however, since Alignment Corridor 5A is constructed in tunnels for approximately 50 percent of its length, fewer environmental impacts are anticipated.

Criteria for environmental permitting are presented in Section 4.9. Unit costs from the 2001 Feasibility Study Cost Refinement were escalated based on actual cost escalation in the southern California region from 2001 to 2012. Quantities from the 2001 Feasibility Study Cost Refinement were utilized. Annual costs for environmental permitting were not considered. Capital and annual costs for environmental permitting are summarized in Table B-9 of Appendix B.

6.10 Comparison with Prior Studies

An evaluation was conducted to compare probable construction costs of prior studies with the estimates prepared as part of this report using 2012 dollars. Results are summarized in Table 6-4.

TABLE 6-4
Probable Construction Cost Comparison

	Alignment Corridor 5A "Tunnel" Alignment		Alignment Corridor 5C "Pipeline" Alignment	
Study	**Capital Costs 300,000 AF/y (2012 Dollars)**	**Annual Operating Costs 300,000 AF/y (2012 Dollars)**	**Capital Costs 300,000 AF/y (2012 Dollars)**	**Annual Operating Costs 300,000 AF/y (2012 Dollars)**
1996 Water Transfer Study	$2,627,829,000	$74,309,000	$2,242,815,000	$93,487,000
2001 Feasibility Study Cost Refinement	$2,415,791,000	$68,900,000	$2,856,006,000	$105,800,000
2002 Feasibility Study	$1,831,000,000	$125,300,000	$2,827,000,000	$163,000,000
2012 Report[1]	$2,080,489,000	$66,159,000	$2,421,333,000	$124,300,000

[1]Cost for Average Annual Flow of 280,200 AF/y and using the Blending Option for treatment.

7.0 Implementation Schedule

7.1 Overview

The 1996 Water Transfer Study assumed a three-year period to prepare the environmental documentation, a three-year period to prepare the design, and a seven-year period for construction for a total of 13 years. These durations were updated in the 2001 Feasibility Study Cost Refinement to reflect the revised construction schedule for the tunnel segments of Alignment Corridor 5A of 10.4 years, resulting in different total project durations for each of the alignment corridors.

The implementation schedule for the CRCF was reevaluated as part of this study. New regulations, coordination with the resource agencies, and litigation have increased the duration to complete environmental documentation on large scale projects. Considering these factors, the environmental documentation phase was extended to four years. Two new tasks were added, preliminary design and agency agreement coordination, and would occur concurrently with the environmental documentation phase. Considering the facilities included in the project - canals, pipelines, tunnels, pump stations, PGFs/PCFs, electric transmission lines, and water treatment – the design phase of three years is appropriated, provided design of these facilities occurs concurrently. The construction durations developed from the detailed evaluation of tunnel construction in the 2001 Feasibility Study Cost Refinement were adopted. The implementation schedule sequence and duration is listed below and illustrated on Figure 7-1. The midpoint of construction is shown for purposes of escalating the probable construction cost.

- EIR/EIS, Preliminary Design, Agency Coordination — 4 years
- Design (All Facilities Concurrently) — 3 years
- Construction
  - Alignment Corridor 5A — 10.4 years
  - Alignment Corridor 5C — 7 years

7.2 Corridor 5A

The total project duration for Alignment Corridor 5A is 17.4 years. The midpoint of construction is February 2026.

7.3 Corridor 5C

The total project duration for Alignment Corridor 5C is 14 years. The midpoint of construction is June 2019.

