Appendix C Wholesale Agency Profiles

This section details the wholesale water systems and their facilities included in this study; the wholesale systems are: the State Water Project, Central Valley Project, Colorado River Aqueduct, Metropolitan Water District of Southern California, Hetch Hetchy (San Francisco Public Utilities Commission), Santa Clara Valley Water District, Los Angeles Aqueduct, Modesto Irrigation District, and San Diego County Water Authority.

This section first describes each wholesale water system. It then provides details on each facility including: location, facility type, upstream facility, downstream facility, points of interconnection to other systems, facility configuration, capacity, and recent retrofits. A detailed analysis of the water flows, energy consumption and energy intensity of each facility follows. The Study Team's recommendations for energy intensity and water flow patterns for each facility are contained in this section.

C.1 Facility Energy Intensity Analysis Methodology

The Study Team calculated the energy intensity at each major facility in each of the wholesale agencies included in this study. This section documents the general methodology used to calculate energy intensity and the steps taken to account for discrepancies in data.

Energy Intensity is calculated by dividing the energy used or produced by a facility by the quantity of water moved through the facility. Energy and delivery data collected were used to calculate energy intensity values at each major facility by month during the data collection period (water years 1994-2005). Data was plotted to reveal any possible relations of Energy Intensity with volume of conveyance or other variables. For the majority of facilities, the calculated energy intensity was constant month-to-month. Some facilities exhibited systematic outliers in their calculate energy intensities. These could be due to sources of error in the two components used to calculate Energy Intensity (Energy Use and Water Conveyance). These data inputs and possible sources of error associated with each are discussed below.

C.1.1 Energy Use

The amount of energy needed to pump water is well understood as a function of the volume of water being pumped, distance, and elevation change (topography). Additional facility-specific factors, however, impact the actual amount of energy that is needed to pump a volume of water from each facility at a particular point in time.

1. Variations in Head. Variations in the elevation of the source water or destination can affect the pumping load for any specific site. The difference in pumping up 50 ft vs. 300 ft can add up to 100 kWh/AF or more. Pumps that operate in connection with reservoirs can experience varying energy intensities as reservoir height varies. Even in-conduit pump stations are subject to variations in head. Water levels in canals can vary up to 15 feet causing variation in energy intensity.
2. Operational Factors. Planned and unplanned outages affect pump operations and resultant energy intensities. In addition, many factors – such as regulatory fish releases and flood control requirements – affect the pattern of water deliveries which, depending on any particular pump facility's configuration, can affect energy intensity.
3. Equipment Efficiency. Motors and pumps operate at widely varying efficiencies. A particular pump station has several pumps and each may be of different size, capacity and efficiency. Operators can utilize any combination of pumps to meet total pumping needs.
4. Friction. If a pipeline is undersized relative to the amount of water being transported or there is excessive friction due to a line outage, higher pumping loads may result. Additionally, as water flow increases, frictional losses increase requiring more pumping energy increasing energy intensity.
5. System Losses. The quantity of water deliveries varies seasonally. More water delivered during the high season can cause additional losses in the delivery system with could lead to higher pumping loads.
6. System Pressure. Some pipelines need to maintain pressures within specified ranges. The nature of the system configuration and pressure requirements can affect energy intensity.

C.1.2 Water Conveyance

The other portion of the energy intensity equation is the amount of wholesale water that is conveyed. There are a number of metering options that are available for flow measurement in water systems. Generally, in conduit flow meters are used at pump stations to track the amount of water pumped. The flow measurement setup used is at the discretion of the design engineer. The accuracy of the metering at a pump station depends on the meter and location used.

For example Banks Pumping Plant (SWP) has 11 pumps and 5 discharge lines. Discharge line 1 has an internal diameter (I.D.) of 13.5 feet and receives water from pumps 1 through 3. Discharge lines 2 – 5 have an I.D. of 15 feet, and receive water from 2 pumps each. A cost effective way to measure total flow is to meter each of the 5 discharge lines, however this can have low accuracy due to line size and flow. The most accurate flow measurements would be to install a meter on each pump prior to the distribution lines.

The type of meter can also affect the accuracy of the flow measurement. There are two standard flow measurement devices for pipelines; magnetic flow meters and propeller meters. Magnetic flow meters have accuracy as low as +/- 1 % depending on manufacturer and flow range. Propeller meters can have accuracy as low as +/- 2 % also depending on manufacturer and flow range. In the case of Banks Pumping Plant the average annual production is 2.6 million acre-feet. Metering in this case could cause a variance in the energy intensity from month to month as much as 4%, on top of the hydraulic factors mentioned above and the accuracy of the associated energy meter.

Where significant fluctuations in calculate Energy Intensity arose, the Study Team conducted interviews of water agencies' engineering and operations staff to identify the likely causes of those fluctuations, and to determine the appropriate energy intensity to use in the model. The Study Team Interviewed: Jim Blood, retired Chief Dispatcher State Water Project; Matthew Gass, Retired Maintenance Manager Hetch Hetchy Water and Power (SFPUC) 1989 to 2008; and Jon Lambeck, Operations Planning Unit Manager Metropolitan Water District of Southern California.

The Study Team's interview with Jim Blood, a retired Chief Dispatcher for the State Water Project, pointed out additional causes of error in flow measurement. Jim indicated most SWP pump stations have the means to monitor energy use and flow. However, the energy usage readings are most trusted as sometimes water flow meters can malfunction or drift from its initial calibration. Thus, every day operators check the total day's energy use against the total days water flow, they calculate energy intensity and compare it to a set value of what its expect it to be. If the calculated energy intensity is too different from the established norms, it indicates the flow meter reading is not correct or another system problem. Operators will calculate a new flow based on the actual energy use and the expected energy intensity value. The expected energy intensity is based on ideal operation and system maintenance, its use to calculate flow is not entire accurate in itself.

C.1.3 Calculation of Energy Intensity

The Study Team initially calculated energy intensity on a monthly basis during water years 1994-2005 and plotted the results. This allowed outliers to be identified. The Study Team attempted to explain the outliers to see if they should be included or excluded in the final energy intensity calculation. Actions taken to account for outliers include:

1. Removing months in which there was no reported flow or energy use by a pump station
2. Removing months in which positive energy use was reported by a power generation station (indicating no power generation but facility energy consumption for administrative uses)
3. Checking data on SWP facilities (obtained from Bulletin 132) against SWP facility monthly reports. When there was a discrepancy, mistake, or a "mismatch" of energy data from the Bulletin 132, the energy data were taken from the monthly reports.

4. Removing data during times of reported facility outages, major maintenance, or documented unusual operations
5. Clarifying data sources for clear outliers
6. Identifying possible “typos” in input data as an explanation for clear outliers and subsequently removing them from consideration.

After correcting for erroneous data and clear outliers, the Study Team removed further anomalous data that could be attributed to the error sources for water and flow data discussed above.

After all outliers, erroneous, and anomalous data were removed, the monthly energy intensity was plotted again to reveal a clearer trend. The total energy intensity of the facility was calculated using the entire set of remaining data. The scatter in the energy intensity was also quantified by calculating an error range equivalent to two times the standard deviation of the data set.

Examples of an initial energy intensity plot, a final energy intensity plot, and a calculated energy intensity of SWP’s Pearblossom pumping plant can be seen below in Error! Reference source not found.**, Figure 1, and** Table 1 respectively.

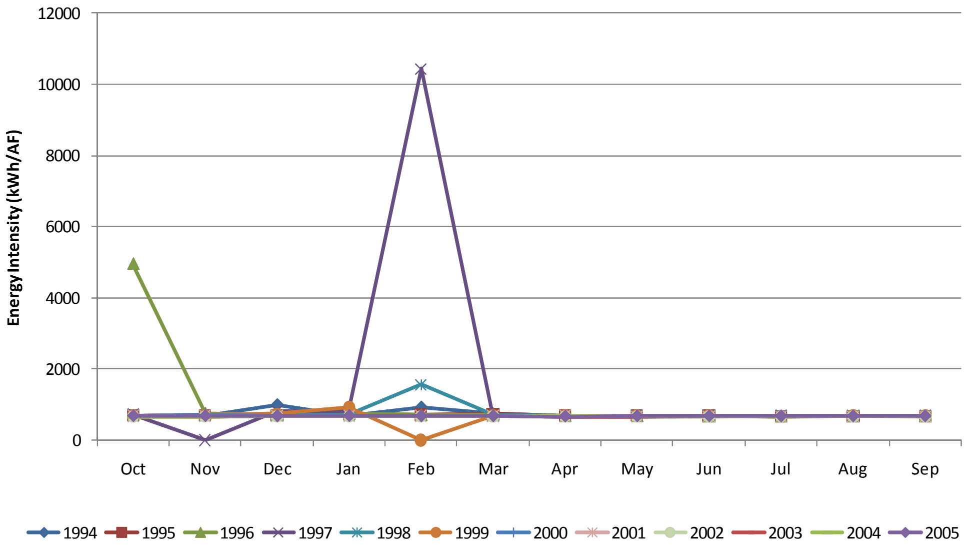


Figure 1: Initial Energy Intensity Plot

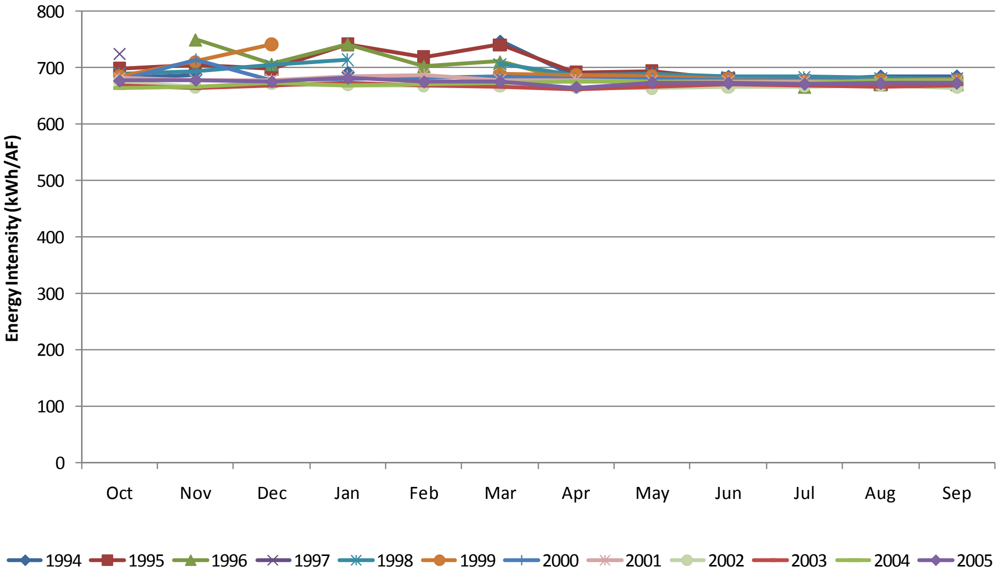


Figure 1: Final Energy Intensity Plot

Table 1: Calculated Energy Intensity and Range

Average Energy Intensity (kWh/AF)	Error Range	Upper Bound	Lower Bound
682.9	5%	718.8	647.0

C.2 The State Water Project

The State Water Project (SWP) is the largest state built, multipurpose water project in the country. It was designed and built to deliver water, control floods, generate power, provide recreational opportunities, and enhance habitat for fish and wildlife. SWP water irrigates about 750,000 acres of farmland, mainly in the south San Joaquin Valley. About 24 million of California's estimated 36 million residents benefit from SWP water. The SWP depends on a complex system of dams, reservoirs, power plants, pumping plants, canals, and aqueducts to deliver water. Although initial transportation facilities were essentially completed in 1973, other facilities have since been built, and still others are either under construction or are planned to be built, as needed. The SWP facilities include 25 dams and reservoirs, 29 pumping and generating plants, and approximately 700 miles of aqueducts in total. The SWP delivered 3,292 TAF of water to long-term contractor in Water Year (WY) 2000 (a "normal" year)

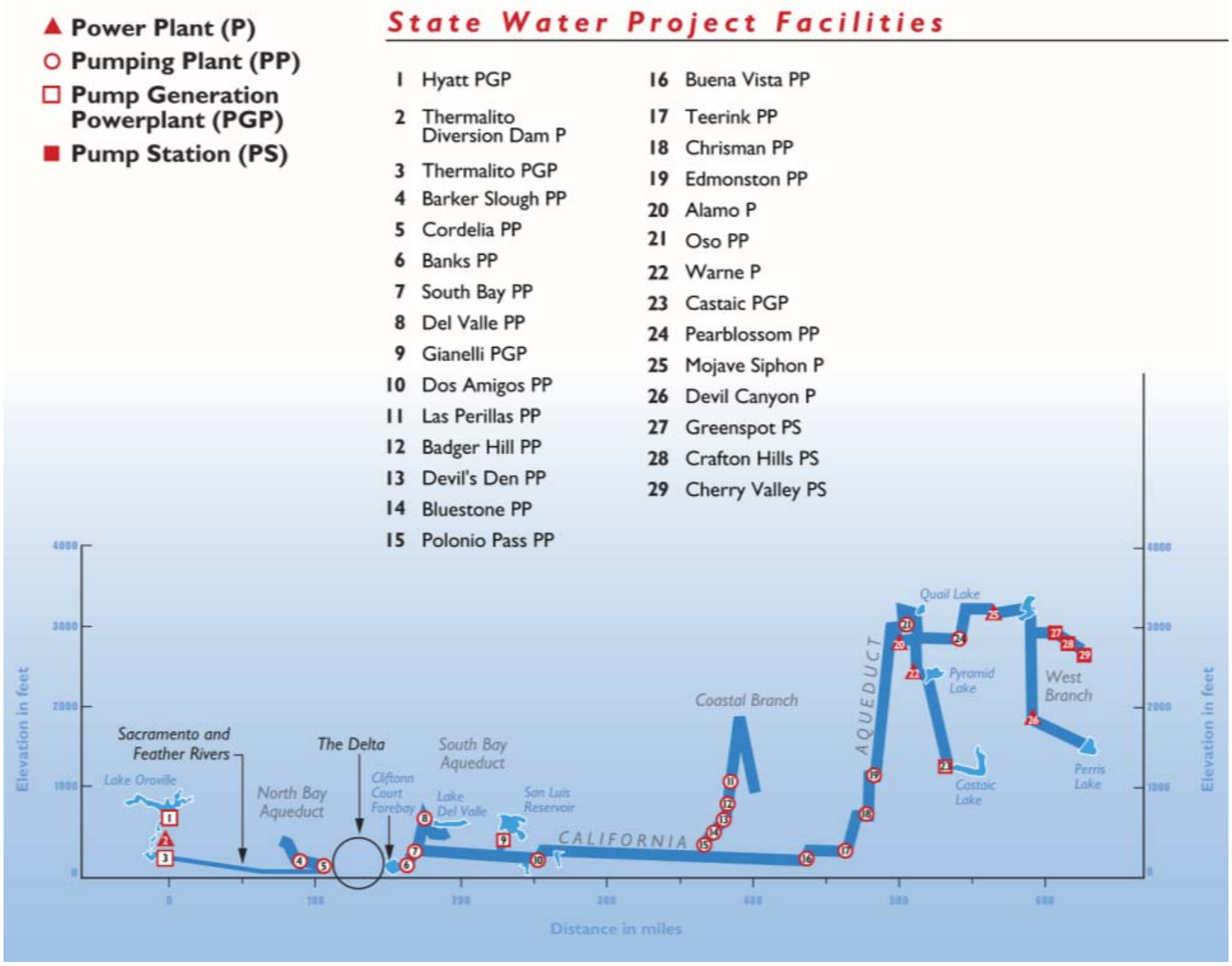
The State Water Project (SWP) was constructed from 1957 to 1973 pursuant to passage of the Burns-Porter Act for the purpose of delivering water, controlling floods, generating power, providing recreational opportunities, and enhancing habitat for fish and wildlife. The SWP is owned and operated by the California Department of Water Resources (DWR). Deliveries to 29 Contractors are made pursuant to long term contracts in which the contractors receiving the benefit of water delivered though SWP pay for allocated shares of capital and operating costs. Operating costs include the cost of energy used to transport water.

Figure 2 and Figure 3 illustrate SWP facilities. The SWP consists of seven primary arteries: North Bay Aqueduct, South Bay Aqueduct, California Aqueduct, Costal Branch, West Branch, East Branch, and East Branch Extension. The North Bay Aqueduct consists of two pump stations and aqueducts that deliver water from the northern part of the Bay Delta to Solono, Napa, and Sonoma Counties. The South Bay Aqueduct delivers water from the Bay Delta to the San Jose area including Santa Clara Valley Water District. The California Aqueduct is the main conveyance artery in the SWP traversing from the Bay Delta to Edmonston pumping plant at the base of the Tehachapi Mountains bifurcating into the East and West Branch. The Coastal Branch separates from the California Aqueduct to supply water to San Luis Obispo and Santa Barbra Counties. The West Branch delivers water from the California Aqueduct to the western part of the Los Angeles Basin terminating at Castaic Lake. The East Branch delivers water from the California Aqueduct to the eastern part of the Los Angeles Basin terminating at Lake Perris. The East Branch Extension is the newest portion of the SWP, it began operation in 2004 extending further east of the East Branch into San Bernardino County. The SWP consists of approximately 700 miles of canals and pipelines spanning from northern to southern California, crossing 7 hydrologic regions and 9 DEER climate zones.

Figure 2: State Water Project Facility Diagram

Source: CDWR 2006

Figure 3: State Water Project Facility Elevations



Source: California Sustainability Alliance, 2009

The SWP is used for the following primary purposes:

1. Deliver water from the Upper Feather River, Lake Oroville, the Sacramento River, and the Sacramento-San Joaquin Delta to the Contractors.
2. Flood control in the Feather River Basin
3. Serve as a transporter of other water purveyors; unutilized capacity in the aqueduct may be used by other purveyors for a fee
4. Emergency deliveries of water along certain paths of interconnected water systems

The SWP is a major user of energy. During WY 2000, a “normal” water year, the SWP delivered 3,553 TAF of water to SWCs and an additional 1,378 TAF of non-SWP water to other contractors. The total annual amount of energy needed to convey all water in the SWP was 8,418 GWh. Of this energy, 28% (2,380 GWh) is needed during summer months (June, July, August); the balance of energy consumption (72%, 6,038 GWh) occurs during the other 9 months of the year. Deliveries and total energy use in other water year types can be seen in Table 2.

Of the energy needed to support SWP deliveries during a “normal” year, 38% (3,227 GWh) is met through in-conduit hydropower generated during the process of delivering the water. An additional 35% (2,958 GWh) is met through other sources of self generation, and the balance (27%, 2,233 GWh) is purchased under long term wholesale power contracts or through short-term power purchases.

Table 2: Water Deliveries and Energy Use by the SWP

Water Year	Data Year	SWP Water Delivered via SWP (TAF)	Total Water Delivered via SWP (TAF)	Energy Used for Water Deliveries (GWh)
Wet	1998	1,734	2,779	4,179
Above Normal	2000	3,553	4,932	8,418
Below Normal	2004	3,204	4,487	9,895
Dry	2002	2,545	3,927	8,233
Critical	2001	1,986	3,492	7,548

In order to support scenario analyses, the Study Team needed to determine an appropriate method of approximating the amount of energy needed to deliver contract water under a range of hydrologic conditions. For this purpose, the Study Team collected and analyzed historical monthly water deliveries and associated energy requirements for the period 1994-2005. The sources of these data for the SWP were: Bulletin 132 annual reports and State Water Project Monthly Reports. Jim Blood, retired Chief Dispatcher of the State Water Project was also interviewed. For a detailed list of sources, see the end of this section.

The results of our findings and recommendations are documented below by facility.

C.2.1 Barker Slough Pumping Plant

Table 3: Barker Slough Summary

<table>
<tr><td>Facility Name</td><td colspan="2">Barker Slough Pumping Plant</td><td colspan="2">Facility ID</td><td>1</td></tr>
<tr><td>Owner</td><td colspan="2">State Water Project</td><td colspan="2">Facility Type</td><td>Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="2">Sacramento River</td><td colspan="2">DEER Climate Zone</td><td>12</td></tr>
<tr><td>Downstream From</td><td colspan="5">Bay Delta</td></tr>
<tr><td>Upstream From</td><td colspan="5">Cordelia Pumping Plant</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="2">Other Wholesale Systems</td><td colspan="2">Storage</td><td colspan="2">Local Water Systems</td></tr>
<tr><td colspan="2">None</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td rowspan="3">Facility Configuration</td><td>Number of Pumps</td><td>Power (HP)</td><td>Speed (RPM)</td><td>Maximum Flow (CFS)</td><td>Static Head (ft)</td></tr>
<tr><td>2</td><td>300</td><td>1200</td><td>14.4</td><td>95-120</td></tr>
<tr><td>7</td><td>600</td><td>900</td><td>28.4</td><td>95-120</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="5">230 CFS</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="2">2001[1]</td><td colspan="2">Description of Last Major Retrofit</td><td>Refurbish pump and motor for unit 2.</td></tr>
</table>

1: From DWR Bulletin 132, 2002

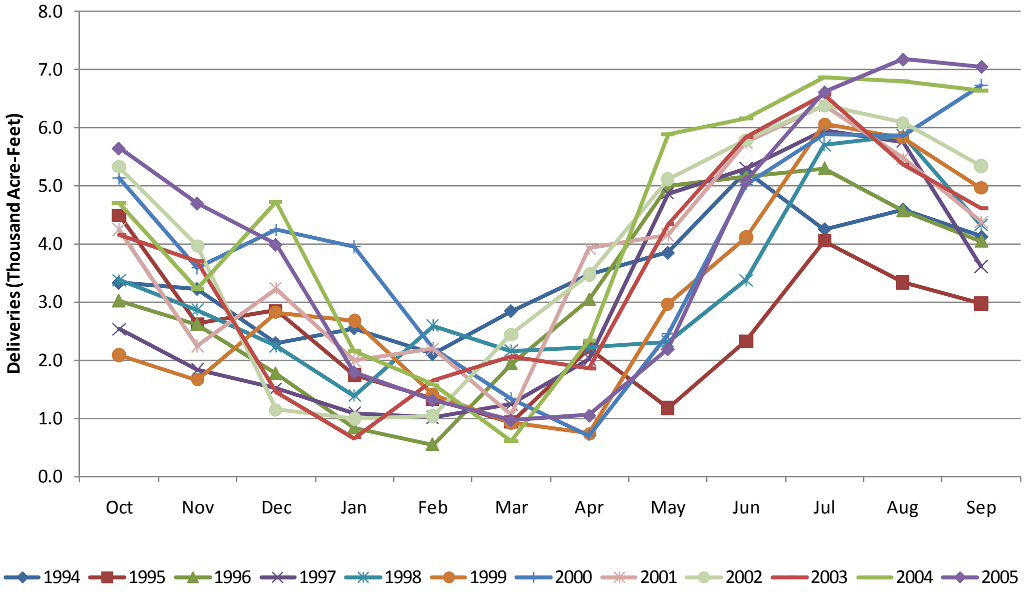
C.2.1.1 Description

Barker Slough Pumping Plant is the first facility in the North Bay Aqueduct of the State Water Project. It pumps water out of the northern part of the Bay Delta at Barker Slough. Water exiting this plant continues to flow to Cordelia Pumping Station. The plant contains nine fixed speed pumping units with a combined maximum capacity of 230 CFS. The plant pumps water to a static head ranging from 95 to 120 feet.

C.2.1.2 Water Flow

Barker Slough Pumping Plant pumped between 30,000 and 51,600 AF/year during the data collection period. Pumping is low during the months of February and March and high during the months of July through September, see Figure 4. Interviews with Jim Blood revealed in the past this facility had two flow meters in series to record water flows. They did not always produce the same flow measurement indicating an error range exists in the water flow measurements.

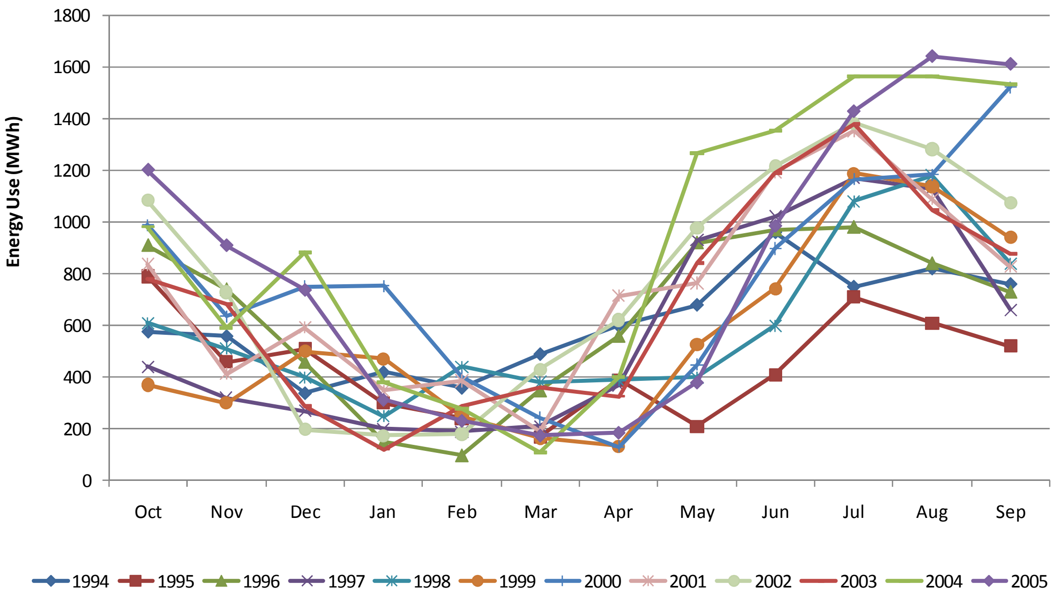
Figure 4: Barker Slough Deliveries



C.2.1.3 Energy Use

Barker Slough Pumping Plant's annual energy consumption ranged between 5,920 and 10,903 MWh/year during the data collection period. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 5.

Figure 5: Barker Slough Energy Use



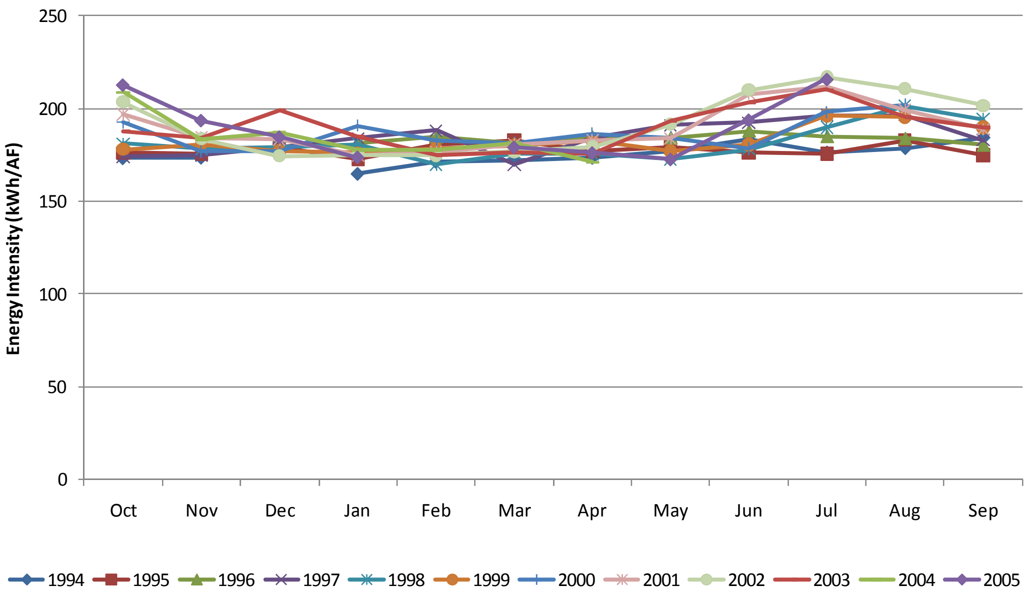
C.2.1.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Barker Slough is 184.5 kWh/AF; scatter in the data reveals an error range of 12%, see Table 4. The value of energy intensity does not significantly change as over time, see Figure 6. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 4: Barker Slough Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
184.5	12%	206.3	162.7

Figure 6: Barker Slough Energy Intensity Plot



C.2.2 Cordelia Pumping Plant

Table 5: Cordelia Summary

Facility Name	Cordelia Pumping Plant			**Facility ID**	2	
Owner	State Water Project			**Facility Type**	Pumping Plant	
Hydrologic Region	San Francisco Bay			**DEER Climate Zone**	12	
Downstream From	Bay Delta					
Upstream From	Barker Slough Pumping Plant					
Points of Interconnection	**Other Wholesale Systems**			**Storage**		**Local Water Systems**
	None					
Facility Configuration	Pipeline	Number of Pumps	Power (HP)	Speed (RPM)	Maximum Flow (CFS)	Static Head (ft)
	Napa	3	800	1800	14.5	439
		1	500	1800	8.9	439
	Benicia	2	550	1800	13.4	332
		1	550	1800	5.8	332
	Vallejo	2	350	900	17.6	140
		2	175	1200	8.9	140
Maximum Plant Capacity	140 CFS					
Date of Last Major Retrofit	2002[1]			**Description of Last Major Retrofit**	Overhauled pump and motor of unit 2	

1: From DWR Bulletin 132, 2002

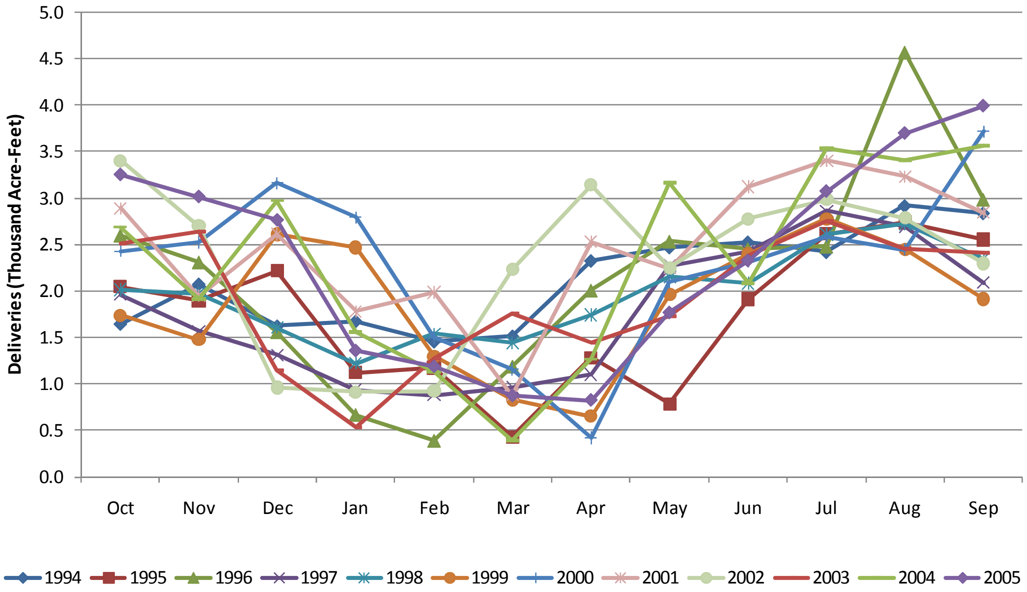
C.2.2.1 Description

Cordelia Pumping Plant is the final SWP pump station in the North Bay Aqueduct. It receives water from Barker Slough and delivers water through three different pipelines to three areas: Napa, Benicia, and Vallejo. Each pipeline is served by its own dedicated pumps. The plant contains a total of 11 pumps. There are 4 pumps on the Napa Pipeline, 3 pumps on the Benicia Pipeline and 4 pumps on the Vallejo Pipeline. The plant pumps water to a static head ranging from 140 to 439 feet.

C.2.2.2 Water Flow

Cordelia Pumping Plant pumped between 20,800 and 29,500 AF/year during the data collection period. Pumping is low during the months of January through April and high during the months of July through September, see Figure 7.

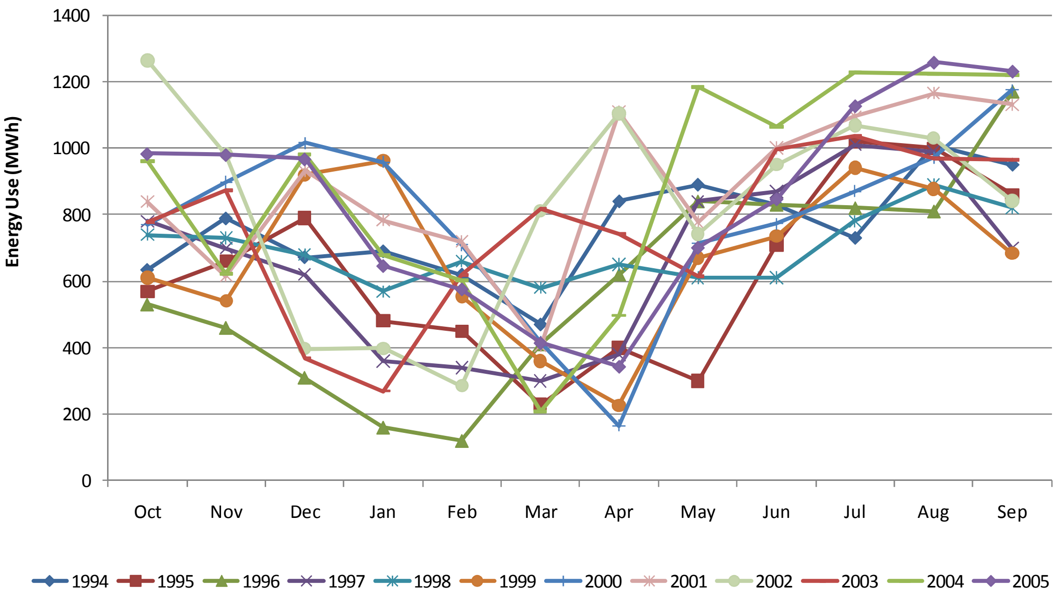
Figure 7: Cordelia Deliveries



C.2.2.3 Energy Use

Cordelia Pumping Plant's annual energy consumption ranged between 7,080 and 10,575 MWh/year during the data collection period. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 8.

Figure 8: Cordelia Energy Use



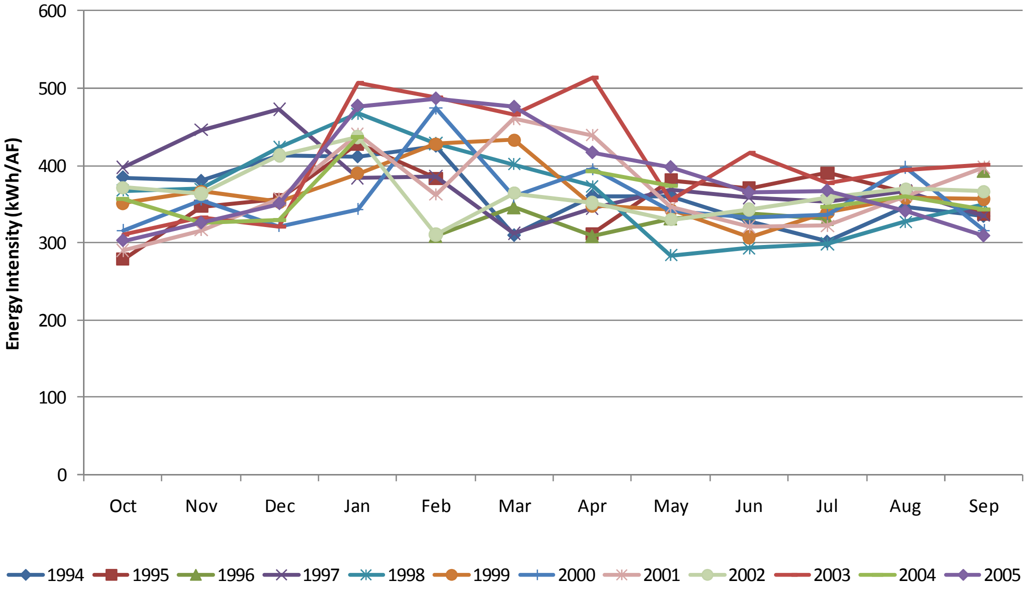
C.2.2.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Cordelia is 368.7 kWh/AF; scatter in the data reveals an error range of 27%, see Table 6. The value of energy intensity for the entire plant varies significantly, see Figure 9. The large variation is due to the three delivery pipelines that originate from the plant. Each pipeline and associated set of pumps deliver water to three different elevations. If individual flow data and energy data was provided for each pipeline and set of pumps, it would likely reveal that each has an energy intensity value that remains relatively constant. However, the energy data could not be disaggregated to each pipeline. The study team hypothesizes that the proportional split of water among the three pipelines varies in different times of the year and in different years causing the variance in energy intensity. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 6: Cordelia Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
368.7	27%	467.9	269.6

Figure 9: Cordelia Energy Intensity Plot



C.2.3 Banks Pumping Plant

Table 7: Banks Summary

<table>
<tr><td>Facility Name</td><td colspan="2">Banks Pumping Plant</td><td>Facility ID</td><td colspan="2">3</td></tr>
<tr><td>Owner</td><td colspan="2">SWP</td><td>Facility Type</td><td colspan="2">Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="2">San Joaquin River</td><td>DEER Climate Zone</td><td colspan="2">12</td></tr>
<tr><td>Downstream From</td><td colspan="5">Clifton Court Forebay</td></tr>
<tr><td>Upstream From</td><td colspan="5">Bethany Reservoir</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="2">Other Wholesale Systems</td><td colspan="2">Storage</td><td>Local Water Systems</td></tr>
<tr><td colspan="2">None</td><td colspan="2">Bethany Reservoir (in-conduit, SWP)</td><td></td></tr>
<tr><td rowspan="4">Facility Configuration</td><td>Number of Pumps</td><td>Power (HP)</td><td>Speed (RPM)</td><td>Maximum Flow (CFS)</td><td>Static Head (ft)</td></tr>
<tr><td>2</td><td>11,500</td><td>400</td><td>375</td><td>236-252</td></tr>
<tr><td>5</td><td>34,500</td><td>225</td><td>1130</td><td>236-252</td></tr>
<tr><td>4</td><td>34,500</td><td>200</td><td>1076</td><td>236-252</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="5">10,700 CFS</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="2">2004[1]</td><td>Description of Last Major Retrofit</td><td colspan="2">Unit 6 motor rewound.</td></tr>
</table>