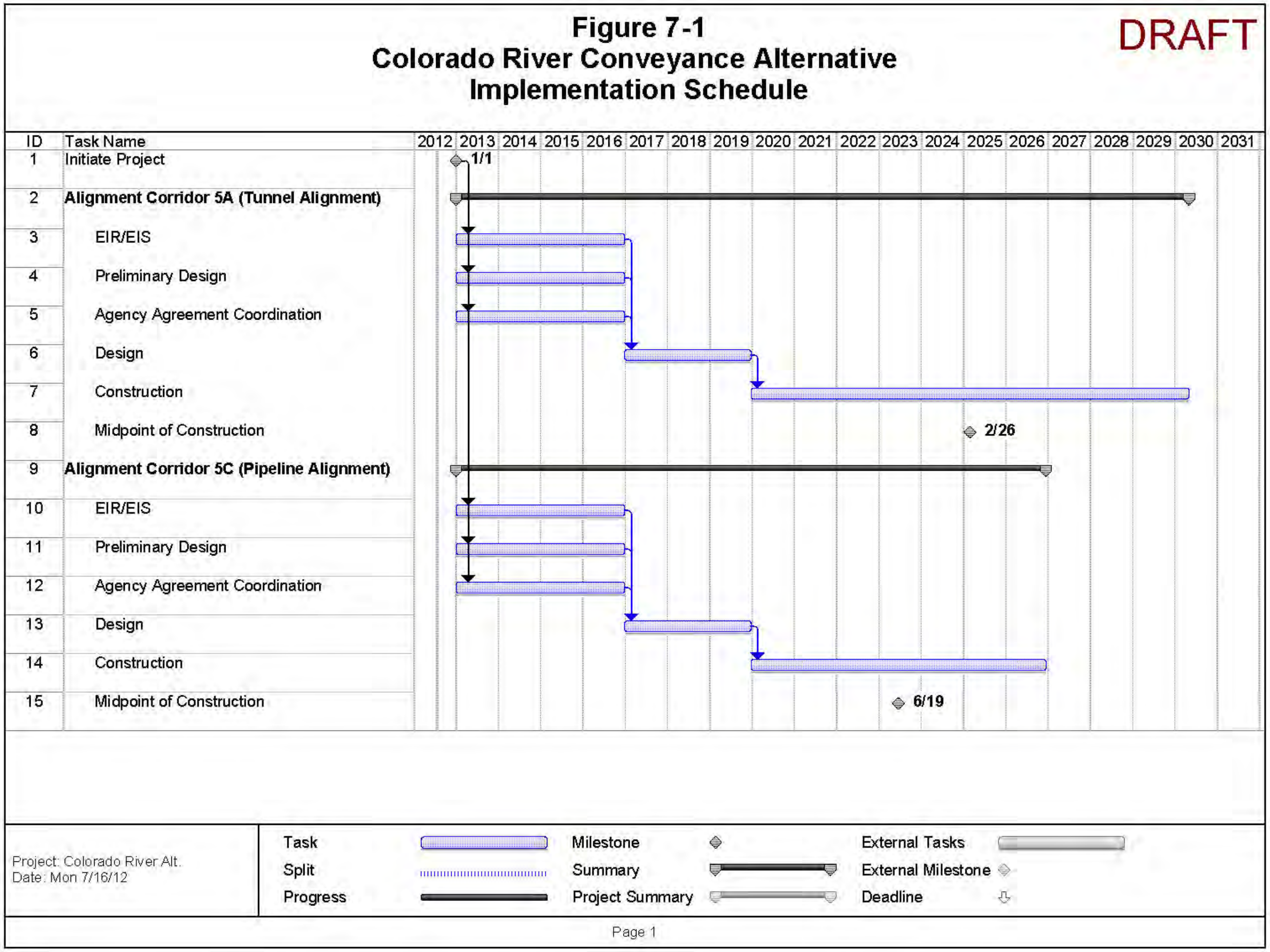


FIGURE 7-1
Colorado River Conveyance Alternative Implementation Schedule

Appendix A
Field Visit Photographs

Appendix B
Cost Estimates

Appendix C
Pipeline and Tunnel Construction Methods

Appendix D
Energy Management Strategy Evaluation

Appendix H
Detailed Cost Information

Cost Estimates

This appendix provides a detailed cost summary for development of project costs for the portfolio project options and for projects common to each portfolio. To account for the preliminary nature of the analysis, allowances for construction contingency and soft costs were applied to the project costs. The allowance assigned for construction contingency varied from 30 to 50 percent for the projects, depending upon how far along projects were in the planning stage. An allowance of 50 percent was applied for soft costs, which include permitting, legal, public outreach, investigations and surveys, engineering and design, construction management, administration, and insurance. An exception is for the several projects for which the Water Authority had previously developed cost estimates; when these estimates were utilized, the contingency and soft costs applied varied from those indicated above.

Based on the current understanding of each project's key design criteria and general assumptions regarding facility locations and configuration alternatives, this opinion is intended to provide a range of costs to bracket any alternatives within a project option. When required, costs were adjusted for inflation by applying a direct ratio of the *Engineering News Record* (ENR) "Construction Cost Index" (CCI) (ENR, 2012). At the time of the estimate, the Los Angeles ENR CCI was 10,283 (October 2012).The costs can be updated once the schedule has been further defined. The costs are feasibility-level costs equivalent to a Class 4 Estimate using the Water Authority's *Cost Estimating Guidelines* (Water Authority, 2008). As such, these estimates have a range of +30 to -20 percent accuracy.

Cost data are presented as follows:

- Project Option Capital Costs
  - Project Option Cost Summary
  - Camp Pendleton Desalination Project Cost Detail
  - Pipeline 6 Project Cost Detail
  - Pipeline 3/Pipeline 4 Conversion Project Cost Detail (including Pipeline 6 Extension)
- Projects Common to Each Portfolio Costs
  - Project Cost Summary
  - Mission Trails Project Cost Detail
  - System Isolation Valves Project Cost Detail
  - System Regulatory Storage Project Cost Detail
  - San Vicente 3rd Pump Drive and Power Project Cost Detail
  - North County Pump Station Project Cost Detail
  - Second Crossover Pipeline Project Cost Detail

San Diego County Water Authority
2013 Master Plan Updated
Project Option Capital Costs

Project Option	Capital Cost ($ million)		
Camp Pendleton Desalination[1]			
50 MGD	$1,420	to	$1,530
100 MGD	$2,070	to	$2,370
150 MGD	$2,660	to	$3,110
Pipeline 6[2]	$440		
Colorado River Conveyance[1]	$2,090	to	$2,430
P3/P4 Conversion[3]	$69		
P6 Extension[2]	$200		

[1] Costs are shown are October 2012 dollars. Unless otherwise noted, costs include an allowance of 30% for construction contingency and an allowance of 25% for implementation (permitting, legal, engineering, etc.).

[2]Costs shown are October 2012 dollars. To be consistent with the Pipeline 6 Feasibility and Alignment Study, costs include 30% contingency for alignment and 50% for tunnel segments. Soft costs are also included, consistent with the study.

[3]Costs shown are October 2012 dollars and include an allowance of 50% for construction contingency and an allowance of 50% for implementation (permitting, legal, engineering, etc).

Camp Pendleton Seawater Desalination Project

Raw Water - Capital Cost[1] Detail

Alt.	Plant Site	Intake Type	Plant Production Capacity		
			50 mgd	100 mgd	150 mgd
1	MCTSSA	Open Ocean	$1,412,000,000	$2,097,000,000	$2,687,000,000
2	MCTSSA	Subsurface	$1,527,000,000	$2,366,000,000	$3,104,000,000
3	SRTTP	Open Ocean	$1,415,000,000	$2,066,000,000	$2,656,000,000
4	SRTTP	Subsurface	$1,513,000,000	$2,318,000,000	$3,056,000,000

Notes:

1. 2012 Dollars
2. 25% Implementation (Engineering, Legal, Admin, CM, Mitigation, etc.)
3. 30% Contingency (Level 4 Cost Estimate, -20% to +30% Accuracy)
4. Includes initial high service pump station
5. Preferred Southern Alignment, including Intermediate PS and forebay
6. Costs provided by Water Authority.

Range represented by:

Low cost

High cost

Camp Pendleton Desalination Cost Summary

Project Option	Capital Cost[1]		
Camp Pendleton Desalination			
50 MGD	$1,412,300,000	to	$1,526,600,000
100 MGD	$2,065,680,000	to	$2,365,600,000
150 MGD	$2,655,980,000	to	$3,103,500,000

[1] Costs shown are October 2012 dollars. Unless otherwise noted, costs include an allowance of 30% for

ALTERNATIVE #1: MCTSSA SITE / OPEN OCEAN INTAKE

Capacity	Intake / Discharge Infrastructure (RBF)	Desalination Plant Site[4] (GHD)	Product Water Conveyance[5] (B&V)			Total
MGD	SUBTOTAL[6]	SUBTOTAL[6]	Pipeline	IPS / Tanks	SUBTOTAL	Capital Cost
50	$401,200,000	$698,000,000	$290,000,000	$23,100,000	$313,100,000	$1,412,300,000
100	$410,800,000	$1,350,100,000	$290,000,000	$45,900,000	$335,900,000	$2,096,800,000
150	$420,400,000	$1,921,000,000	$290,000,000	$55,700,000	$345,700,000	$2,687,100,000

ALTERNATIVE #2: MCTSSA SITE / SUBSURFACE INTAKE

Capacity	Intake / Discharge Infrastructure (RBF)	Desalination Plant Site[4] (GHD)	Product Water Conveyance[5] (B&V)			Total
MGD	SUBTOTAL[6]	SUBTOTAL[6]	Pipeline	IPS / Tanks	SUBTOTAL	Capital Cost
50	$543,400,000	$670,100,000	$290,000,000	$23,100,000	$313,100,000	$1,526,600,000
100	$735,600,000	$1,294,100,000	$290,000,000	$45,900,000	$335,900,000	$2,365,600,000
150	$920,800,000	$1,837,000,000	$290,000,000	$55,700,000	$345,700,000	$3,103,500,000

ALTERNATIVE #3: SRTTP SITE / OPEN OCEAN INTAKE

Capacity	Intake / Discharge Infrastructure (RBF)	Desalination Plant Site[4] (GHD)	Product Water Conveyance[5] (B&V)			Total
MGD	SUBTOTAL[6]	SUBTOTAL[6]	Pipeline	IPS / Tanks	SUBTOTAL	Capital Cost
50	$449,200,000	$663,680,000	$279,000,000	$23,100,000	$302,100,000	$1,414,980,000
100	$458,800,000	$1,281,980,000	$279,000,000	$45,900,000	$324,900,000	$2,065,680,000
150	$468,400,000	$1,852,880,000	$279,000,000	$55,700,000	$334,700,000	$2,655,980,000

ALTERNATIVE #4: SRTTP SITE / SUBSURFACE INTAKE

Capacity	Intake / Discharge Infrastructure (RBF)	Desalination Plant Site[4] (GHD)	Product Water Conveyance[5] (B&V)			Total
MGD	SUBTOTAL[6]	SUBTOTAL[6]	Pipeline	IPS / Tanks	SUBTOTAL	Capital Cost
50	$575,400,000	$635,780,000	$279,000,000	$23,100,000	$302,100,000	$1,513,280,000
100	$767,600,000	$1,225,980,000	$279,000,000	$45,900,000	$324,900,000	$2,318,480,000
150	$952,800,000	$1,768,880,000	$279,000,000	$55,700,000	$334,700,000	$3,056,380,000

*updated to indicate revised Reach 2C and Reach 2D as preferred.

Pipeline 6 Project
Cost Detail

Source: San Diego P6 Feasibility and Alignment Study (TM No. 4), by MWH, dated December 19, 2008

December 2008 LA ENR CCI	9823.19
October 2012 LA ENR CCI	10283.18

Pipeline Alternatives

Option	Pipeline Alignment	Total Length (LF)	Construction Cost[2] (Dec 2008)	Tunnel Length (LF)	Open Trench Length (LF)	Percentage Tunnel	Percentage Open Trench	Construction Cost (Oct 2012)	Cost w/Soft Costs [3]	
1	West	57,200	$281,700,000	4,174	53,026	7%	93%	$294,891,151	$387,486,972	WA indicated this is preferred alternative
2	East	90,400	$547,800,000	29,404	60,996	33%	67%	$573,451,802	$573,451,802	
3	Central	63,600	$319,600,000	4,800	58,800	8%	92%	$334,565,892	$334,565,892	
4	2A	74,200	$391,900,000	10,057	64,143	14%	86%	$410,251,481	$410,251,481	

Structures

Option[1]	Facility	Construction Cost (Dec 2008)	Construction Cost (Oct 2012)	Cost w/ Soft Costs[4]
A	P6 FCHF	$30,500,000	$31,928,222	$45,689,286
B	Twin Oaks PCHF	$26,500,000	$27,740,914	$39,697,248
C	6MG Circular Concrete Tank (FRS II Alternative)	$26,700,000	$27,950,279	$27,950,279
D	15 MG Circular Concrete Tank FRS II Alternative)	$21,500,000	$22,506,779	$22,506,779
E	Rectangle FRS Alternative	$42,000,000	$43,966,732	$43,966,732

[1] Per input from the WA, storage shall be provided as part of the System Regulatory Storage Project; thus only the FCHF and PCHF structures are included in the P6 project cost.

[2]Costs include 30% contingency for alignment and control structures, and 50% for tunnel segments

[3] Soft costs are as outlined in the P6 Study and include markup for design (8.3%), construction management (10%), other consultants (5%), Water Authority Labor (3%), Water Authority Exepenses (0.1%) and CIP overhead (5%)

[4] Soft costs are as outlined in the P6 Study and include markup for design (15%), construction management (15%), other consultants (5%), Water Authority Labor (3%), Water Authority Expenses (0.1%), and CIP overhead (5%)

Cost

Option	Cost w/ Contingency and Implementation[1]
1 w/ A	$433,176,258

[1]Per input from the WA, storage shall be provided as part of the System Regulatory Storage Project; thus only the FCHF and PCHF structures are included in the P6 project cost.

Pipeline 6 Project Cost Summary

Project Option	Capital Cost[1] ($ million)
Pipeline 6[2]	$433,177,000

[1] Costs are shown are October 2012 dollars.

[2] To be consistent with the Pipeline 6 Feasibility and Alignment Study, costs include 30% contingency for alignment and control structures, and 50% for tunnel segments. Soft costs are also included, consistent with the study.

Colorado River Conveyance Project
Cost Detail

May 2012 LA ENR CCI 10300.05
October 2012 LA ENR CCI 10283.18

ESTIMATED CAPITAL COSTS

Source: (orginated from Colorado River Conveyance Alternative Letter Report, by Black & Veatch and dated September 2012)

ITEM	May 2012 Costs		October 2012 Costs		
	CORRIDOR 5A "TUNNEL"	CORRIDOR 5C "PIPELINE"	CORRIDOR 5A "TUNNEL"	CORRIDOR 5C "PIPELINE"	
Canals	$10,328,000	$1,790,000	$10,311,084	$1,787,068	
Pipelines	$206,121,000	$759,458,000	$205,783,403	$758,214,117	
Tunnels	$969,507,000	$370,369,000	$967,919,087	$369,762,389	
Pumping Plants	$85,387,000	$213,468,000	$85,247,148	$213,118,370	
Power Generating/Pressure Control Facilities	$26,353,000	$150,877,000	$26,309,838	$150,629,885	
Electric Transmission Lines	$33,906,000	$46,074,000	$33,850,467	$45,998,537	
Water Treatment	$0	$0	$0	$0	
Environmental Permitting/Mitigation	$12,852,000	$22,677,000	$12,830,950	$22,639,858	
SUBTOTAL	$1,344,454,000	$1,564,713,000	$1,342,251,978	$1,562,150,225	$1,344,454,000
Contingency (30%)	$403,336,200	$469,413,900	$402,675,593	$468,645,068	
Implementation (25%)	$336,113,500	$391,178,250	$335,562,994	$390,537,556	
TOTAL COST	$2,083,903,700	$2,425,305,150	**$2,080,490,566**	**$2,421,332,849**	

Low cost
High cost

Colorado River Conveyance Cost Summary

Project Option	Capital Cost[1]		
Colorado River Conveyance	$2,080,491,000	to	$2,421,333,000

[1] Costs are shown are October 2012 dollars. Unless otherwise noted, costs include an allowance of 30% for construction contingency and an allowance of 25% for implementation (permitting, legal, engineering, etc.).

Proposed Pipeline 3 and 4 Conversion Project
Cost Detail

*Source: FY 14-15 Master Plan CIP Projects; B&V Master Plan Costs spreadsheet/Unit Cost Tool (December 2011)

December 2011 LA ENR CCI	10088.00	(Unit Cost Tool)
October 2012 LA ENR CCI	10283.18	
September 2006 LA ENR CCI	8572.47	(San Vicente Pump Station)
June 2007 LA ENR CCI	8854.77	(PBS&J North County Memo)