1: From DWR Bulletin 132, 2005

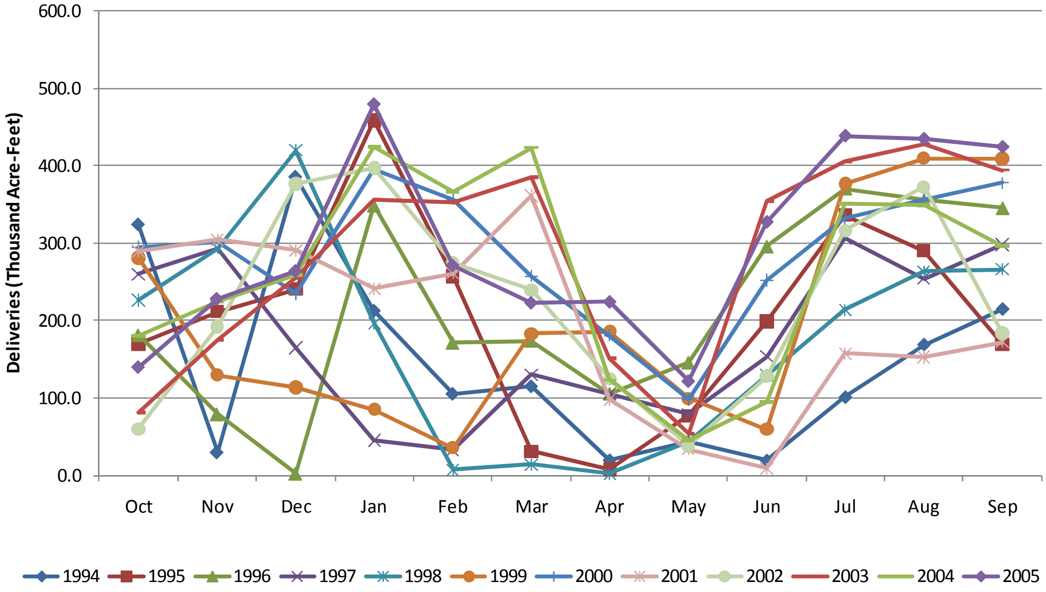
C.2.3.1 Description

Banks Pumping Plant is the first pumping plant in the California Aqueduct; it pumps water out of the Delta at Clifton Court Forebay and into Bethany Reservoir. Banks Pumping Plant occasionally is used to convey water for the CVP under a joint operations agreement with the SWP; however, this use is limited. Currently flow through the pumps at Banks is limited by regulations protecting Delta fisheries. Interviews with Jim Blood revealed that the facility pumps as much water as it's allowed to in a given day. Any water that exceeds ultimate SWP demand is put in San Luis Reservoir further down the California Aqueduct. The plant contains eleven fixed speed pumping units with a combined maximum capacity of 10,700 CFS. The plant pumps water to a static head ranging from 236 to 252 feet.

C.2.3.2 Water Flow

Banks Pumping Plant pumped between 1.74 million and 3.57 million AF/year for SWP use during the data collection period. Pumping is generally low during the months of April through June and generally high during the months of July through September, see Figure 10.

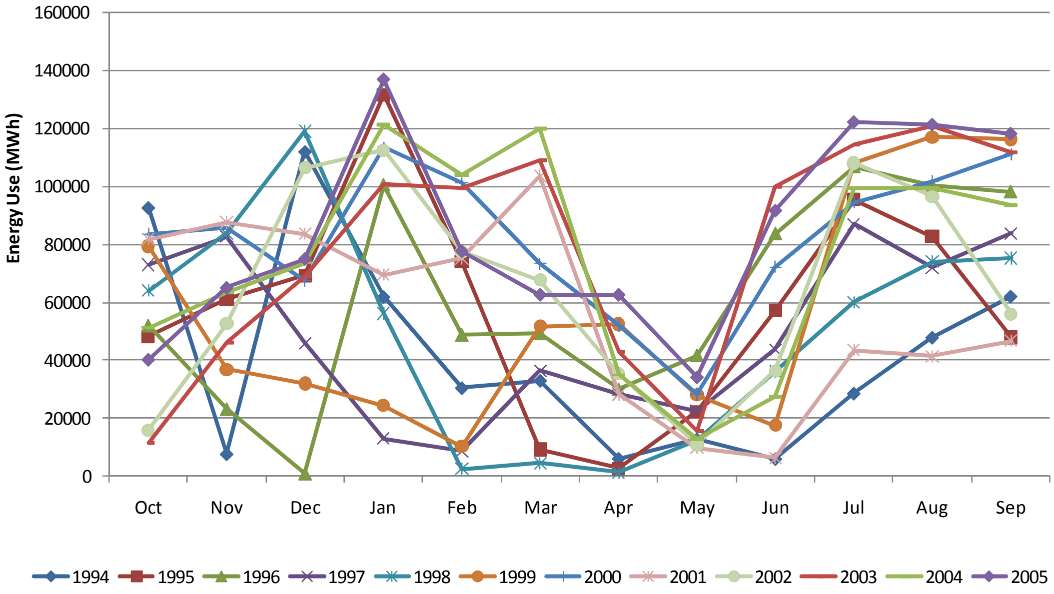
Figure 10: Banks Deliveries



C.2.3.3 Energy Use

Banks Pumping Plant's annual energy consumption ranged between 501,635 and 1,004,646 MWh/year during the data collection period. This energy is that which is used to move SWP water only. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 11.

Figure 11: Banks Energy Use



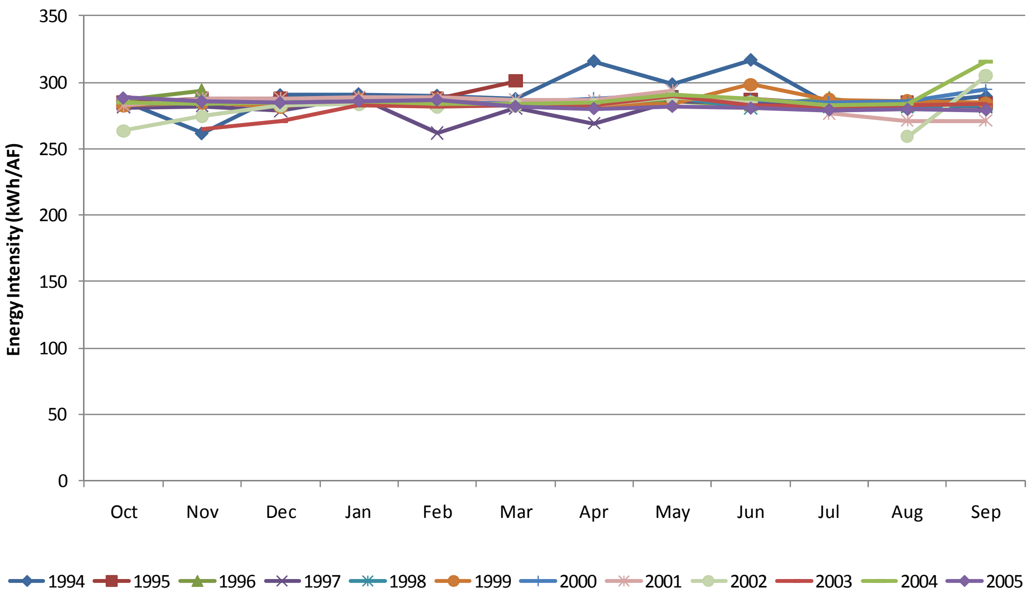
C.2.3.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Banks is 284.7 kWh/AF; scatter in the data reveals an error range of 6%, see Table 8. The value of energy intensity does not significantly change as over time, see Figure 12. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 8: Banks Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
284.7	6%	300.8	268.6

Figure 12: Banks Energy Intensity Plot



C.2.4 South Bay Pumping Plant

Table 9: South Bay Summary

Facility Name	South Bay Pumping Plant	**Facility ID**	4		
Owner	State Water Project	**Facility Type**	Pumping Plant		
Hydrologic Region	San Joaquin River	**DEER Climate Zone**	12		
Downstream From	Bethany Reservoir				
Upstream From	Del Valle Pumping Plant				
Points of Interconnection	**Other Wholesale Systems**	**Storage**	**Local Water Systems**		
	Connects to SCVWD	Delivers water to Santa Clara Terminal Reservoir			
Facility Configuration	**Number of Pumps**	**Power (HP)**	**Speed (RPM)**	**Maximum Flow (CFS)**	**Static Head (ft)**
	1	1250	1200	15	566
	3	2500	900	30	566
	3	4000	900	45	566
	2	3500	900	45	566
Maximum Plant Capacity	330 CFS				
Date of Last Major Retrofit	2005[1]	**Description of Last Major Retrofit**	Enlarge the South Bay Pumping Plant to accommodate four additional units		

1: From DWR Bulletin 132, 2006

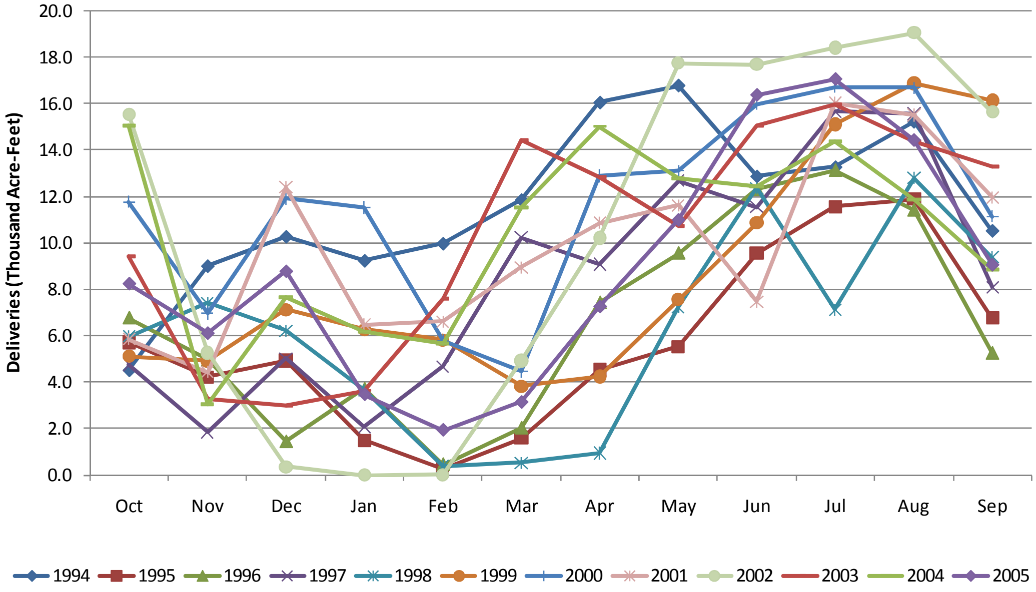
C.2.4.1 Description

The South Bay Pumping Plant is the first and main facility in the South Bay Aqueduct. It draws water from Bethany Reservoir along the California Aqueduct and pumps it towards the Santa Clara Terminal Reservoir. The plant has 2 discharge lines. The plant contains nine fixed speed pumping units with a combined maximum capacity of 330 CFS. The plant pumps water to a static head of 566 feet.

C.2.4.2 Water Flow

South Bay Pumping Plant pumped between 68,000 and 139,500 AF/year during the data collection period. Pumping is low during the months of January and February and high during the months of June through August, see Figure 13.

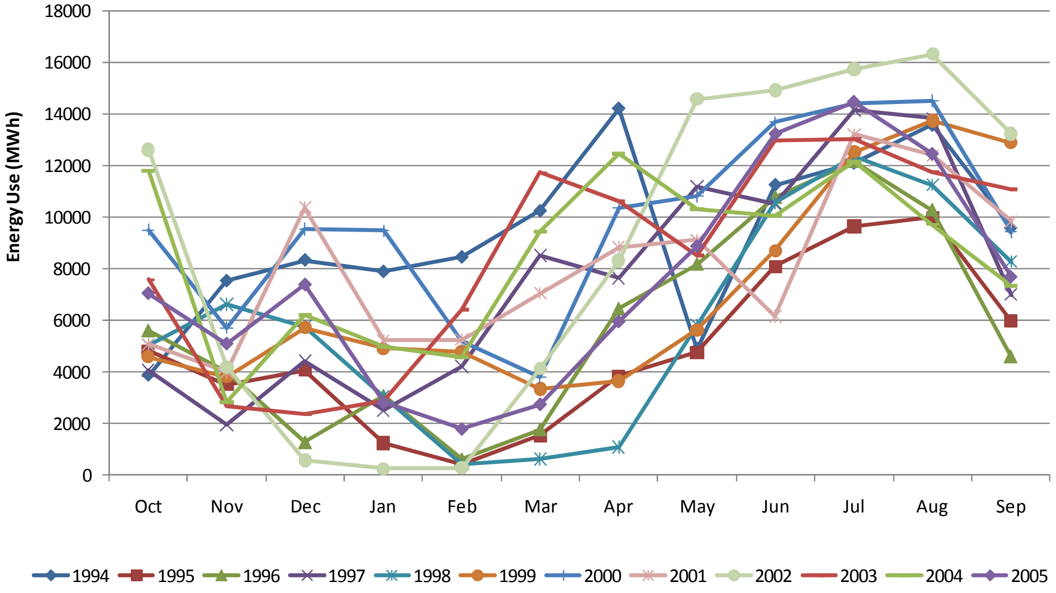
Figure 13: South Bay Deliveries



C.2.4.3 Energy Use

South Bay Pumping Plant's annual energy consumption ranged between 57,930 and 116,433 MWh/year during the data collection period. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 14.

Figure 14: South Bay Energy Use



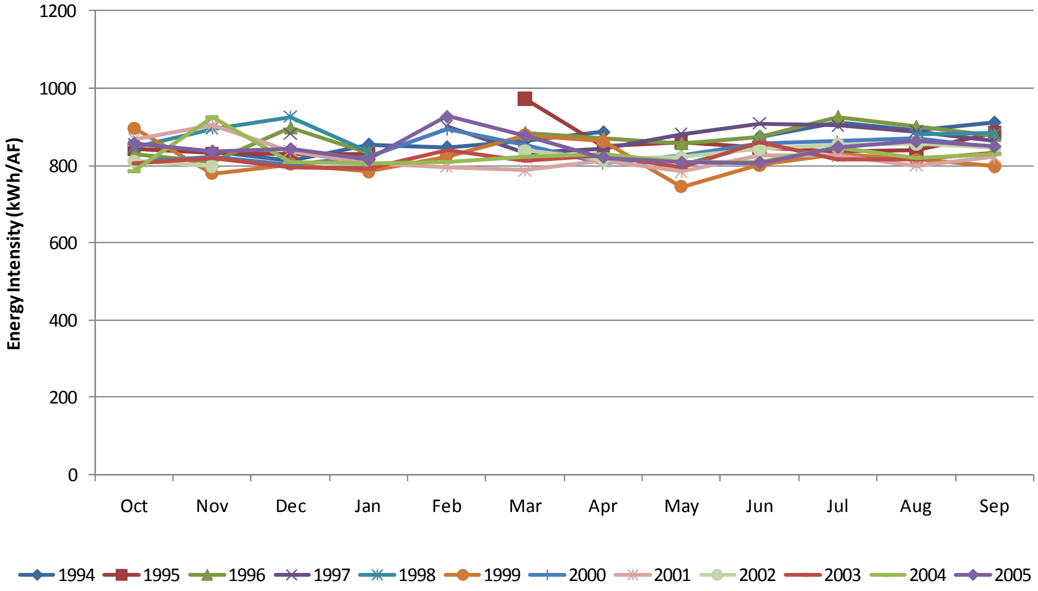
C.2.4.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at South Bay is 843.2 kWh/AF; scatter in the data reveals an error range of 9%, see Table 10. The value of energy intensity does not significantly change as over time, see Figure 15. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 10: South Bay Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
843.2	9%	919.0	767.3

Figure 15: South Bay Energy Intensity Plot



C.2.5 Del Valle Pumping Plant

Table 11: Del Valle Summary

<table>
<tr><td>Facility Name</td><td colspan="5">Del Valle Pumping Plant</td><td colspan="5">Facility ID</td><td colspan="5">5</td></tr>
<tr><td>Owner</td><td colspan="5">State Water Project</td><td colspan="5">Facility Type</td><td colspan="5">Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="5">San Francisco Bay</td><td colspan="5">DEER Climate Zone</td><td colspan="5">12</td></tr>
<tr><td>Downstream From</td><td colspan="15">Bay Delta</td></tr>
<tr><td>Upstream From</td><td colspan="15">Cordelia Pumping Plant</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="5">Other Wholesale Systems</td><td colspan="5">Storage</td><td colspan="5">Local Water Systems</td></tr>
<tr><td colspan="5"></td><td colspan="5">Lake Del Valle (off-canal storage)</td><td colspan="5"></td></tr>
<tr><td rowspan="2">Facility Configuration</td><td colspan="3">Number of Pumps</td><td colspan="3">Power (HP)</td><td colspan="3">Speed (RPM)</td><td colspan="3">Maximum Flow (CFS)</td><td colspan="3">Static Head (ft)</td></tr>
<tr><td colspan="3">4</td><td colspan="3">250</td><td colspan="3">360-720[a]</td><td colspan="3">30</td><td colspan="3">0-38</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="15">120 CFS</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="5">2005[1]</td><td colspan="5">Description of Last Major Retrofit</td><td colspan="5">Overhauled motor and pump of unit 2.</td></tr>
</table>

1: From DWR Bulletin 132, 2006

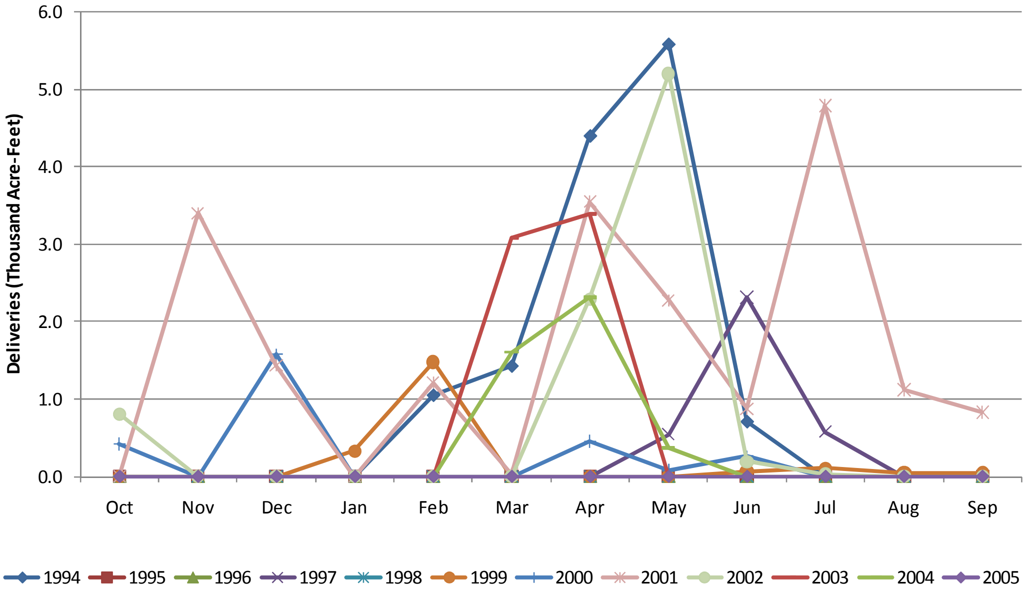
C.2.5.1 Description

The Del Valle Pumping Plant is used to store water off of the South Bay Aqueduct. Water is pumped from the aqueduct up to Del Valle reservoir for storage during wet months. Water is released during dry months to meet demand of customers on the South Bay Aqueduct, the SWP does not make any deliveries directly from the lake. No power generation is performed during reservoir withdrawals. The reservoir sees minimal use compared to other reservoirs in the SWP. The plant contains four variable speed pumping units with a combined maximum capacity of 120 CFS. The plant pumps water to a static head ranging from 0-38 feet (depending on reservoir height)

1.1.1.1 Water Flow

Del Valle Pumping Plant pumped between 0 and 19,500 AF/year during the data collection period. Pumping is highly dependent on the year, with many years not have any use, see Figure 16.