Pipelines 3 and 4 Conversion Unit Costs

Description	Unit	December 2011 - Unit Cost	October 2012 - Unit Cost	Notes			
90" Steel Pipe*	LF	$2,110	$2,151	extrapolated between 96-inch and 84-inch pipe; includes fittings, tees, elbows, and caps.			
76" Steel Pipe*	LF	$1,600	$1,631	extrapolated between 84-inch and 72-inch pipe; includes fittings, tees, elbows, and caps.			
72" Steel Pipe*	LF	$1,490	$1,519	includes fittings, tees, elbows, and caps.			
48" Steel Pipe*	LF	$820	$836	includes fittings, tees, elbows, and caps.			
36" Steel Pipe*	LF	$550	$561	includes fittings, tees, elbows, and caps.			
24" Steel Pipe*	LF	$325	$331	includes fittings, tees, elbows, and caps.			
Connection to Pipe	Ea	--	$200,000	includes demo, excavation, vault ($100,000), BFV ($50,000), and fittings. See costs developed for CIP.	72" BFV cost from vendor w/ added equipment and labor (early 2013). Scaled down to 24". Vault cost from SVPS Estimate:	$	97,164
Connection to inlet pipe at FCFs	inch of pipe diameter	--	$400	Scaled down from 2006 SVPS 90" Connection Cost of $24,354. Includes additional $75 per inch to account for demo, excavation, and capping existing connection.			
Easement	acre	--	$50,000	provided by WA			
Tunneling	lf	--	$2,250				
Mobilization	LS	--	10%	of total cost			

Contingency	50%
Soft Costs	50%

Pipelines 3 and 4 Conversion Cost (October 2012)

Facility	Description	Quantity	Unit	Unit Cost	Total Cost
P4 Extension	75" Pipe	6,240	lf	$1,631	$10,177,168
	P3 Connection (75-inch)	1	ea	$29,970	$29,970
	P4 Connection (36-inch)	1	ea	$14,386	$14,386
	36" Pipe	8,320	lf	$561	$4,664,535
	Tunnel under I-15 and creek	1,800	lf	$2,250	$4,050,000
	Connection to WR-26/27 (36-inch)	1	ea	$14,386	$14,386
	Mobilization				$1,895,044
SUBTOTAL					$20,845,489
DLZ 1	24" Pipe	2,720	lf	$331	$901,103
	Connection to DLZ 1 inlet line	1	ea	$9,590	$9,590
	Mobilization				$91,069
SUBTOTAL					$1,001,763
RB9	24" Pipe	50	lf	$331	$16,564
	Connection to RB9 inlet line	1	ea	$9,590	$9,590
	Mobilization				$2,615
SUBTOTAL					$28,770
FB6	24" Pipe	3,350	lf	$331	$1,109,815
	Connection to FB6 inlet line	1	ea	$400	$400
	Mobilization				$111,021
SUBTOTAL					$1,221,236
DLZ 1 / RB9 / FB6	48" Pipe (Preferred Freeway Crossing)	7,275	lf	$836	$6,080,919
	Connection to P3	1	ea	$250,000	$250,000
	Valve Vault	1	ea	$250,000	$250,000
	Mobilization				$658,092
SUBTOTAL					$7,239,011

RB8	24" Pipe	1,820	lf	$331	$602,944
	Connection to RB8 inlet line	1	ea	$9,590	$9,590
	Connection to P3	1	ea	$200,000	$200,000
	Mobilization				$81,253
SUBTOTAL					$893,788
RB7	24" Pipe	55	lf	$331	$18,221
	Connection to RB7 inlet line	1	ea	$9,590	$9,590
	Connection to P3	1	ea	$200,000	$200,000
	Mobilization				$22,781
SUBTOTAL					$250,592
FB4	24" Pipe	50	lf	$331	$16,564
	Connection to FB4 inlet line	1	ea	$9,590	$9,590
	Connection to P3	1	ea	$200,000	$200,000
	Mobilization				$22,615
SUBTOTAL					$248,770
RB6	24" Pipe	95	lf	$331	$31,472
	Connection to RB6 inlet line	1	ea	$9,590	$9,590
	Connection to P3	1	ea	$200,000	$200,000
	Mobilization				$24,106
SUBTOTAL					$265,169
VC4	24" Pipe	40	lf	$331	$13,252
	Connection to VC4 inlet line	1	ea	$9,590	$9,590
	Connection to P3	1	ea	$200,000	$200,000
	Mobilization				$22,284
SUBTOTAL					$245,126
VCPP04 / VC8	24" Pipe	80	lf	$331	$26,503
	Connection to VCPP04 inlet line	1	ea	$9,590	$9,590
	Connection to P3	1	ea	$200,000	$200,000
	Mobilization				$23,609
SUBTOTAL					$259,703
RB3	24" Pipe	40	lf	$331	$13,252
	Connection to RB3 inlet line	1	ea	$9,590	$9,590
	Connection to P3	1	ea	$200,000	$200,000
	Mobilization				$22,284
SUBTOTAL					$245,126
VC7	24" Pipe	25	lf	$331	$8,282
	Connection to VC7 inlet line	1	ea	$9,590	$9,590
	Connection to P3	1	ea	$200,000	$200,000
	Mobilization				$21,787
SUBTOTAL					$239,660
OC3	24" Pipe	55	lf	$331	$18,221
	Connection to OC3 inlet line	1	ea	$9,590	$9,590
	Connection to P3	1	ea	$200,000	$200,000
	Mobilization				$22,781
SUBTOTAL					$250,592
OC2	24" Pipe	50	lf	$331	$16,564
	Connection to OC2 inlet line	1	ea	$9,590	$9,590
	Connection to P4	1	ea	$200,000	$200,000
	Mobilization				$22,615
SUBTOTAL					$248,770
NCDP	72" Pipe	110	lf	$1,519	$167,071
	NCDP FCF	1	ea	$9,590	$9,590
	Connection to P3	1	ea	$200,000	$200,000
	Mobilization				$37,666
SUBTOTAL					$414,328
Crossover P3-->P4	90" Pipe	55	lf	$2,151	$118,295
	Connections	2	ea	$35,964	$71,928
	Mobilization				$19,022
SUBTOTAL					$209,246
Crossover P4-->P3	76" Pipe	55	lf	$1,600	$88,000
	Connections	2	ea	$30,370	$60,739
	Mobilization				$14,874
SUBTOTAL					$163,613
SUBTOTAL					**$ 34,270,753**
Contingency					**$ 17,135,377**
Soft Costs					**$ 17,135,377**
Easement (48" pipe from DLZ 1 / RB9 / FB6 to P3; 8 acres)					**$ 400,000.00**
TOTAL					**$ 68,941,506**

Pipeline 6 Extension - Unit Cost

Description	Unit	October 2012-Unit Cost	Notes
120" Steel Pipe	LF	$6,774	Utilizes unit cost from P6 alternative with minimal tunneling; includes contingencies and soft costs noted on P6 tab; no additional contingency required
Connection to Pipe	Ea	$400,000	Includes demo, excavation, vault ($80,000), BFV ($250,000), and fittings. See costs developed for CIP.

WA indicated that the extension between P3 and P4 should indicate 90 inches in the project description.

December 2008 LA ENR CCI	9823.19
October 2012 LA ENR CCI	10283.18

Pipeline 6 Extension Cost (October 2012)

Facility	Description	Quantity	Unit	Unit Cost	Total
P6 Extension	120" Pipe	28,850	lf	$6,774	$195,437,048
	Connection	1	ea	$400,000	$400,000
	Connection to P4	1	ea	$400,000	$400,000
TOTAL					$ 196,237,048

Pipelines 3 and 4 Conversion Summary

Facility	Cost[1]
P4 Extension	$20,846,000
DLZ 1	$1,002,000
RB9	$29,000
FB6	$1,222,000
DLZ 1 / RB9 / FB6	$7,240,000
RB8	$894,000
RB7	$251,000
FB4	$249,000
RB6	$266,000
VC4	$246,000
VCPP04 / VC8	$260,000
RB3	$246,000
VC7	$240,000
OC3	$251,000
OC2	$249,000
NCDP	$415,000
Crossover P3-->P4	$210,000
Crossover P4-->P3	$164,000
SUBTOTAL	$34,280,000
Contingency	$17,140,000
Soft Costs	$17,140,000
Easement	$400,000
TOTAL	$68,960,000

[1] Costs shown are October 2012 dollars. Costs include an allowance of 50% for construction contingency and an allowance of 50% for implementation (permitting, legal, engineering, etc.)

Pipeline 6 Extension Cost Summary

Facility	Cost[1]
P6 Extension	$196,238,000
TOTAL	$196,238,000

[1] Costs shown are October 2012 dollars. To be consistent with the Pipeline 6 Feasibility and Alignment Study, costs include 30% contingency for alignment and 50% for tunnel segments.

San Diego County Water Authority
2013 Master Plan Updated
Projects Common to Each Portfolio - Capital Costs

Near Term Project	Capital Cost ($)
Mission Trails	
Alternative 1[1]	$43,848,000 to $53,059,000
Alternative 2[2]	$3,065,000
System Isolation Valves[2]	$11,000,000
System Regulatory Storage[2]	$56,153,000 to $97,469,000
San Vicente 3rd Pump Drive and Power[2]	$16,093,000 to $31,949,000
North County Pump Station[3]	$23,450,000 to $37,424,000
Second Crossover Pipeline	$371,040,000

[1] Costs originated from the Mission Trails FRS II 100% Cost Estimate; August 2007 (O'Connor CM Inc. for HDR). Costs shown are October 2012 dollars and include an allowance of 10% for soft costs and a lump sum of $500K for final design.

[2] Costs are shown are October 2012 dollars. Unless otherwise noted, costs include an allowance of 50% for construction contingency and an allowance of 50% for implementation (permitting, legal, engineering, etc.)

[3] Costs shown are October 2012 dollars and include an allowance of 30% for construction contingency and an allowance of 50% for implementation (permitting, legal, engineering, etc.)

Mission Trails Cost Summary

Description	Cost
Alternative 1a[1]	$ 53,059,000
Alternative 1b[1]	$ 43,848,000
Alternative 2[2]	$ 3,065,000

[1]Costs originated from the Mission Trails FRS II 100% Cost Estimate; August 2007 (O'Connor CM Inc. for HDR). Costs shown are October 2012 dollars and include an allowance of 10% for soft costs and a lump sum of $500K for final design.

[2] Costs shown are October 2012 dollars. Costs include an allowance of 50% for construction contingency and an allowance of 50% for implementation (permitting, legal, engineering, etc.)

Isolation Valves Cost Summary `

Description	Cost[1]
San Luis Rey River Crossing at P5 (1 valve)	$1,375,000
Between San Luis Rey River and TOV WTP at P4 (1 valve)	$1,375,000
Mission Trails at P3 (1 valve)	$1,375,000
Otay at SR-125 at P4 (1 valve)	$1,375,000
SUBTOTAL	**$5,500,000**
Contingency	**$2,750,000**
Soft Costs	**$2,750,000**
TOTAL	**$11,000,000**

[1] Costs shown are October 2012 dollars and include valves, reducers, vaults, and mobilization. Total cost includes an allowance of 50% for construction contingency and an allowance of 50% for implementation (permitting, legal, engineering, etc.)

System Regulatory Storage Cost Summary

Description	Cost[1]
Project w/ one 5 MG Reservoir at TOV WTP and One 3 MG Reservoir at the First Aqueduct/Valley Center Pipeline	$56,153,000
Project w/ Two 10 MG Reservoir at TOV WTP and One 3 MG Reservoir at the First Aqueduct/Valley Center Pipeline	$97,469,000

[1] Costs shown are October 2012 dollars and include valves, reducers, vaults, and mobilization. Costs include an allowance of 50% for construction contingency and an allowance of 50% for implementation (permitting, legal, engineering, etc.)

San Vicente 3rd Pump Power and Drive Cost Summary

Description	Cost[1]
Electrical Power Option	$ 31,949,000
Natural Gas Power Option	$ 27,732,000
Diesel Generator Option	$ 16,093,000

[1] Costs shown are October 2012 dollars. Costs include an allowance of 50% for construction contingency and an allowance of 50% for implementation (permitting, legal, engineering, etc.)

North County Pump Station Cost Summary `

Description	Cost[1]
Red Mtn Reservoir Site w/out P3/P4 Conversion OR P3 Site w/ P3/P4 Conversion	$23,450,000
Red Mtn Reservoir Site w/ P3/P4 Conversion	$37,424,000
Site South of RB8 w/ P3/P4 Conversion	$34,625,000

[1] Costs shown are October 2012 dollars. Costs include an allowance of 30% for construction contingency and an allowance of 50% for implementation (permitting, legal, engineering, etc.)

Second Crossover Pipeline Cost Summary

Description	Cost[1]
Second Crossover Pipeline	$371,040,000

[1] Costs include continency and soft costs.

Mission Trails Project
Cost Detail

January 2013 LA ENR CCI	10276.68	(B&V estimate)
October 2012 LA ENR CCI	10283.18	
December 2011 LA ENR CCI	10088.00	(Unit Cost Tool)
March 2009 LA ENR CCI	9799.19	(ESA Estimate)
August 2007 LA ENR CCI	8863.27	(FRS II 100% Cost Estimate; O'Connor for HDR)
September 2006 LA ENR CCI	8572.47	(SVPS Estimate)
June 2007 LA ENR CCI	8854.77	(PBS&J North County Memo)

October 2012 Unit Cost

Alternative 2 Unit Cost Data

Item	Unit	Unit Cost	
Reservoir	MG	$1,252,000	
FCF	Ea	$10,600,000	per MP CIP Budget; no contingency required
48" Pipeline	LF	$836	from Unit Cost Tool
P3 Connection	ea	$150,000	B&V estimate
P4 Connection w/ Valves and Vault	ea	$825,000	see Isolation Valve tab
Land Acquisition	acre	$35,000	provided by WA

Contingency	50%
Soft Costs	50%

Mission Trails Cost (October 2012)

Description	Quantity	Unit	Unit Cost	Total Cost	
Alternative 1a (12 MG Reservoir)					
Mission Trails FRS II 100% Cost Estimate; August 2007 (O'Connor CM Inc. for HDR)		LS		$ 33,198,722	
FCF	1	ea	$10,600,000	$ 10,600,000	
SUBTOTAL (OCT 2012)				**$ 43,798,722**	
Soft Costs (20%)				**$ 8,759,744**	Per WA input
Final Design				**$ 500,000**	
TOTAL				**$ 53,058,467**	
Alternative 1b (3MG Reservoir)					
Mission Trails FRS II 100% Cost Estimate; August 2007 (O'Connor CM Inc. for HDR)		LS		$ 53,058,467	
Mission Trails FRS II 100% Cost Estimate; 12 MG Reservoir Cost		LS		$ 12,966,486	
3 MG Reservoir	3	MG	$1,252,000	$ 3,756,000	
TOTAL[1]				**$ 43,847,981**	
Alternative 2					
48" Pipe	500	LF	$836	$ 417,933	assumes PL in street ROW
P3 Connection	1	ea	$150,000	$ 150,000	
P4 Connection with two valves and vault	1	ea	$825,000	$ 825,000	
Mobilization		LS		$ 139,293	
SUBTOTAL				**$ 1,532,226**	
Contingency				**$ 766,113**	
Soft Costs				**$ 766,113**	
TOTAL				**$ 3,064,452**	

[1] Total calculated by taking difference between 100% Estimate for 12 MG Reservoir and B&V cost for 3MG Reservoir, and subtracting from 100% Estimate total.