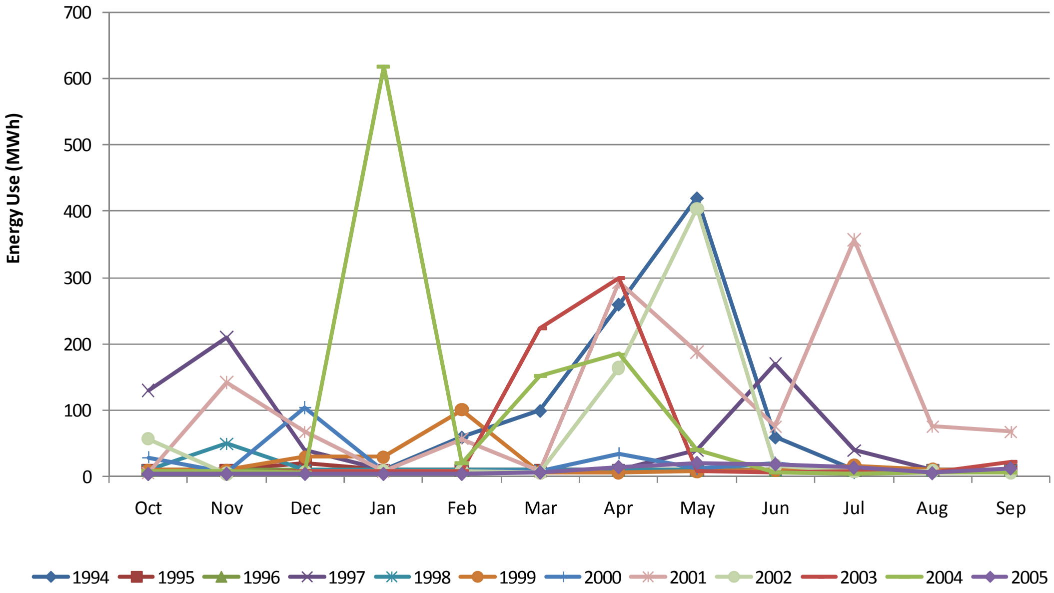
Figure 16: Del Valle Deliveries



C.2.5.2 Energy Use

Del Valle Pumping Plant's annual energy consumption ranged between 120 and 1,348 MWh/year during the data collection period. Energy use varies significantly month-to-month and year-to-year, see Figure 17.

Figure 17: Del Valle Energy Use



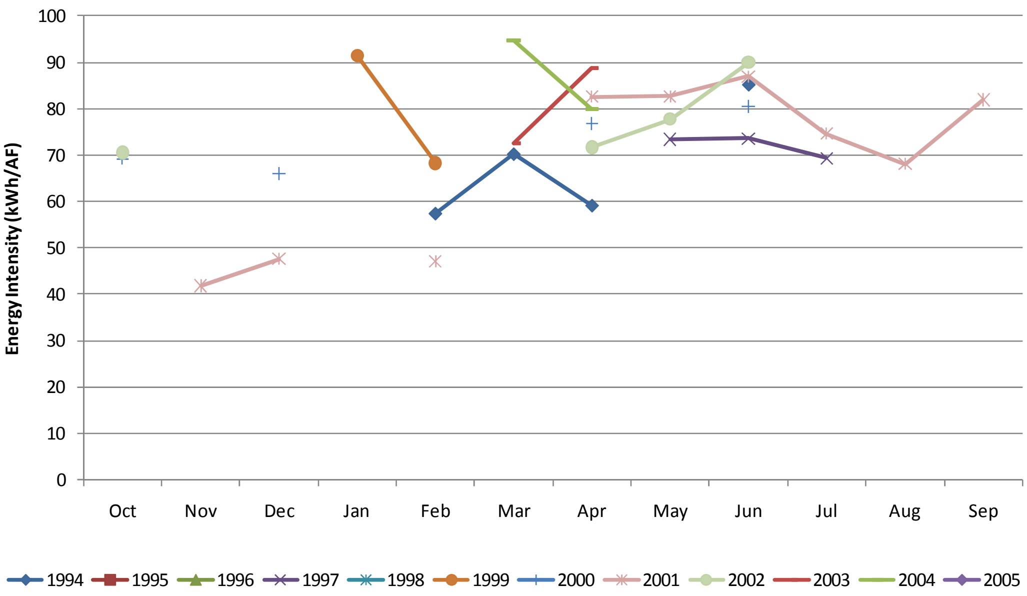
C.2.5.3 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Del Valle is 73.3 kWh/AF; scatter in the data reveals an error range of 36%, see Table 12. The value of energy intensity varies significantly over time due to lack of data, see Figure 18. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 12: Del Valle Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
73.3	36%	99.5	47.2

Figure 18: Del Valle Energy Intensity Plot



C.2.6 Gianelli Pumping-Generating Plant

Table 13: Gianelli Summary

<table>
<tr><td>Facility Name</td><td colspan="2">Gianelli Pumping-Generating Plant</td><td>Facility ID</td><td colspan="2">6</td></tr>
<tr><td>Owner</td><td colspan="2">SWP and CVP</td><td>Facility Type</td><td colspan="2">Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="2">San Joaquin River</td><td>DEER Climate Zone</td><td colspan="2">12</td></tr>
<tr><td>Downstream From</td><td colspan="5">Banks Pumping Plant</td></tr>
<tr><td>Upstream From</td><td colspan="5">San Luis Reservoir</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="2">Other Wholesale Systems</td><td colspan="2">Storage</td><td>Local Water Systems</td></tr>
<tr><td colspan="2">Connected to CVP via O’Neil Forebay and San Luis Reservoir</td><td colspan="2">San Luis Reservoir (off-canal storage, SWP)</td><td></td></tr>
<tr><td rowspan="3">Facility Configuration</td><td>Number of Units</td><td>Power (HP)</td><td>Speed (RPM)</td><td>Maximum Flow (CFS)</td><td>Static Head (ft)</td></tr>
<tr><td>6</td><td>34,000 (P)
63,000 (G)</td><td>120/150</td><td>3470/2300 (G/P)</td><td>99-327</td></tr>
<tr><td>2</td><td>34,000 (P)
63,000 (G)</td><td>120</td><td>3470/2300 (G/P)</td><td>99-327</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="5">21,620 CFS (Generating), 13,800 (Pumping)</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="2">2005[1]</td><td>Description of Last Major Retrofit</td><td colspan="2">Refurbish pump/turbine on unit 4.</td></tr>
</table>

1: From DWR Bulletin 132, 2006

C.2.6.1 Description

SWP operates Gianelli Pumping/Generating station in conjunction with San Luis Reservoir as a seasonal and operational storage facility. San Luis Reservoir and Gianelli are not and cannot be operated as a pump-storage facility for a collection of reasons: 1) O’Neill forebay below the facility has limited storage to accept water releases during the day, 2) the primary operation of the entire SWP is to maximize conveyance at night and minimize it during the day, and 3) if large volumes of water are released for generation during the day from San Luis Reservoir, it must be conveyed down the California Aqueduct requiring significant pumping from other conveyance facilities. This facility is shared with CVP; storage in San Luis Reservoir is also shared between the two agencies.

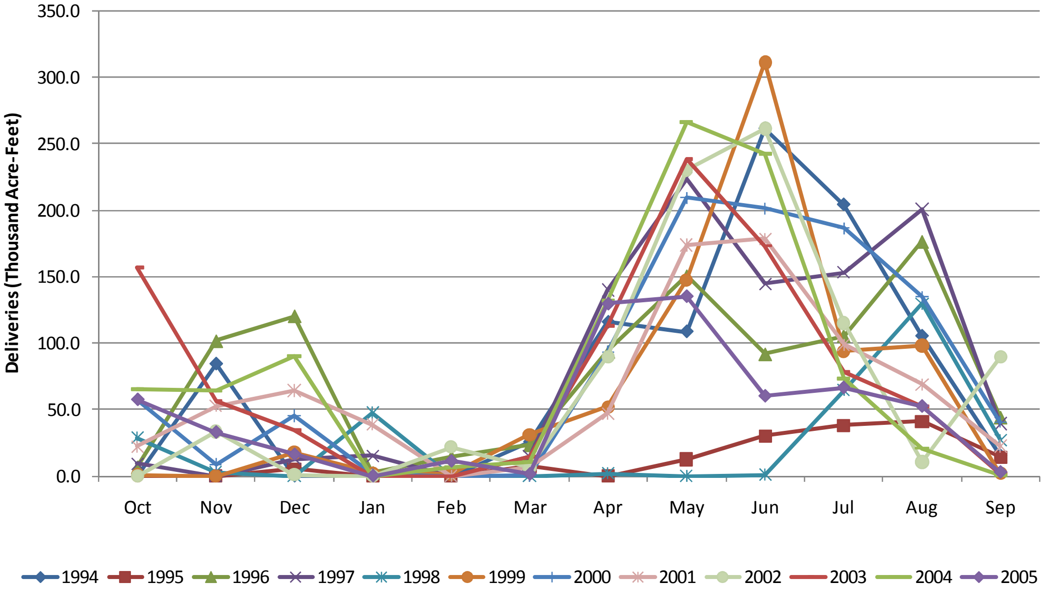
The eight units at Gianelli are reversible units capable of pumping and generating. Six of the units are dual speed units; they have the ability to operate a two different RPM’s ultimately determined by the elevation of San Luis Reservoir. Jim Blood informed the Study Team that as the reservoir elevation drops below a certain level, the speed of the unit is changed to provide the best pumping or generating efficiency.

The changing reservoir level affects the energy required to pump or the amount of energy that can be generated. At higher reservoir levels, pumping requires more energy but generators can produce more energy. This trend seen in the data provided to the study team.

C.2.6.2 Water Flow (Generating)

Gianelli Generating operations moved between 148,000 and 978,600 AF/year of water for SWP use during the data collection period.   Flow is low during the months of January through March and high during the months of May and June, see Figure 19.

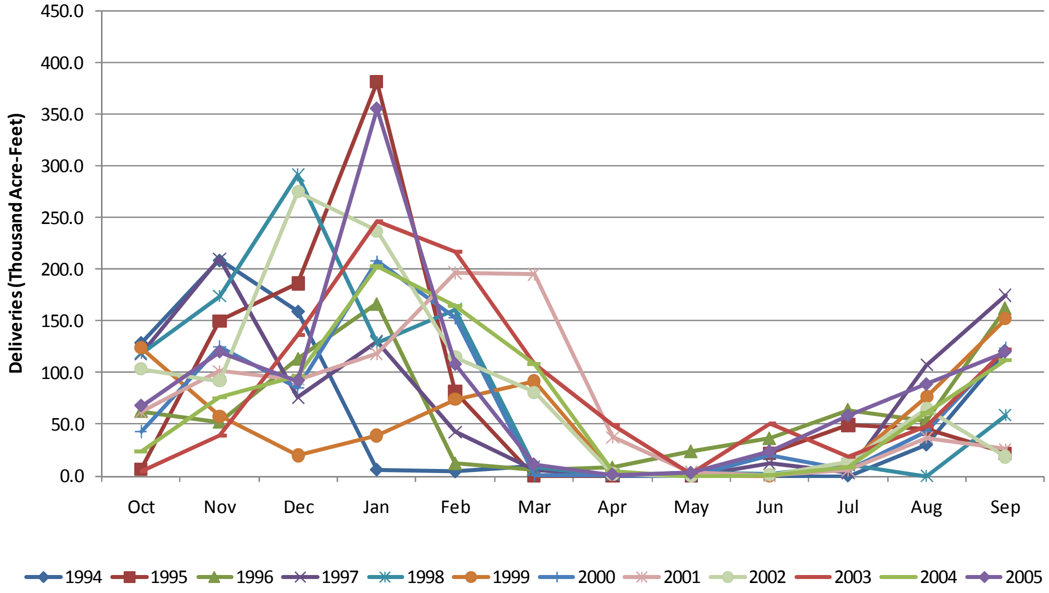
Figure 19: Gianelli Deliveries (Generating)



C.2.6.3 Water Flow (Pumping)

Gianelli Pumping operations moved between 651,000 and 1,047,700 AF/year of water for SWP use during the data collection period. Flow is low during the months of April through June and high during the months of December and January, see Figure 20. Flows for pumping were high while flows for generating were low. This illustrates the seasonal storage functionality of San Luis Reservoir. Water is pumped into the reservoir during wet months and held until it's released in the dry months when it is needed.

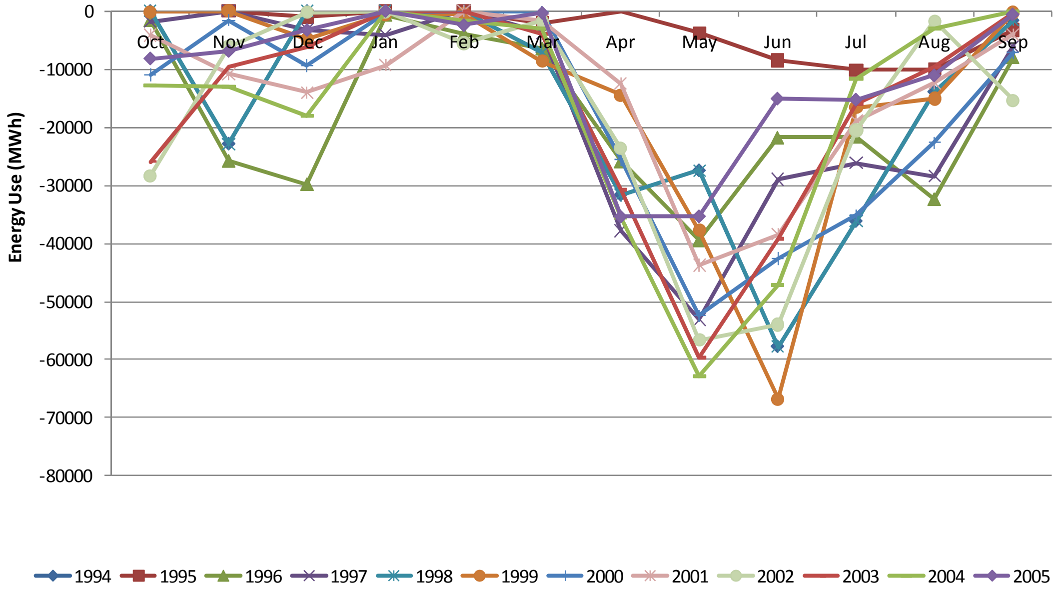
Figure 20: Gianelli Deliveries (Pumping)



C.2.6.4 Energy Production (Generating)

Gianelli Generating Plant’s annual energy production ranged between 38,680 and 217,040 MWh/year during the data collection period. This energy is that which is generated by moving SWP water only. Energy production is low during months of low flow indicated above and high during months of high flow, see Figure 21.

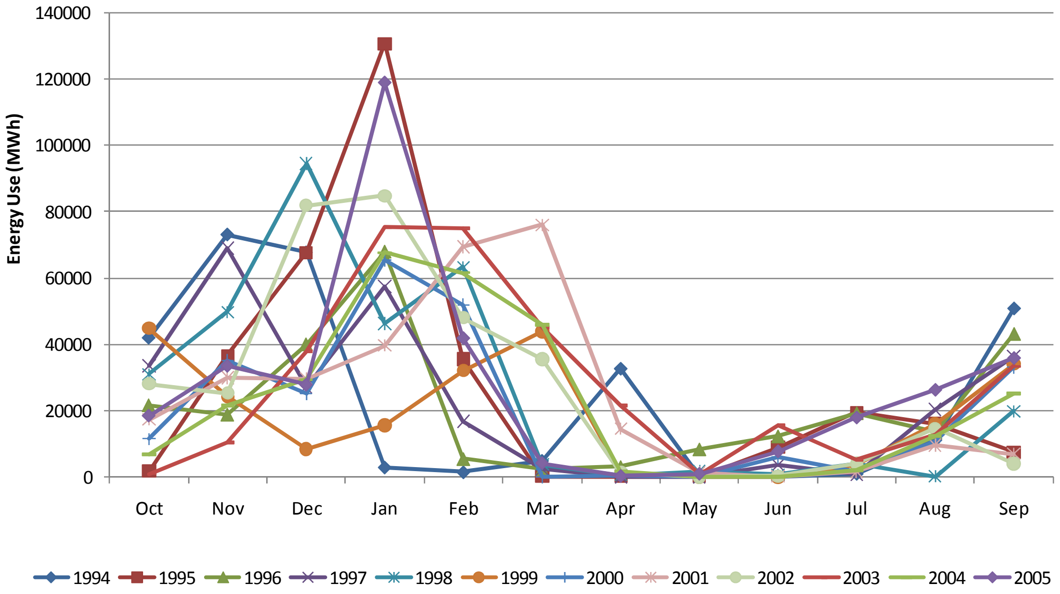
Figure 21: Gianelli Energy Use (Generating)



C.2.6.5 Energy Use (Pumping)

Gianelli Pumping Plant's annual energy consumption ranged between 224,652 and 335,098 MWh/year during the data collection period. This energy is that which is used to move SWP water only. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 22.

Figure 22: Gianelli Energy Use (Pumping)



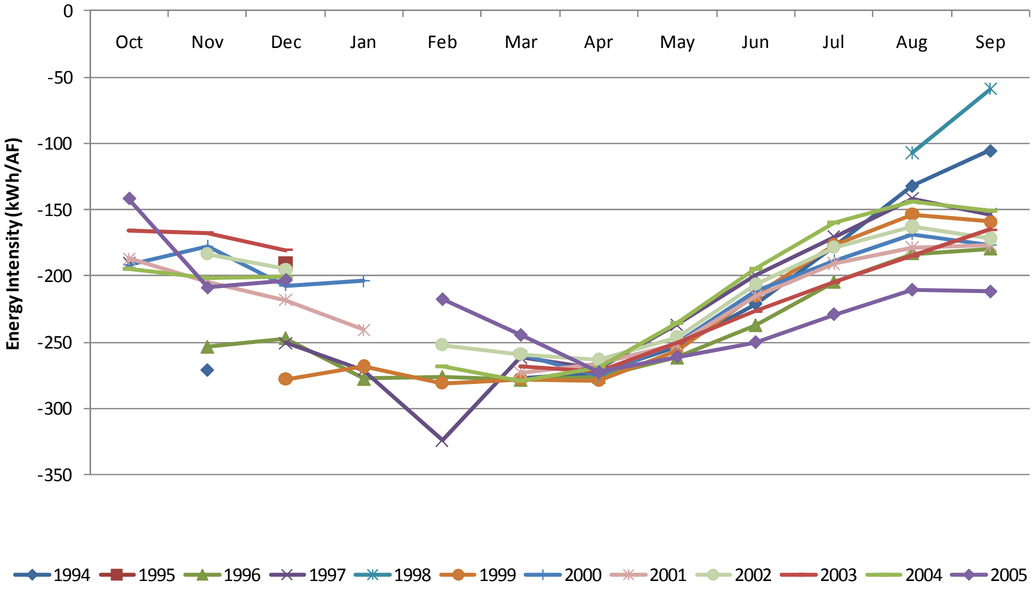
C.2.6.6 Energy Intensity (Generating)

The Study Team determined the energy intensity of generating operations at Gianelli is -217.1 kWh/AF; scatter in the data reveals an error range of 45%, see Table 14. The value of energy intensity varies over time, it is larger in magnitude during January through April and smaller July though October, see Figure 23. Energy intensity varies because the elevation of San Luis Reservoir changes throughout the year. Higher reservoir elevations in February and March produce a greater head to drive the turbines and produce more energy per unit of water than low reservoir elevations. For the purposes of the Study Team's model, the variation of energy intensity over time did not need to be captured at this facility. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 14: Gianelli Energy Intensity (Generating)

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
-217.1	45%	-120.3	-313.8

Figure 23: Gianelli Energy Intensity Plot (Generating)



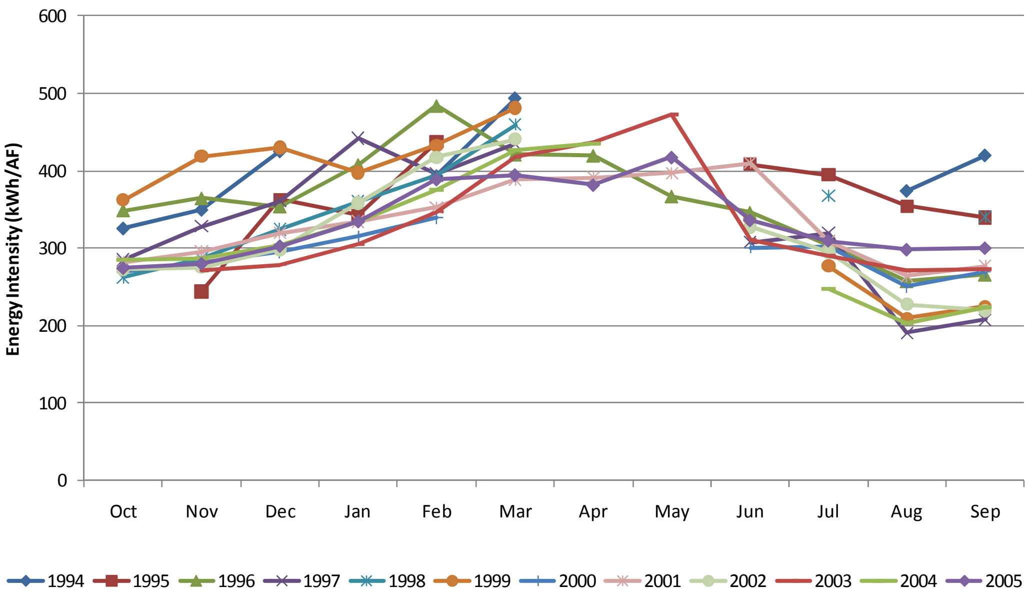
C.2.6.7 Energy Intensity (Pumping)

The Study Team determined the energy intensity of pumping operations at Gianelli is 338.1 kWh/AF; scatter in the data reveals an error range of 41%, see Table 15. The value of energy intensity varies over time, it is larger in magnitude during January through April and smaller July though October, see Figure 24. Energy intensity varies because the elevation of San Luis Reservoir changes throughout the year. Higher reservoir elevations in February and March produce a greater head against which the pumps must operate and require more pumping energy per unit of water than low reservoir elevations. For the purposes of the Study Team's model, the variation of energy intensity over time did not need to be captured at this facility. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 15: Gianelli Energy Intensity (Pumping)

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
338.1	41%	476.4	199.9

Figure 24: Gianelli Energy Intensity Plot (Pumping)



C.2.7 Dos Amigos Pumping Plant

Table 16: Dos Amigos Summary

<table>
<tr><td>Facility Name</td><td colspan="2">Dos Amigos Pumping Plant</td><td>Facility ID</td><td colspan="2">7</td></tr>
<tr><td>Owner</td><td colspan="2">SWP and CVP</td><td>Facility Type</td><td colspan="2">Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="2">San Joaquin River</td><td>DEER Climate Zone</td><td colspan="2">12</td></tr>
<tr><td>Downstream From</td><td colspan="5">Banks Pumping Plant and O’Neil Forebay</td></tr>
<tr><td>Upstream From</td><td colspan="5">Las Perillas Pumping Plant</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="2">Other Wholesale Systems</td><td colspan="2">Storage</td><td>Local Water Systems</td></tr>
<tr><td colspan="2">Central Valley Project</td><td colspan="2"></td><td></td></tr>
<tr><td rowspan="3">Facility Configuration</td><td>Number of Pumps</td><td>Power (HP)</td><td>Speed (RPM)</td><td>Maximum Flow (CFS)</td><td>Static Head (ft)</td></tr>
<tr><td>3[1]</td><td>40,000</td><td>120[1]</td><td>2550</td><td>107-125</td></tr>
<tr><td>3</td><td>40,000</td><td>120</td><td>2600</td><td>107-125</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="5">15,450 CFS</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="2">2001[2]</td><td>Description of Last Major Retrofit</td><td colspan="2">Repair pump and motor on unit 1 and unit 4.</td></tr>
</table>

1: Variable capacity pumps, flow rating represents maximum flow

2: From DWR Bulletin 132, 2002

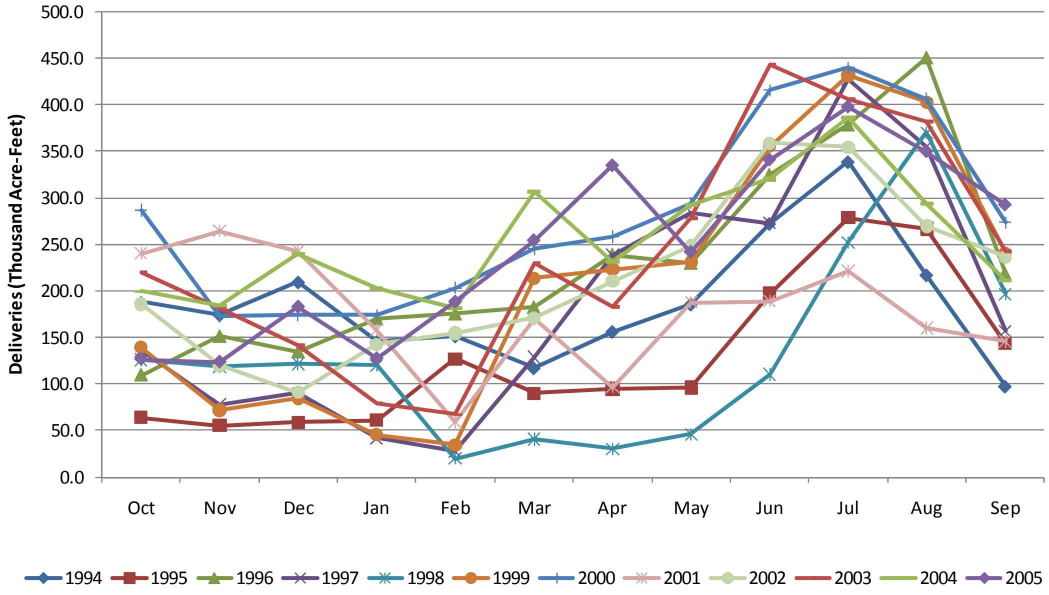
C.2.7.1 Description

Dos Amigos is the second pumping plant in the California Aqueduct, it is downstream from Banks Pumping plant, Bethany Reservoir, and O’Neil Forebay and upstream from the Las Perillas Pumping Plant. Dos Amigos has three pumps that are variable capacity units, the other three are fixed speed. The original intent for operating this plant was to run the variable capacity units constantly, and turn on and off the fixed capacity units as needed. The variable capacity units would then be adjusted to meet the required demand. The facility has a combined maximum capacity of 15,450 CFS. The plant pumps water to a static head ranging from 107 to 125 feet. Dos Amigos pumping plant is a shared facility with the CVP.

C.2.7.2 Water Flow

Dos Amigos Pumping Plant pumped between 1.55 million and 3.34 million AF/year for SWP use during the data collection period. Pumping is low during the months of November through February and high during the months of June through August, see Figure 25.

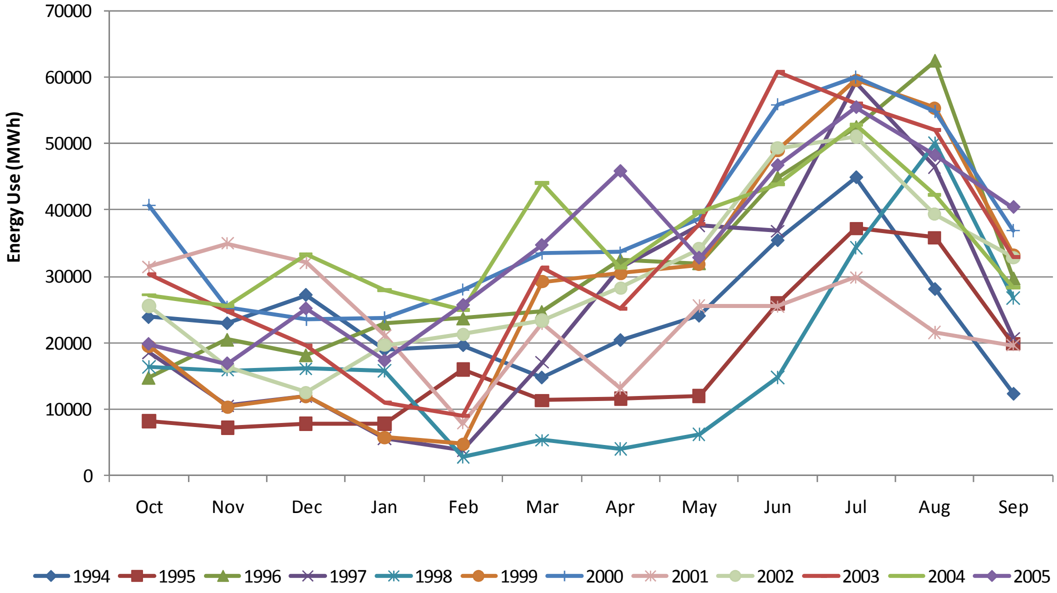
Figure 25: Dos Amigos Deliveries



C.2.7.3 Energy Use

Dos Amigos Pumping Plant's annual energy consumption ranged between 201,010 and 454,992 MWh/year during the data collection period. This energy is that which is used to move SWP water only. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 26.

Figure 26: Dos Amigos Energy Use



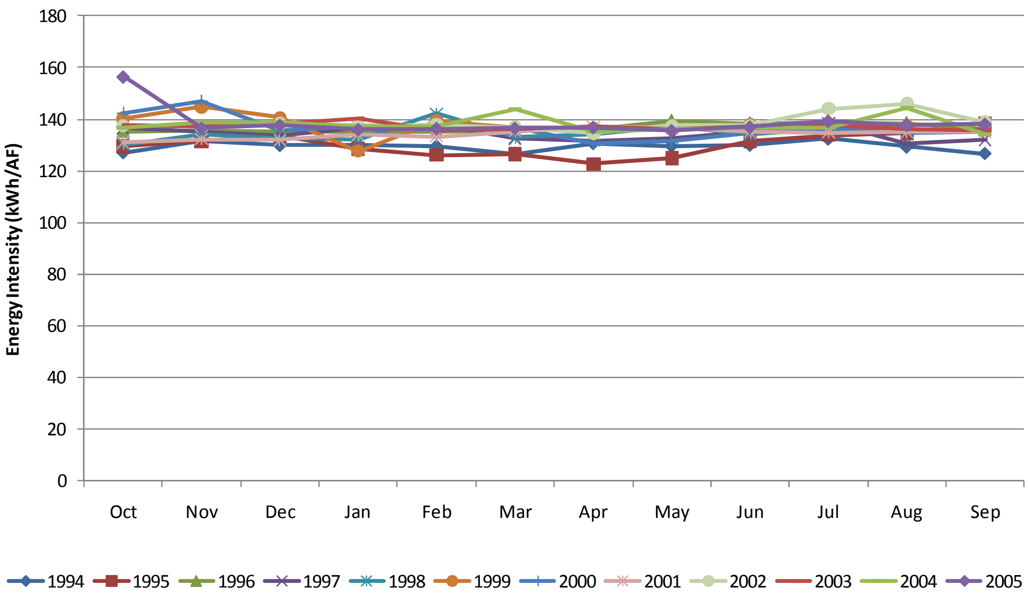
C.2.7.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Dos Amigos is 135.6 kWh/AF; scatter in the data reveals an error range of 6%, see Table 17. The value of energy intensity does not significantly change as over time, see Figure 27. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 17: Dos Amigos Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
135.6	6%	144.3	126.8

Figure 27: Dos Amigos Energy Intensity Plot



C.2.8 Buena Vista Pumping Plant

Table 18: Buena Vista Summary

Facility Name	Buena Vista Pumping Plant		**Facility ID**	8	
Owner	State Water Project		**Facility Type**	Pumping Plant	
Hydrologic Region	Tulare Lake		**DEER Climate Zone**	13	
Downstream From	Dos Amigos Pumping Plant				
Upstream From	Teerink Pumping Plant				
Points of Interconnection	**Other Wholesale Systems**		**Storage**		**Local Water Systems**
	None				
Facility Configuration	**Number of Pumps**	**Power (HP)**	**Speed (RPM)**	**Maximum Flow (CFS)**	**Static Head (ft)**
	3	8,500	360	320	205
	7	17,000	257	635	205
Maximum Plant Capacity	5405 CFS				
Date of Last Major Retrofit	2005[1]		**Description of Last Major Retrofit**	Overhauled motor, pump and discharge valve of unit 7.	

1: From DWR Bulletin 132, 2006

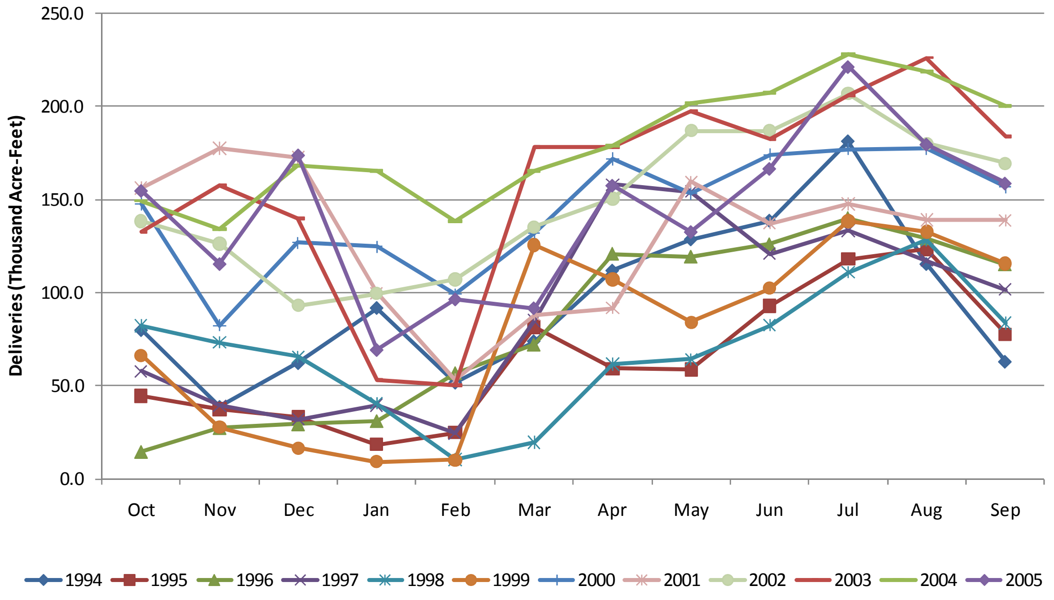
C.2.8.1 Description

Buena Vista Pumping Plant is located in the California Aqueduct; it is downstream of Dos Amigos Pumping Plant and upstream from Teerink Pumping Plant. Of Buena Vista's 10 pumps, only 9 can operate at once. This is because of capacity limitations up and downstream of the plant as well as in-conduit storage limitations. The extra pump is effectively a “reserve” pump; however, no single pump is a dedicated reserve pump, all 10 pumps are regularly used. The Buena Vista turbines were upgraded in the early 1990’s, prior to the data collection period. The plant contains ten fixed speed pumping units with a combined maximum capacity of 5405 CFS. The plant pumps water to a static head of 205 feet.

C.2.8.2 Water Flow

Buena Vista Pumping Plant pumped between 0.77 million and 2.16 million AF/year during the data collection period. Pumping is low during the months of November through February and high during the months of July and August, see Figure 28.

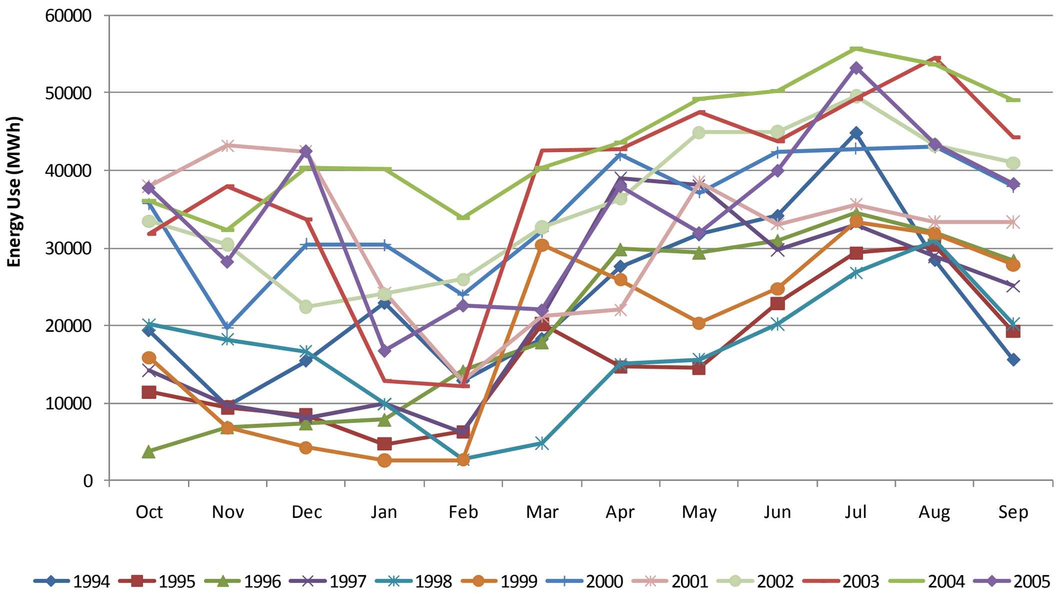
Figure 28: Buena Vista Deliveries



C.2.8.3 Energy Use

Buena Vista Pumping Plant’s annual energy consumption ranged between 191,610 and 524,347 MWh/year during the data collection period. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 29.