Mission Trails Cost Summary

`

Description	Cost	
Alternative 1a (12 MG Reservoir)[1]	$	53,059,000
Alternative 1b (3 MG Reservoir)[1]	$	43,848,000
Alternative 2[2]	$	3,065,000

[1]Costs originated from the Mission Trails FRS II 100% Cost Estimate; August 2007 (O'Connor CM Inc. for HDR). Costs shown are October 2012 dollars and include an allowance of 10% for soft costs and a lump sum of $500K for final design.

[2]Costs shown are October 2012 dollars. Costs include an allowance of 50% for construction contingency and an allowance of 50% for implementation (permitting, legal, engineering, etc.)

OR

Mission Trails Cost Summary

Description	Cost			
Alternative 1[1]	$43,848,000	to	$	53,059,000
Alternative 2[2]	$3,065,000			

[1]Costs originated from the Mission Trails FRS II 100% Cost Estimate; August 2007 (O'Connor CM Inc. for HDR). Costs shown are October 2012 dollars and include an allowance of 10% for soft costs and a lump sum of $500K for final design.

[2]Costs shown are October 2012 dollars. Costs include an allowance of 50% for construction contingency and an allowance of 50% for implementation (permitting, legal, engineering, etc.)

System Isolation Valves
Cost Detail

January 2013 LA ENR CCI	10276.68	
October 2012 LA ENR CCI	10283.18	
September 2006 LA ENR CCI	8572.47	
December 2011 LA ENR CCI	10088.00	(Unit Cost Tool)

October 2012 Unit Cost

Item	Oct 2012 Unit Cost	
Piping, Fittings, and BFV for P3, P4, or P5	$650,000	includes demo of existing piping and installation of new piping, valves, and fittings
Cast-in-place concrete vault for P3, P4, or P5	$175,000	
Shutdown	$200,000	assume 2 shutdowns per valve per Water Authority input
Isolation Valve Bypass	$25,000	includes 12-inch valve and piping
Mobilization and sitework	10%	of total cost per location

Contingency	50%
Soft Costs	50%

Isolation Valves Cost (October 2012)

Description	Quantity	Unit	Unit Cost	Total Cost
San Luis Rey River Crossing at P5				
Piping, Fittings, and Valves	1	ea	$650,000	$ 650,000
Vaults	1	ea	$175,000	$ 175,000
Shutdown	2	ea	$200,000	$ 400,000
Bypass	1	ea	$25,000	$ 25,000
Mobilization		Lump Sum		$ 125,000
SUBTOTAL				$ 1,375,000
Between San Luis Rey River and Twin Oaks at P4				
Piping, Fittings, and Valves	1	ea	$650,000	$ 650,000
Vaults	1	ea	$175,000	$ 175,000
Shutdown	2	ea	$200,000	$ 400,000
Bypass	1	ea	$25,000	$ 25,000
Mobilization		Lump Sum		$ 125,000
SUBTOTAL				$ 1,375,000
Mission Trails at P3				
Piping, Fittings, and Valves	1	ea	$650,000	$ 650,000
Vaults	1	ea	$175,000	$ 175,000
Shutdown	2	ea	$200,000	$ 400,000
Bypass	1	ea	$25,000	$ 25,000
Mobilization		Lump Sum		$ 125,000
SUBTOTAL				$ 1,375,000
Otay at SR-125 at P4				
Piping, Fittings, and Valves	1	ea	$650,000	$ 650,000
Vaults	1	ea	$175,000	$ 175,000
Shutdown	2	ea	$200,000	$ 400,000
Bypass	1	ea	$25,000	$ 25,000
Mobilization		Lump Sum		$ 125,000
SUBTOTAL				$ 1,375,000
SUBTOTAL				**$ 5,500,000**
Contingency				**$ 687,500**
Soft Costs				**$ 687,500**
TOTAL				**$ 6,875,000**

Isolation Valves Cost Summary

`

Description		Cost[1]
San Luis Rey River Crossing at P5 (1 valve)	$	1,375,000
Between San Luis Rey River and TOV WTP at P4 (1 valve)	$	1,375,000
Mission Trails at P3 (1 valve)	$	1,375,000
Otay at SR-125 at P4 (1 valve)	$	1,375,000
SUBTOTAL	**$**	**5,500,000**
Contingency	**$**	**2,750,000**
Soft Costs	**$**	**2,750,000**
TOTAL		**$11,000,000**

[1] Costs shown are October 2012 dollars and include valves, reducers, vaults, and mobilization. Costs include an allowance of 50% for construction contingency and an allowance of 50% for implementation (permitting, legal, engineering, etc.)

System Regulatory Storage Project
Cost Detail

January 2013 LA ENR CCI	10276.68 (Ramiro estimate)
October 2012 LA ENR CCI	10283.18
December 2011 LA ENR CCI	10088.00 (Unit Cost Tool)
September 2011 LA ENR CCI	10076.80 (Jamacha Estimate)
March 2009 LA ENR CCI	9799.19 (ESA Estimate)
June 2007 LA ENR CCI	8854.77 (PBS&J North County Memo)
April 2007 LA ENR CCI	8874.82 (CAPS Estimate)
September 2006 LA ENR CCI	8572.47 (SVPS Estimate)
December 2003 LA ENR CCI	7531.77 (RPPCHF Estimate)

October 2012 Unit Cost

Item	Unit	Unit Cost	
Reservoir	MG	$1,252,000	originated from Mission Trails tab
Demolition of FCF and Rejection Tower	LS	$560,000	Jamacha estimate (880 sf; $285000 for Phase 2 Demo; ~$330/sf)
Rehab Existing Pressure Control Facility	ea	$5,000,000	Per discussion w/ WA; includes contingency and soft costs
Pressure Control Facility (First Aq/ Valley Center PL)	ea	$2,000,000	Per WA input
Pipeline Connection	ea	$150,000	
Connection w/ valve and vault	ea	$825,000	see Isolation Valve tab
96" Piping	LF	$2,372	from Unit Cost Tool
72" Piping	LF	$1,516	from Unit Cost Tool
60" Piping	LF	$1,154	from Unit Cost Tool
Land Acquisition	acre	$50,000	provided by WA
Easement	acre	$50,000	provide by WA
Mobilization	LS	10%	of total cost

Contingency	50%
Soft Costs	50%

System Regulatory Storage (October 2012)
Twin Oaks Location

Description	Quantity	Unit	Unit Cost	Total Cost
5 MG Reservoir				
Reservoir (5MG)	5	MG	$1,252,000	$6,260,000
Demolition of FCF and Rejection Tower		LS		$ 560,000
Rehab Existing Pressure Control Facility	1	ea	$5,000,000	$ 5,000,000
P5 Connection	3	ea	$150,000	$ 450,000
TOFRS Connection w/ Valve and Vault	1	ea	$825,000	$ 825,000
Reservoir Piping Connection w/ Valve and Vault	1	ea	$825,000	$ 825,000
96" Piping (to/from reservoir)	2,500	LF	$2,372	$ 5,930,055
72" Piping (P5 to TOFRS)	300	LF	$1,516	$ 454,731
Mobilization		LS		$ 2,030,479
SUBTOTAL				**$ 22,335,265**
Contingency[1]				**$ 8,667,633**
Soft Costs[1]				**$ 8,667,633**
Land Acquisition (10 acres)				**$ 500,000**
Easement (3 acres)				**$ 150,000**
TOTAL				**$ 40,320,530**
10 MG Reservoir (2-5 MG or 1-10 MG)				
Reservoir (5MG)	10	MG	$1,252,000	$ 12,520,000
Demolition of FCF and Rejection Tower		LS		$ 560,000
Rehab Existing Pressure Control Facility	1	ea	$5,000,000	$ 5,000,000
P5 Connection	3	ea	$150,000	$ 450,000
TOFRS Connection w/ Valve and Vault	1	ea	$825,000	$ 825,000
Reservoir Piping Connection w/ Valve and Vault	1	ea	$825,000	$ 825,000
96" Piping (to/from reservoir)	2500	LF	$2,372	$ 5,930,055
72" Piping (P5 to TOFRS)	300	LF	$1,516	$ 454,731
Mobilization		LS		$ 2,656,479
SUBTOTAL				**$ 29,221,265**
Contingency[1]				**$ 12,110,633**
Soft Costs[1]				**$ 12,110,633**
Land Acquisition (10 acres)				**$ 500,000**
Easement (3 acres)				**$ 150,000**
TOTAL				**$ 54,092,530**
20 MG Reservoir (2-10 MG)				
Reservoir (10MG)	20	MG	$1,252,000	$ 25,040,000
Demolition of FCF and Rejection Tower		LS		$ 560,000
Rehab Existing Pressure Control Facility	1	ea	$5,000,000	$ 5,000,000
P5 Connection	3	ea	$150,000	$ 450,000
TOFRS Connection w/ Valve and Vault	1	ea	$825,000	$ 825,000
Reservoir Piping Connection w/ Valve and Vault	1	ea	$825,000	$ 825,000
96" Piping (to/from reservoir)	2500	LF	$2,372	$ 5,930,055
72" Piping (P5 to TOFRS)	300	LF	$1,516	$ 454,731
Mobilization		LS		$ 3,908,479
SUBTOTAL				**$ 42,993,265**
Contingency[1]				**$ 18,996,633**
Soft Costs[1]				**$ 18,996,633**
Land Acquisition (10 acres)				**$ 500,000**
Easement (3 acres)				**$ 150,000**
TOTAL				**$ 81,636,530**

[1] Per WA input, contingency and soft costs are not required for the existing PCF rehab.

First Aqueduct/Valley Center Pipeline Location

Description	Quantity	Unit	Unit Cost	Total Cost
3 MG Reservoir				
Reservoir (3MG)	3	MG	$1,252,000	$ 3,756,000
Pressure Control Facility	1	ea	$2,000,000	$ 2,000,000
First Aqueduct Connection	1	ea	$150,000	$ 150,000
60" Piping	1000	LF	$1,154	$ 1,153,902
Mobilization		LS		$ 705,990
SUBTOTAL				**$ 7,765,892**
Contingency				**$ 3,882,946**
Soft Costs				**$ 3,882,946**
Land Acquisition (5 acres)				**$ 250,000**
Easement (1 acres)				**$ 50,000**
TOTAL				**$ 15,831,784**

Configurations Summary

Description[1]	Cost[1]
Project w/ one 5 MG Reservoir	$ 56,153,000
Project w/ two 5 MG Reservoir	$ 69,925,000
Project w/ one 10 MG Reservoir	$ 69,925,000
Project w/ two 10 MG Reservoir	$ 97,469,000

[1] Assumes storage at both locations

System Regulatory Storage Cost Summary

Description	Cost[1]
Project w/ 5 MG Reservoir	$ 56,153,000
Project w/ two 10 MG Reservoirs	$ 97,469,000

[1] Costs shown are October 2012 dollars. Costs include an allowance of 50% for construction contingency and an allowance of 50% for implementation (permitting, legal, engineering, etc.)

OR

System Regulatory Storage Cost Summary

Description	Cost[1]
System Regulatory Storage	$ 56,153,000 to $ 97,469,000

[1] Costs shown are October 2012 dollars. Costs include an allowance of 50% for construction contingency and an allowance of 50% for implementation (permitting, legal, engineering, etc.)

San Vicente 3rd Pump Drive and Power Project
Cost Detail

January 2013 LA ENR CCI	10276.68	(B&V estimate)
October 2012 LA ENR CCI	10283.18	
December 2011 LA ENR CCI	10088.00	(Unit Cost Tool)
March 2009 LA ENR CCI	9799.19	(ESA Estimate/SVDR Power Study)
2008 Average LA ENR CCI	9410.60	
June 2007 LA ENR CCI	8854.77	(PBS&J North County Memo)
April 2007 LA ENR CCI	8874.82	(CAPS Estimate)
September 2006 LA ENR CCI	8572.47	(SVPS Estimate)

October 2012 Unit Cost

Item	Unit Cost	
12kV Feed	$15,299,000	estimate of $14M in 2008; no contingency required per WA input
VFD	$1,000,000	
Transformer	$300,000	
Electrical	$600,000	
Controls	$500,000	
General Construction	$300,000	
Natural Gas Generator (2 MW)	$2,281,000	vendor quote; includes 30% markup and $500K for cost of exhaust after treatment
6" Pipeline/LF	$100	
Diesel Generator (2 MW)	$1,449,000	vendor quote; includes 30% markup and $500K for cost of exhaust after treatment
Fuel Storage Tank	$89,198	from SVDR Power Study (15,000 gallons for a 2 MW unit to provide 4 days of storage)
Mobilization	10%	of total cost

Contingency	50%
Soft Costs	50%

San Vicente 3rd Pump Power and Drive (October 2012)

Description	Quantity	Unit	Unit Cost	Total Cost
Electrical Power Option				
12kV Feed[1]		LS		$ 15,299,000
VFD		LS		$ 1,000,000
Transformer		LS		$ 300,000
Electrical		LS		$ 600,000
Controls		LS		$ 500,000
General Construction		LS		$ 300,000
Mobilization		LS		$ 1,799,900
SUBTOTAL				$ 19,798,900
Contingency[1]				$ 2,249,950
Soft Costs				$ 9,899,450
TOTAL				$ 31,948,300
Natural Gas Power Option				
Natural Gas Generator (2 MW)	3	ea	$2,281,000	$ 6,843,000
6" Natural Gas Pipeline	30,624	LF	$100	$ 3,062,400
VFD		LS		$ 1,000,000
Transformer		LS		$ 300,000
Electrical		LS		$ 600,000
Controls		LS		$ 500,000
General Construction		LS		$ 300,000
Mobilization		LS		$ 1,260,540
SUBTOTAL				$ 13,865,940
Contingency				$ 6,932,970
Soft Costs				$ 6,932,970
TOTAL				$ 27,731,880
Diesel Generator Option[1]				
Diesel Generator (2 MW)	3	ea	$1,449,000	$ 4,347,000
Fuel Storage Tank[2]	3	ea	$89,198	$ 267,595
VFD		LS		$ 1,000,000
Transformer		LS		$ 300,000
Electrical		LS		$ 600,000
Controls		LS		$ 500,000
General Construction		LS		$ 300,000
Mobilization		LS		$ 731,459
SUBTOTAL				$ 8,046,054
Contingency				$ 4,023,027
Soft Costs				$ 4,023,027
TOTAL				$ 16,092,108

[1] APCD permitting diesel generators for non-emergency use could prove challenging. Assumes outdoor installation.