Figure 29: Buena Vista Energy Use



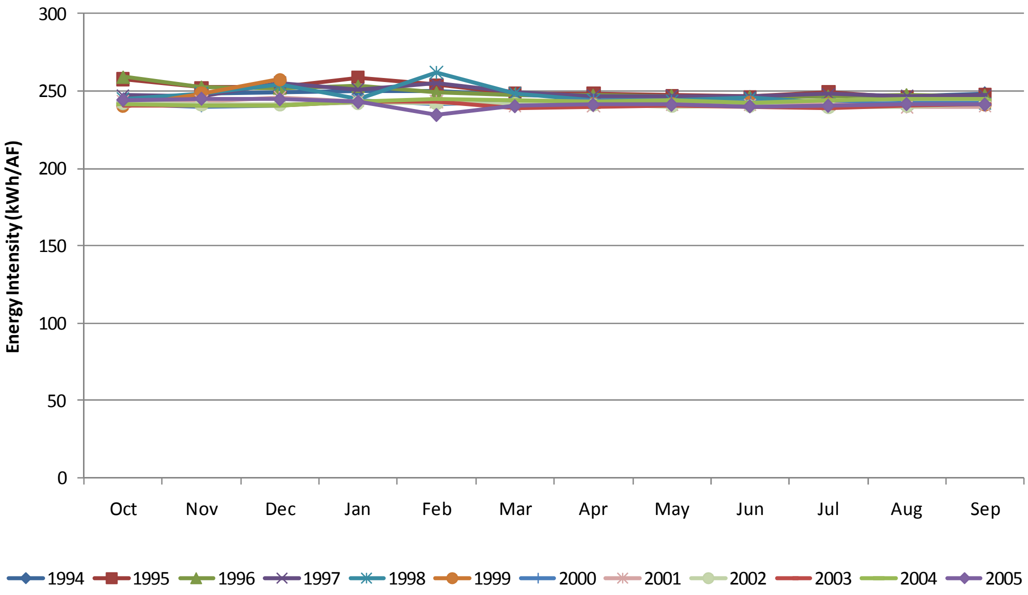
C.2.8.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Buena Vista is 244.8 kWh/AF; scatter in the data reveals an error range of 4%, see Table 19. The value of energy intensity does not significantly change as over time, see Figure 30. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 19: Buena Vista Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
244.8	4%	254.1	235.5

Figure 30: Buena Vista Energy Intensity Plot



C.2.9 Teerink Pumping Plant

Table 20: Teerink Summary

Facility Name	Teerink Pumping Plant	**Facility ID**	9		
Owner	State Water Project	**Facility Type**	Pumping Plant		
Hydrologic Region	Tulare Lake	**DEER Climate Zone**	13		
Downstream From	Buena Vista Pumping Plant				
Upstream From	Chrisman Pumping Plant				
Points of Interconnection	**Other Wholesale Systems**	**Storage**	**Local Water Systems**		
	None				
Facility Configuration	**Number of Pumps**	**Power (HP)**	**Speed (RPM)**	**Maximum Flow (CFS)**	**Static Head (ft)**
	3	10,000	400	335	223
	6	20,000	227	740	223
Maximum Plant Capacity	5445 CFS				
Date of Last Major Retrofit	2004	**Description of Last Major Retrofit**	Overhaul pump and motor on unit 5.		

1: From DWR Bulletin 132, 2005

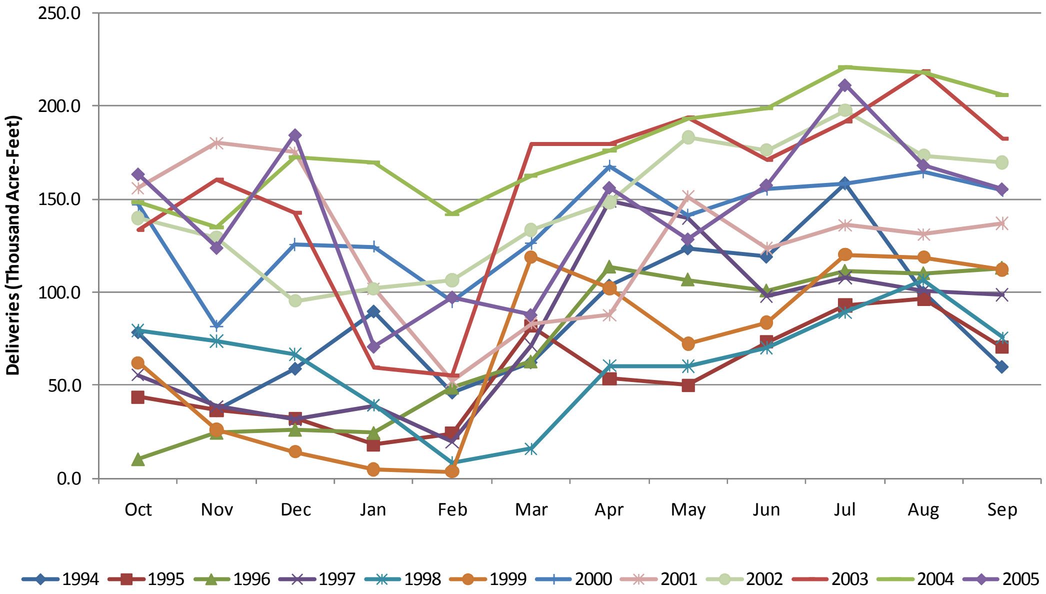
C.2.9.1 Description

Teerink Pumping Plant is located in the California Aqueduct; it is downstream of Buena Vista Pumping Plant and upstream from Chrisman Pumping Plant. Of Teerink's 9 pumps, only 8 can operate at once. This is because of capacity limitations up and downstream of the plant as well as in-conduit storage limitations. The extra pump is effectively a "reserve" pump; however, no single pump is a dedicated reserve pump, all 9 pumps are regularly used. The Teerink turbines were upgraded in the early 1990's, prior to the data collection period. The plant contains nine fixed speed pumping units with a combined maximum capacity of 5445 CFS. The plant pumps water to a static head of 223 feet.

C.2.9.2 Water Flow

Teerink Pumping Plant pumped between .67 million and 2.14 million AF/year during the data collection period. Pumping is low during the months of November through February and high during the months of July and August, see Figure 31.

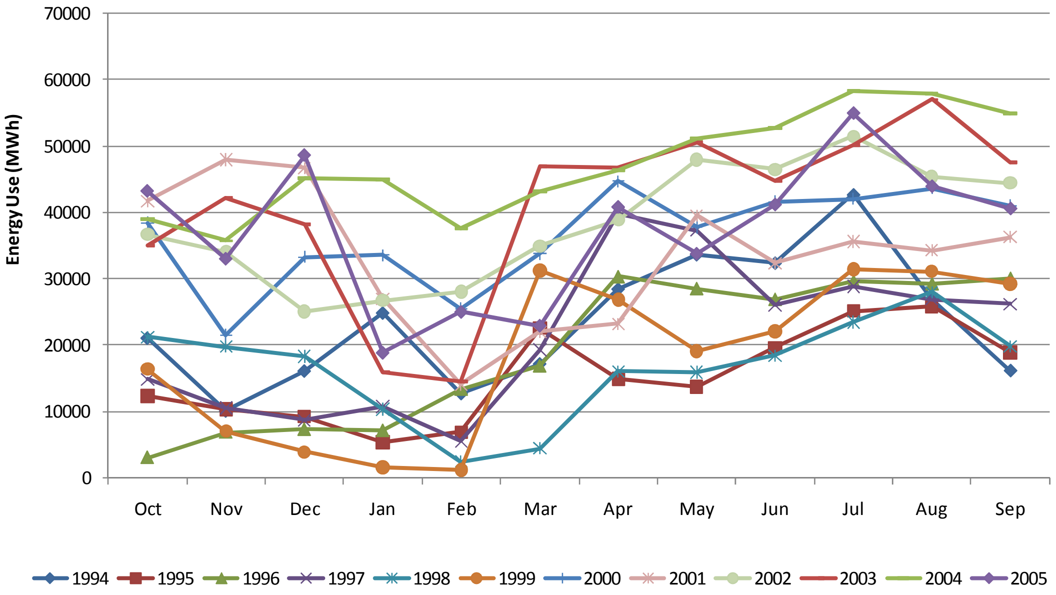
Figure 31: Teerink Deliveries



C.2.9.3 Energy Use

Teerink Pumping Plant's annual energy consumption ranged between 184,810 and 567,100 MWh/year during the data collection period. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 32.

Figure 32: Teerink Energy Use



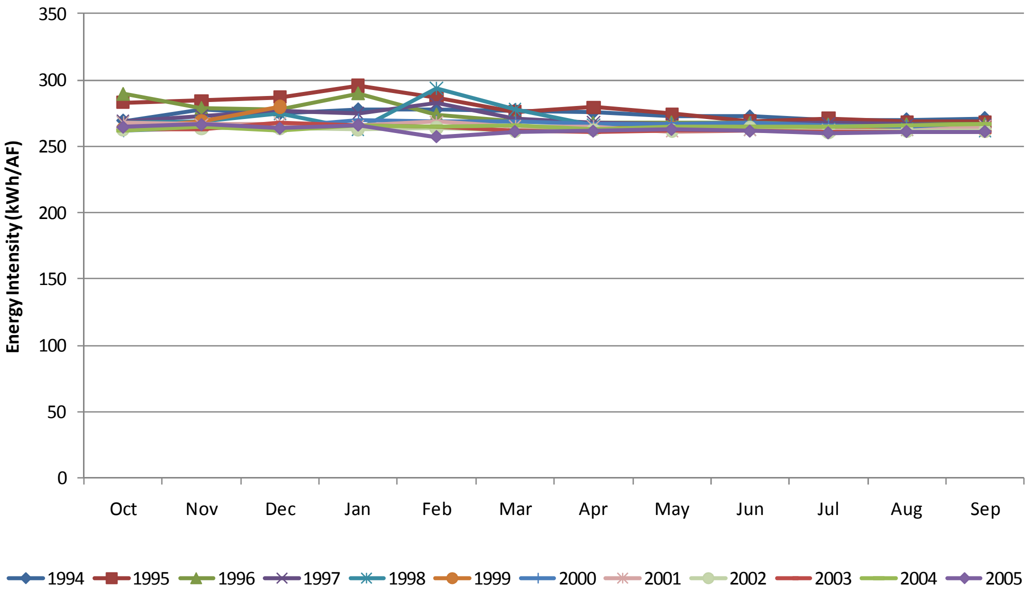
C.2.9.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Teerink is 267.8 kWh/AF; scatter in the data reveals an error range of 5%, see Table 21. The value of energy intensity does not significantly change as over time, see Figure 33. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 21: Teerink Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
267.8	5%	282.2	253.4

Figure 33: Teerink Energy Intensity Plot



C.2.10 Chrisman Pumping Plant

Table 22: Chrisman Summary

<table>
<tr><td>Facility Name</td><td colspan="10">Chrisman Pumping Plant</td><td colspan="10">Facility ID</td><td colspan="10">10</td></tr>
<tr><td>Owner</td><td colspan="10">State Water Project</td><td colspan="10">Facility Type</td><td colspan="10">Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="10">Tulare Lake</td><td colspan="10">DEER Climate Zone</td><td colspan="10">13</td></tr>
<tr><td>Downstream From</td><td colspan="30">Teerink Pumping Plant</td></tr>
<tr><td>Upstream From</td><td colspan="30">Edmonston Pumping Plant</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="10">Other Wholesale Systems</td><td colspan="10">Storage</td><td colspan="10">Local Water Systems</td></tr>
<tr><td colspan="10">None</td><td colspan="10"></td><td colspan="10"></td></tr>
<tr><td rowspan="4">Facility Configuration</td><td colspan="6">Number of Pumps</td><td colspan="6">Power (HP)</td><td colspan="6">Speed (RPM)</td><td colspan="6">Maximum Flow (CFS)</td><td colspan="6">Static Head (ft)</td></tr>
<tr><td colspan="6">3</td><td colspan="6">22,000</td><td colspan="6">514</td><td colspan="6">310</td><td colspan="6">518</td></tr>
<tr><td colspan="6">3</td><td colspan="6">44,000</td><td colspan="6">360</td><td colspan="6">685</td><td colspan="6">518</td></tr>
<tr><td colspan="6">3</td><td colspan="6">44,000</td><td colspan="6">360</td><td colspan="6">670</td><td colspan="6">518</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="30">4995 CFS</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="10">2005[1]</td><td colspan="10">Description of Last Major Retrofit</td><td colspan="10">Overhaul motor, and pump, and replace piping of unit 7</td></tr>
</table>

1: From DWR Bulletin 132, 2006

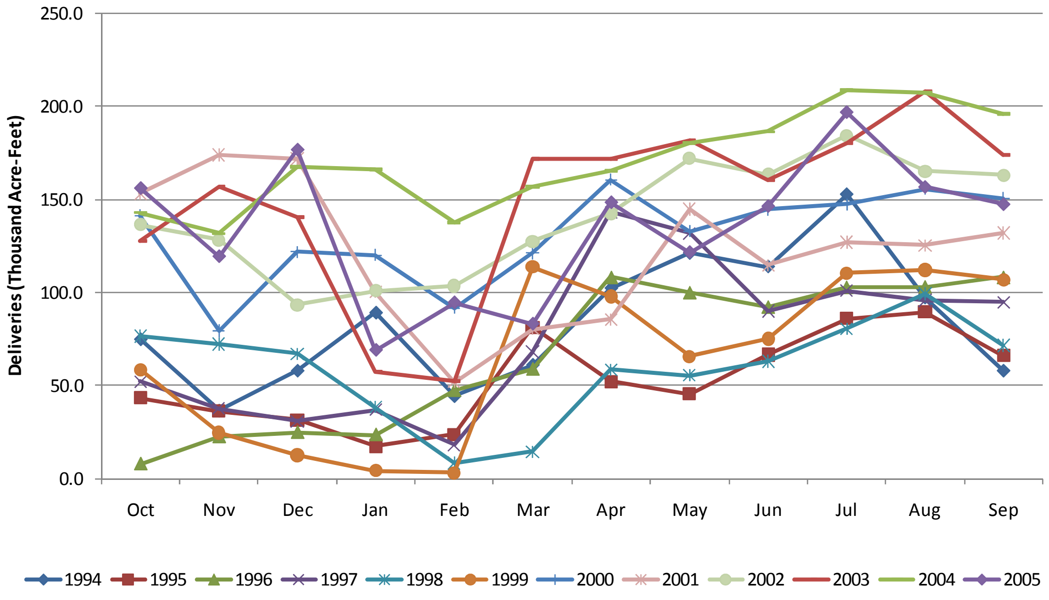
C.2.10.1 Description

Chrisman Pumping Plant is located in the California Aqueduct; it is downstream of Teerink Pumping Plant and upstream from Edmonston Pumping Plant. Of Chrisman's 9 pumps, only 8 can operate at once. This is because of capacity limitations up and downstream of the plant as well as in-conduit storage limitations. The extra pump is effectively a "reserve" pump; however, no single pump is a dedicated reserve pump, all 9 pumps are regularly used. The plant contains nine fixed speed pumping units with a combined maximum capacity of 4995 CFS. The plant pumps water to a static head of 518 feet. Chrisman had electrical and mechanical problems over the years associated with high head.

C.2.10.2 Water Flow

Chrisman Pumping Plant pumped between .64 million and 2.05 million AF/year during the data collection period. Pumping is low during the months of November through February and high during the months of July and August, see Figure 34.

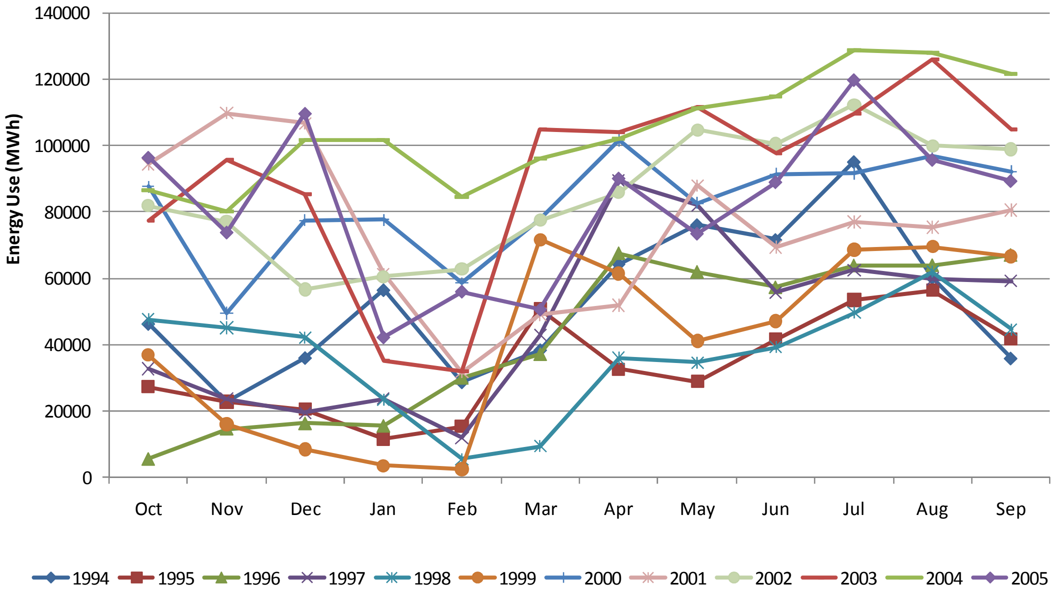
Figure 34: Chrisman Deliveries



C.2.10.3 Energy Use

Chrisman Pumping Plant's annual energy consumption ranged between 403,720 and 1,256,414 MWh/year during the data collection period. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 35.