[2] Fuel cost not included.

San Vicente 3rd Pump Power and Drive Cost Summary

Description	Cost[1]
Electrical Power Option	$ 31,949,000
Natural Gas Power Option	$ 27,732,000
Diesel Generator Option	$ 16,093,000

[1] Costs shown are October 2012 dollars. Costs include an allowance of 50% for construction contingency and an allowance of 50% for implementation (permitting, legal, engineering, etc.)

or

Description	Cost[1]		
San Vicente 3rd Pump Power and Drive	$ 16,093,000	to	$ 31,949,000

[1] Costs shown are October 2012 dollars. Costs include an allowance of 50% for construction contingency and an allowance of 50% for implementation (permitting, legal, engineering, etc.)

North County Pump Station Project
Cost Detail

January 2013 LA ENR CCI	10276.68	(B&V estimate)
October 2012 LA ENR CCI	10283.18	
December 2011 LA ENR CCI	10088.00	(Unit Cost Tool)
March 2009 LA ENR CCI	9799.19	(ESA Estimate)
June 2007 LA ENR CCI	8854.77	(PBS&J North County Memo)
April 2007 LA ENR CCI	8874.82	(CAPS Estimate)
September 2006 LA ENR CCI	8572.47	(SVPS Estimate)

Cost Background

Pump Station Cost

Cactus Avenue Pump Station

	Total Cost (Oct 2012)	Cost per cfs (Oct 2012)	
CAPS Pumps (14 cfs)	$ 363,697	$ 25,978	includes installation
Base Pump Station Cost w/out Pumps	$ 8,398,197		

October 2012 Unit Cost

Item	Unit	Unit Cost	
Pump Station (30 cfs)	LS	$9,178,000	
Pump Station (50 cfs)	LS	$9,698,000	
24" Pipeline	LF	$331	from Unit Cost Tool
30" Pipeline	LF	$432	from Unit Cost Tool
36" Pipeline	LF	$561	from Unit Cost Tool
Valve and vault	ea	$825,000	see Isolation valve tab
Pipeline Connection	ea	$150,000	B&V estimate
Power	LS	$580,658	$500K from PBS&J North County Memo
Land Acquisition	acre	$50,000	provided by WA
Easement	acre	$50,000	provided by WA
Tunnel Under Freeway (assume 60-inches)	LF	$3,420	From ESA
Mobilization	LS	10%	of total cost

Contingency	30%	(lesser contingency required than other projects since this project is further developed)
Soft Costs	50%	

North County Pump Station Cost (October 2012)

Description	Quantity	Unit	Unit Cost	Total Cost	
Location w/out P3/P4 Conversion - Red Mtn Reservoir Site OR Location along P3 w/ P3/P4 Conversion					
Pump Station (30 cfs)		LS		$ 9,178,000	
36" Pipeline (influent & effluent)	150	LF	$561	$ 84,096	
Valve and vault	2	ea	$825,000	$ 1,650,000	
Connection to P4	2	ea	$150,000	$ 300,000	
Power		LS		$ 580,658	
Mobilization		LS		$ 1,179,275	
SUBTOTAL				**$ 12,972,029**	
Contingency				**$ 3,891,609**	
Soft Costs				**$ 6,486,015**	
Land Acquisition (2 acres)				**$ 100,000**	
TOTAL				**$ 23,449,653**	
Location w/ P3/P4 Conversion - Red Mtn Reservoir Site					
Pump Station (30 cfs)		LS		$ 9,178,000	
36" Pipeline (influent & effluent to P4)	150	LF	$561	$ 84,096	
Valve and vault	2	ea	$825,000	$ 1,650,000	
Connection to P4	2	ea	$150,000	$ 300,000	
Power		LS		$ 580,658	
30" Pipeline (influent & effluent to P3)	11,000	LF	$432	$ 4,752,000	(two 5,500' long pipelines)
Connection to P3	2	ea	$150,000	$ 300,000	
Tunnel Under Freeway (assume 60")	520	LF	$3,420	$ 1,778,400	(assumes one tunnel for two pipelines)
Mobilization		LS		$ 1,862,315	
SUBTOTAL				**$ 20,485,469**	
Contingency				**$ 6,145,641**	
Soft Costs				**$ 10,242,735**	
Land Acquisition (2 acres)				**$ 100,000**	
Easement (9 acres)				**$ 450,000**	
TOTAL				**$ 37,423,845**	
Location w/ P3/P4 Conversion - South of RB8					
Pump Station (50 cfs)		LS		$ 9,698,000	
24" Pipeline	15,500	LF	$331	$ 5,130,500	
Valve and vault	2	ea	$825,000	$ 1,650,000	
Connection to FB6	1	ea	$150,000	$ 150,000	
Power		LS		$ 580,658	
Mobilization		LS		$ 1,720,916	
SUBTOTAL				**$ 18,930,073**	
Contingency				**$ 5,679,022**	
Soft Costs				**$ 9,465,037**	
Land Acquisition (2 acres)				**$ 100,000**	
Easement (9 acres)				**$ 450,000**	
TOTAL				**$ 34,624,132**	

North County Pump Station Cost Summary `

Description	Cost[1]	
Red Mtn Reservoir Site w/out P3/P4 Conversion OR P3 Site w/ P3/P4 Conversion	$	23,450,000
Red Mtn Reservoir Site w/ P3/P4 Conversion	$	37,424,000
Site South of RB8 w/ P3/P4 Conversion	$	34,625,000

or

Description	Cost[1]				
North County Pump Station	$	23,450,000	to	$	37,424,000

[1] Costs shown are October 2012 dollars. Costs include an allowance of 30% for construction contingency and an allowance of 50% for implementation (permitting, legal, engineering, etc.)

Second Crossover Pipeline
Cost Detail

*Source: Master Plan CIP Chart (provided by WA on October 16, 2013)

Second Crossover Pipeline

Item	Total Cost
Second Crossover Pipeline	$371,039,824

[1] Costs include contingencies and soft costs.

Second Crossover Pipeline Summary

Description	Cost[1]
Second Crossover Pipeline	$371,040,000

[1] Costs include contingencies and soft costs.