Figure 35: Chrisman Energy Use



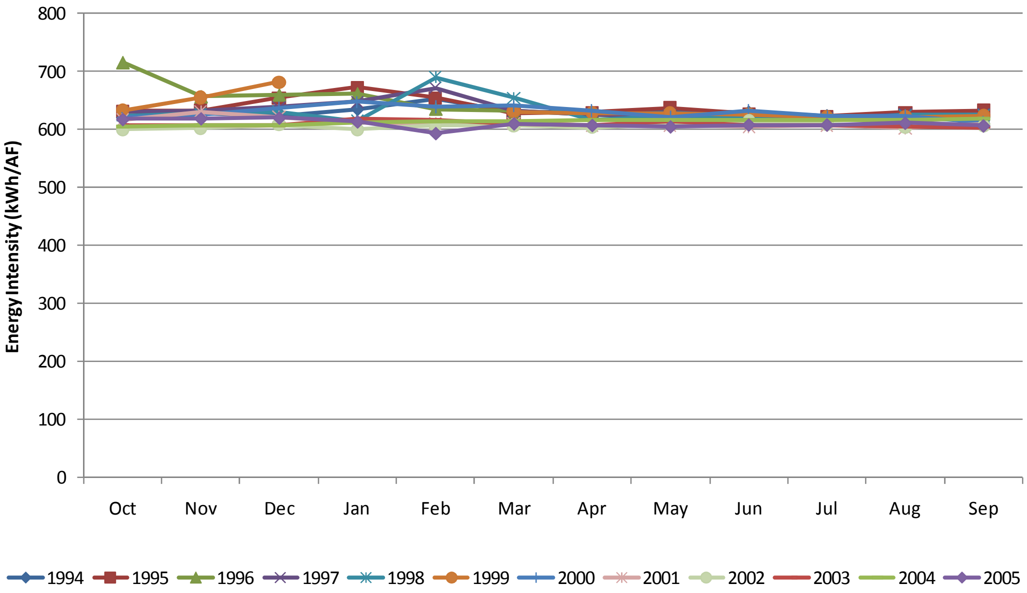
C.2.10.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Chrisman is 623.8 kWh/AF; scatter in the data reveals an error range of 6%, see Table 23. The value of energy intensity does not significantly change as over time, see Figure 36. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 23: Chrisman Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
623.8	6%	660.2	587.4

Figure 36: Chrisman Energy Intensity Plot



C.2.11 Edmonston Pumping Plant

Table 24: Edmonston Summary

<table>
<tr><th>Facility Name</th><td colspan="2">Edmonston Pumping Plant</td><th>Facility ID</th><td colspan="2">11</td></tr>
<tr><th>Owner</th><td colspan="2">State Water Project</td><th>Facility Type</th><td colspan="2">Pumping Plant</td></tr>
<tr><th>Hydrologic Region</th><td colspan="2">Tulare Lake</td><th>DEER Climate Zone</th><td colspan="2">13</td></tr>
<tr><th>Downstream From</th><td colspan="5">Chrisman Pumping Plant</td></tr>
<tr><th>Upstream From</th><td colspan="5">Alamo Power Plant</td></tr>
<tr><th rowspan="2">Points of Interconnection</th><th colspan="2">Other Wholesale Systems</th><th colspan="2">Storage</th><th>Local Water Systems</th></tr>
<tr><td colspan="2">None</td><td colspan="2"></td><td></td></tr>
<tr><th rowspan="2">Facility Configuration</th><th>Number of Pumps</th><th>Power (HP)</th><th>Speed (RPM)</th><th>Maximum Flow (CFS)</th><th>Static Head (ft)</th></tr>
<tr><td>14</td><td>80,000</td><td>600</td><td>4480</td><td>1,926</td></tr>
<tr><th>Maximum Plant Capacity</th><td colspan="5">62,720 CFS</td></tr>
<tr><th>Date of Last Major Retrofit</th><td colspan="2">2005[1]</td><th>Description of Last Major Retrofit</th><td colspan="2">Replace 4 pumps and other significant improvements</td></tr>
</table>

1: From DWR Bulletin 132, 2006

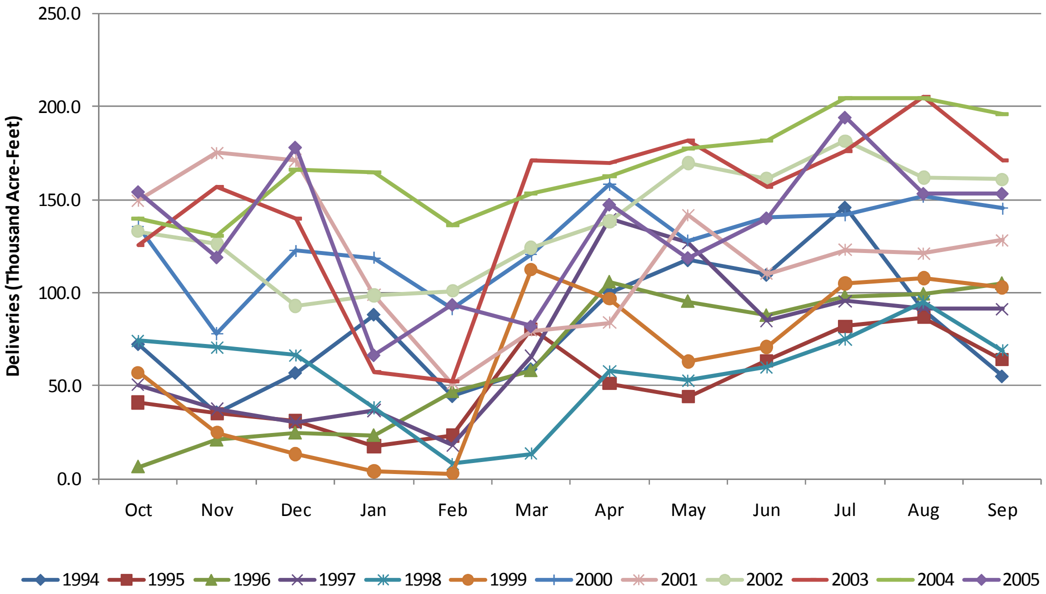
C.2.11.1 Description

Edmonston Pumping Plant is located in the California Aqueduct; it is downstream of Chrisman Pumping Plant and upstream from Alamo Power Plant Pumping Plant. Of the 14 pumps, only 13 can be used at once, the other is “reserve”. Edmonston is in the process of being rebuilt, major mechanical upgrades began around 2005, though the impact on our data should be minimal if any. The plant contains fourteen fixed speed pumping units with a combined maximum capacity of 62,720 CFS. The plant pumps water to a static head of 1,926 feet.

C.2.11.2 Water Flow

Edmonston Pumping Plant pumped between .62 million and 2.02 million AF/year during the data collection period. Pumping is low during the months of November through February and high during the months of July and August, see Figure 37.

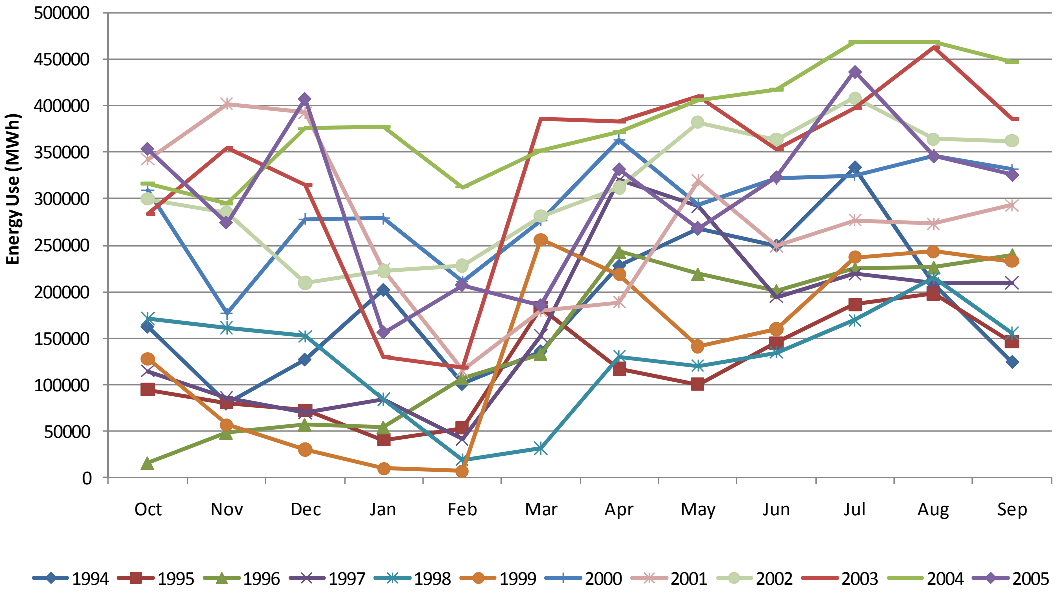
Figure 37: Edmonston Deliveries



C.2.11.3 Energy Use

Edmonston Pumping Plant's annual energy consumption ranged between 1,418,150 and 4,606,601 MWh/year during the data collection period. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 38. Edmonston is the largest energy consuming facility in the SWP due to its need to pump to an elevation of almost 2,000 feet.

Figure 38: Edmonston Energy Use



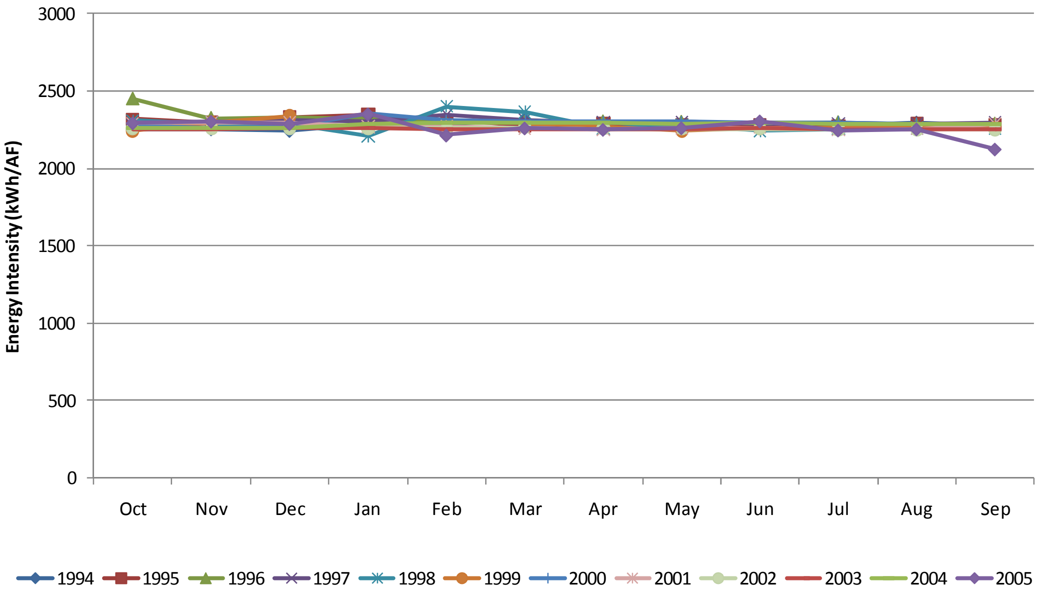
C.2.11.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Edmonston is 2280.8 kWh/AF; scatter in the data reveals an error range of 2%, see Table 25. The value of energy intensity does not significantly change as over time, see Figure 39. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 25: Edmonston Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
2280.8	3%	2349.4	2212.2

Figure 39: Edmonston Energy Intensity Plot



C.2.12Oso Pumping Plant

Table 26: Oso Summary

<table>
<tr><td>Facility Name</td><td colspan="2">Oso Pumping Plant</td><td>Facility ID</td><td colspan="2">12</td></tr>
<tr><td>Owner</td><td colspan="2">State Water Project</td><td>Facility Type</td><td colspan="2">Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="2">South Lahontan</td><td>DEER Climate Zone</td><td colspan="2">14</td></tr>
<tr><td>Downstream From</td><td colspan="5">Edmonston Pumping Plant</td></tr>
<tr><td>Upstream From</td><td colspan="5">Warne Power Plant</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="2">Other Wholesale Systems</td><td colspan="2">Storage</td><td>Local Water Systems</td></tr>
<tr><td colspan="2">None</td><td colspan="2">Quail Lake (in-conduit, SWP)</td><td></td></tr>
<tr><td rowspan="3">Facility Configuration</td><td>Number of Pumps</td><td>Power (HP)</td><td>Speed (RPM)</td><td>Maximum Flow (CFS)</td><td>Static Head (ft)</td></tr>
<tr><td>4</td><td>18,750</td><td>300</td><td>645</td><td>231</td></tr>
<tr><td>4</td><td>4,700</td><td>600</td><td>168</td><td>231</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="5">3252 CFS</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="2">2005[1]</td><td>Description of Last Major Retrofit</td><td colspan="2">Unit 7 motor rewound.</td></tr>
</table>

1: From DWR Bulletin 132, 2006

C.2.12.1 Description

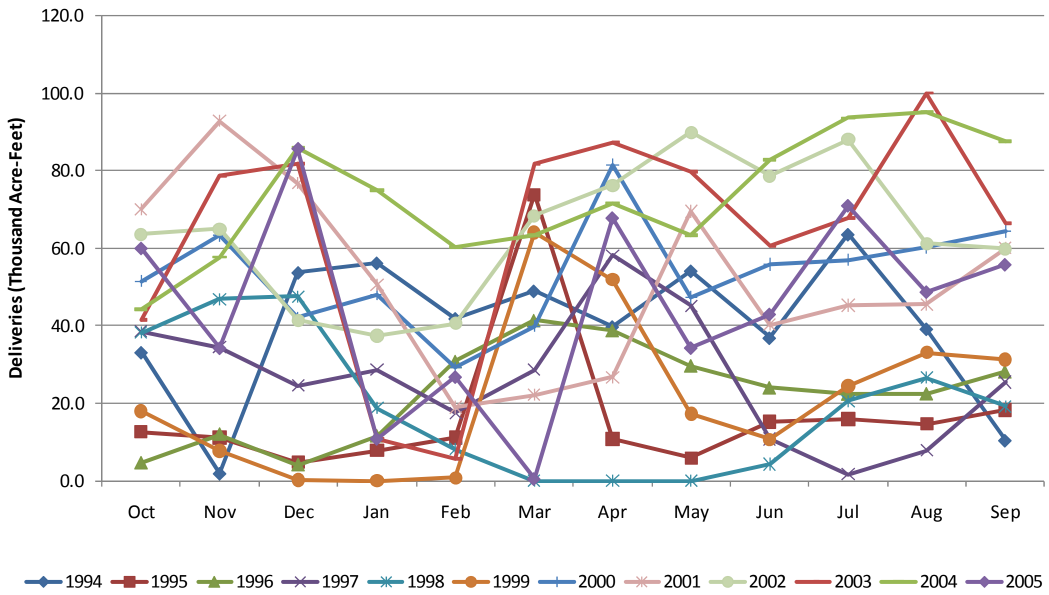
Oso Pumping Plant is the first facility West Branch Aqueduct of the State Water Project. It pumps water out of the California Aqueduct. Water exiting this plant continues to flow to Quail

Lake which feeds Warne Power Plant. The plant contains eight fixed speed pumping units with a combined maximum capacity of 3252 CFS. The plant pumps water to a static head of 231 feet.

C.2.12.2 Water Flow

Oso Pumping Plant pumped between 201,900 and 880,500 AF/year during the data collection period. Pumping is low during the months of January and February and high during the months of March through May, see Figure 40.

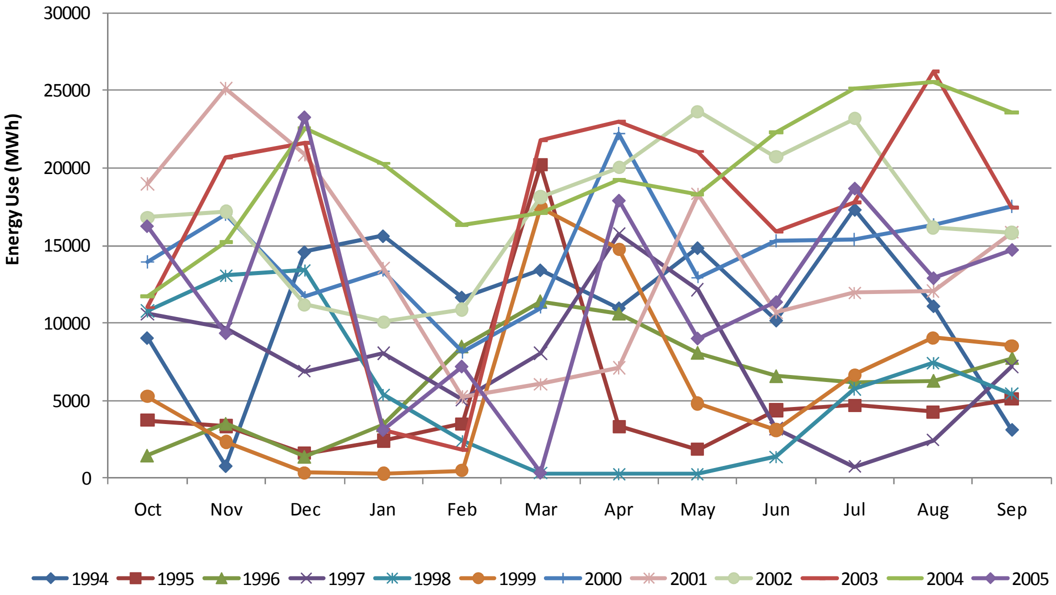
Figure 40: Oso Deliveries



C.2.12.3 Energy Use

Oso Pumping Plant's annual energy consumption ranged between 58,420 and 237,296 MWh/year during the data collection period. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 41.

Figure 41: Oso Energy Use



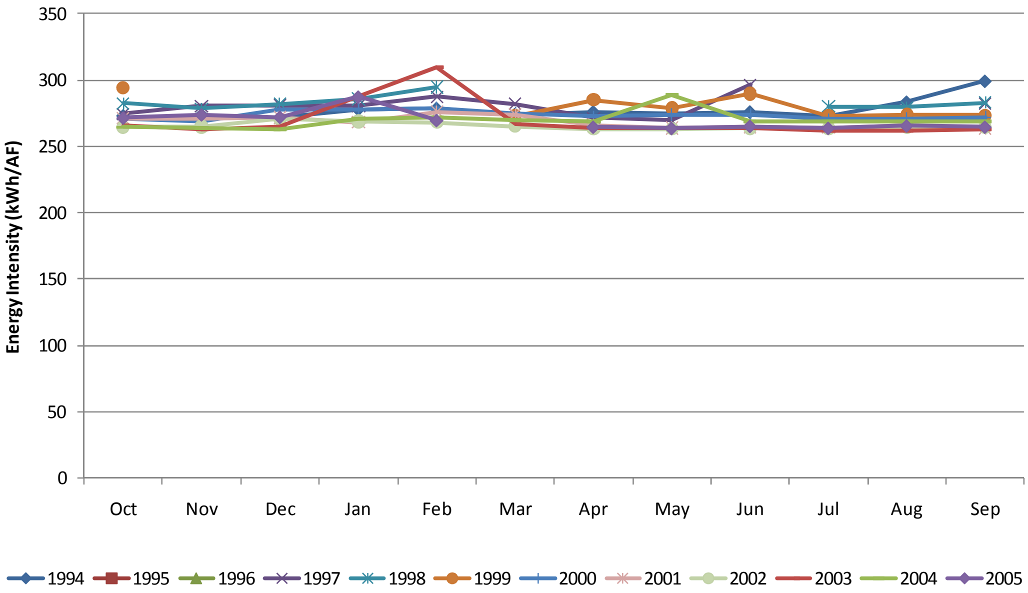
C.2.12.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Oso is 273 kWh/AF; scatter in the data reveals an error range of 7%, see Table 27. The value of energy intensity does not significantly change as over time, see Figure 42. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 27: Oso Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
273.0	7%	291.4	254.6

Figure 42: Oso Energy Intensity Plot



C.2.13Warne Power Plant

Table 28: Warne Summary

<table>
<tr><td>Facility Name</td><td colspan="6">Warne Power Plant</td><td colspan="3">Facility ID</td><td colspan="3">13</td></tr>
<tr><td>Owner</td><td colspan="6">State Water Project</td><td colspan="3">Facility Type</td><td colspan="3">Power Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="6">South Coast</td><td colspan="3">DEER Climate Zone</td><td colspan="3">16</td></tr>
<tr><td>Downstream From</td><td colspan="12">Quail Lake and Oso Pumping Plant</td></tr>
<tr><td>Upstream From</td><td colspan="12">Castaic Power Plant</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="4">Other Wholesale Systems</td><td colspan="4">Storage</td><td colspan="4">Local Water Systems</td></tr>
<tr><td colspan="4">None</td><td colspan="4">Pyramid Lake (in-conduit, SWP)</td><td colspan="4"></td></tr>
<tr><td rowspan="2">Facility Configuration</td><td colspan="3">Number of Generators</td><td colspan="3">Power Generation (MVA)</td><td colspan="3">Maximum Flow (CFS)</td><td colspan="3">Static Head (ft)</td></tr>
<tr><td colspan="3">2</td><td colspan="3">39.1</td><td colspan="3">782</td><td colspan="3">719-739</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="12">1564 CFS</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="6">2005[1]</td><td colspan="3">Description of Last Major Retrofit</td><td colspan="3">Unit 1 motor rewound.</td></tr>
</table>

1: From DWR Bulletin 132, 2006

C.2.13.1 Description

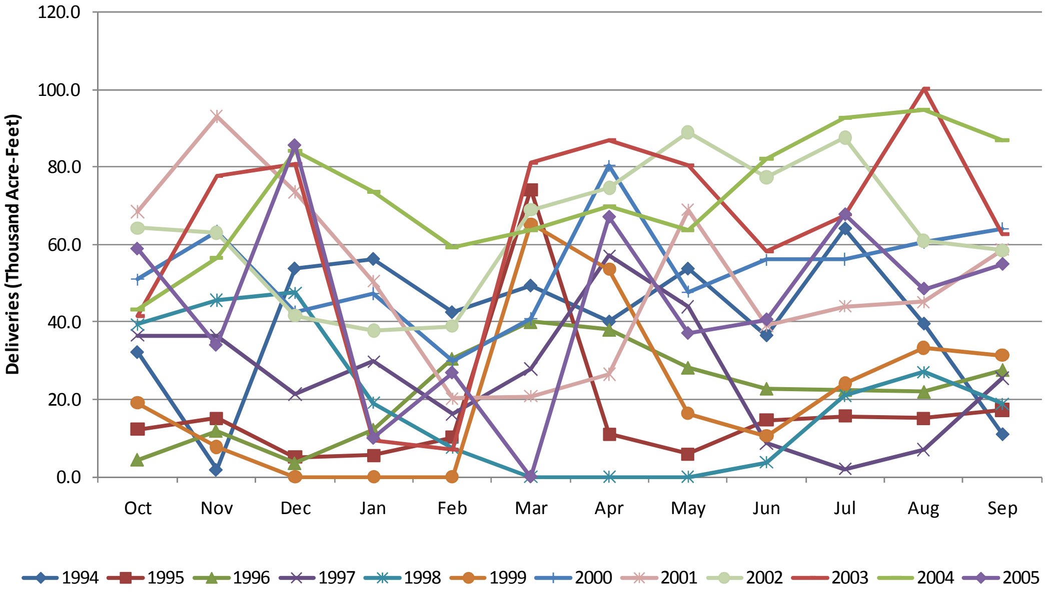
Warne Power Plant is the second SWP facility in the West Branch of the State Water Project. Water exiting this plant continues to flow to Pyramid Lake which feeds Castaic Power Plant. The plant contains two generating units with a combined maximum capacity of 1564 CFS. The plant operates at a static head ranging from 719 to 739 feet.

The Warne Power Plant has a creek that flows into its forebay. During wet years this creek brings significant amount of silt and builds up sediment in the forebay. When sediment builds up dredging is requiring sometimes cause outages or other issues with the plant.

C.2.13.2 Water Flow

Warne Power Plant moved between 201,800 and 870,300 AF/year of water during the data collection period. Flow is low during the months of January and February and high during the months of March through May, see Figure 43.

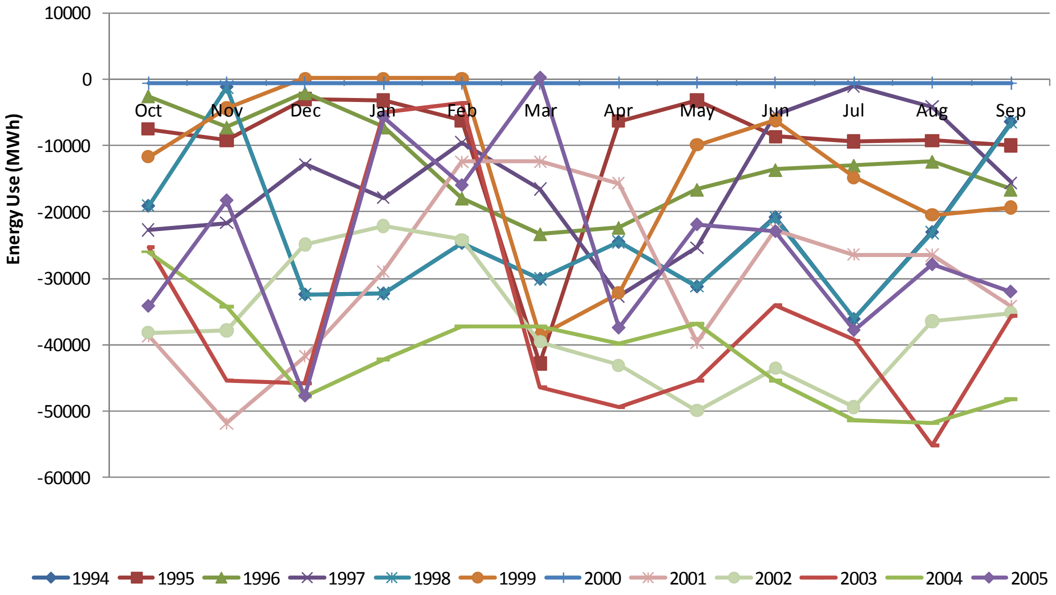
Figure 43: Warne Deliveries



C.2.13.3 Energy Production

Warne Power Plant's annual energy production ranged between 6,890 and 498,305 MWh/year during the data collection period. Energy production is low during months of low flow indicated above and high during months of high flow, see Figure 44.

Figure 44: Warne Energy Use



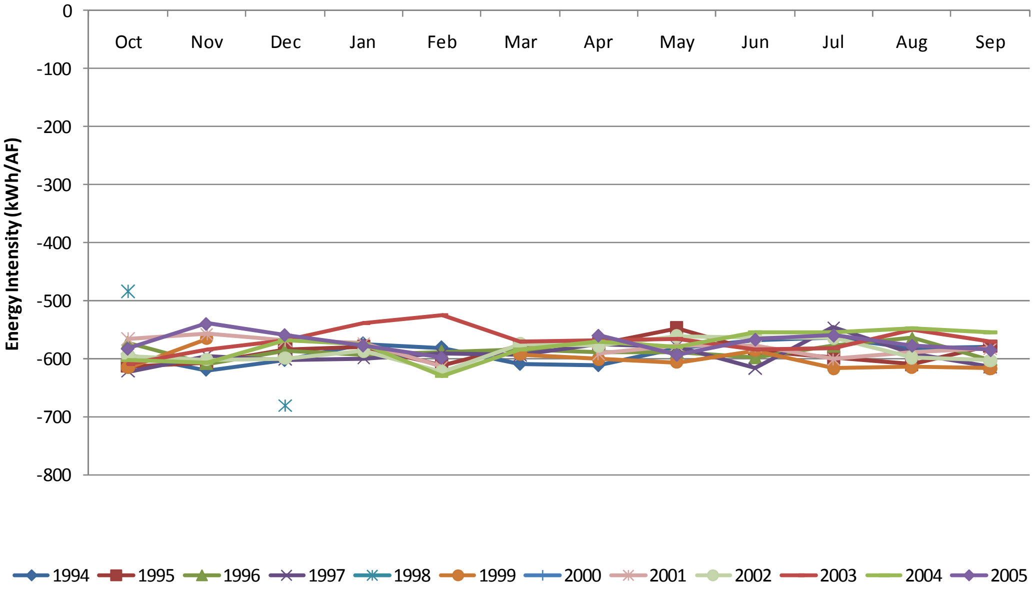
C.2.13.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Warne is -584.1 kWh/AF; scatter in the data reveals an error range of 8%, see Table 29. The value of energy intensity does not significantly change as over time, see Figure 45. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 29: Warne Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
-584.1	8%	-535.7	-632.5

Figure 45: Warne Energy Intensity Plot



C.2.14Castaic Power Plant

Table 30: Castaic Summary

<table>
<tr><td>Facility Name</td><td colspan="2">Castaic Power Plant</td><td>Facility ID</td><td colspan="2">14</td></tr>
<tr><td>Owner</td><td colspan="2">State Water Project</td><td>Facility Type</td><td colspan="2">Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="2">South Coast</td><td>DEER Climate Zone</td><td colspan="2">9</td></tr>
<tr><td>Downstream From</td><td colspan="5">Warne Power Plant and Pyramid Lake</td></tr>
<tr><td>Upstream From</td><td colspan="5">Castaic Lake</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="2">Other Wholesale Systems</td><td colspan="2">Storage</td><td>Local Water Systems</td></tr>
<tr><td colspan="2">Connects to MWD via Castaic Lake</td><td colspan="2">Castaic Lake (in-conduit, SWP)</td><td></td></tr>
<tr><td rowspan="3">Facility Configuration</td><td>Number of Units</td><td>Power (HP)</td><td>Power Generation (MVA)</td><td>Maximum Flow (CFS)</td><td>Static Head (ft)</td></tr>
<tr><td>6</td><td>320,000 (P)</td><td>210 (G)</td><td>3470/2300 (G/P)</td><td>1048 (G), 1078 (P)</td></tr>
<tr><td>1</td><td>N/A</td><td>59.7 (G)</td><td>800 (G)</td><td>1050 (G)</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="5">21,620 CFS (G), 13,800 (P)</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="2">N/A</td><td>Description of Last Major Retrofit</td><td colspan="2"></td></tr>
</table>

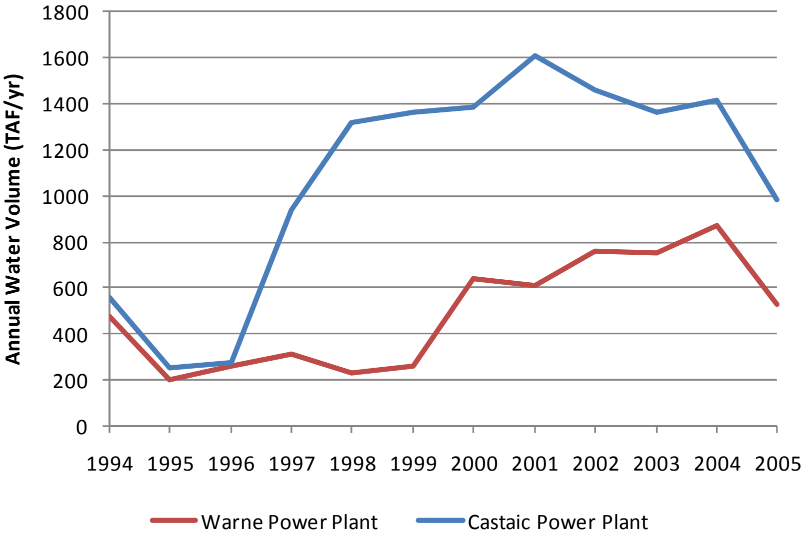
C.2.14.1 Description

Castaic Plant is the final facility in the SWP West Branch; it is owned by SWP but operated by LADWP. SWP schedules ultimate deliveries through the plant and owns 250 MW of generating capacity at Castaic. Castaic is operated as a pump-storage facility by LADWP; water is pumped up to storage at night when electric rates and demand are low and is released to generate power during the day when electric rates and demand are higher. When generating, water flows down from Pyramid Lake through the plant to Elderberry Forebay above Castaic Lake. When pumping, the flow of water reverses pumping water up to Pyramid Lake. The plant contains six pumping/ generating units and one dedicated generating unit. These create a combined maximum capacity of 21,620 CFS for generation and 13,800 CFS for pumping. The plants generators operate at a static head ranging from 1048 to 1050 feet, and pumps water to a static head of 1078 feet.

Water flow and power generation data was available from DWR; however the study team noticed an anomaly in the data set. The Study Team first noted erratic patterns in the energy intensity data calculated using data received from DWR. Unlike other SWP facilities and power plants, energy intensity did not display a relatively consistent pattern. Upon closer inspection of the data, the Study Team isolated the water flow data as a contributing factor to the erratic energy intensity. The Study Team hypothesizes data recording protocols for water flows and possibly energy production changed in May 1997, see below for details. The Study Team's made several efforts to contact staff at LADWP to verify the hypothesis and collection additional data; however, there were no responses regarding this issue.

Castaic Lake is downstream from Warne Power Plant; Pyramid Lake lies between the two facilities. While the lake's storage can cause month to month differences in the flows through each facility, annual flows through each are comparable. Additional analysis by the Study Team found an insignificant amount of water (if any) was delivered between the two pump stations throughout the data collection years. Thus the annual flow though each facility should be relatively consistent. Plotting the annual flow through Warne Power Plant and Castaic Power Plant (as provided) yields Figure 46.

Figure 46: Castaic and Warne Power Plant Annual Deliveries



Based on this comparison the Study Team hypothesizes the following:

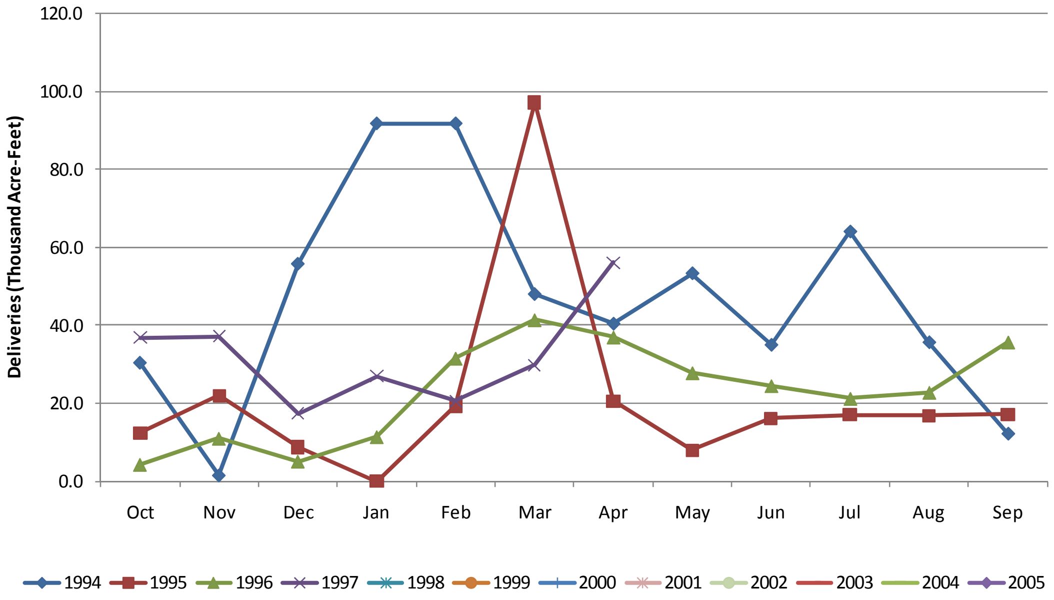
- Water flow measurements at Castaic Lake include all water that passed through its generators
- Water flow measurements do not subtract water that was pumped from Elderberry Forebay to Pyramid Lake during pumped-storage operations
- Water flow at Castaic "double counts" water deliveries by not subtracting water pumped during pumped storage operations and subsequently released through the generators
- Prior to 1997, water flow properly accounted for pumped storage operations as flows match closely to that of Warne Power Plant

The Study team attempted to locate additional data on the separate pumping and generating flows from DWR but was unsuccessful as the plant is operated by LADWP. Attempts to contact LADWP on this matter were also unsuccessful. The Study Team thus decided to: 1) use water and energy data from 1994-1996 to estimate energy intensity at Castaic Power Plant and 2) use flow data from Warne Power Plant as a proxy for flow at Castaic Power Plant for use in the model and calculation of net energy generation.

C.2.14.2 Energy Intensity

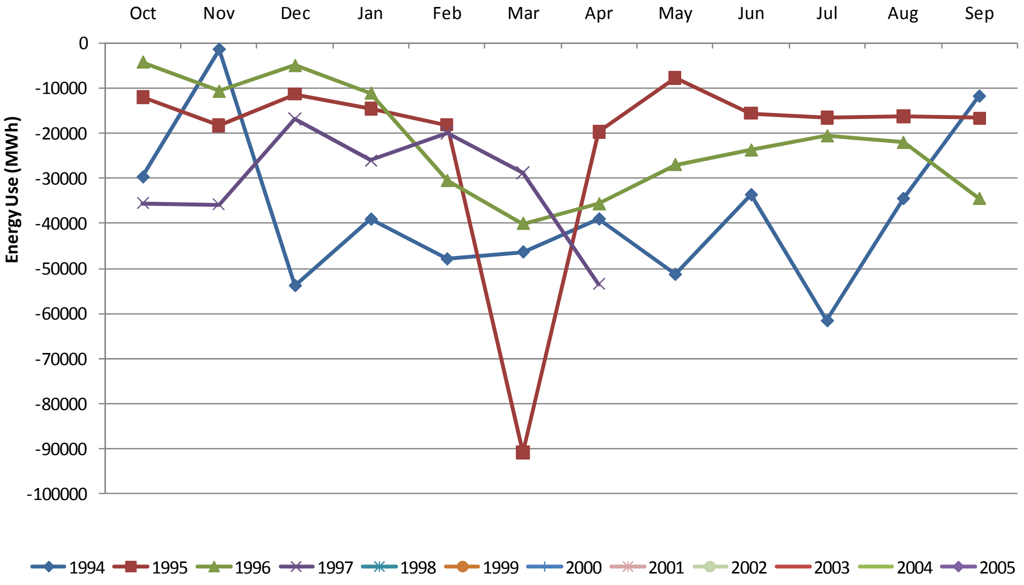
Castaic Power Plant moved between 254,900 and 558,800 AF/year of water during 1994-1998. Deliveries are erratic but tend to be higher during low during February through April, see Figure 47.

Figure 47: Castaic Deliveries (1994-1996)



Castaic Power Plant's net energy production ranged between 257 and 559 GWh/year during 1994-1996. Energy production is low during months of low flow indicated above and high during months of high flow, see Figure 48.

Figure 48: Castaic Net Energy Use (1994-1996)

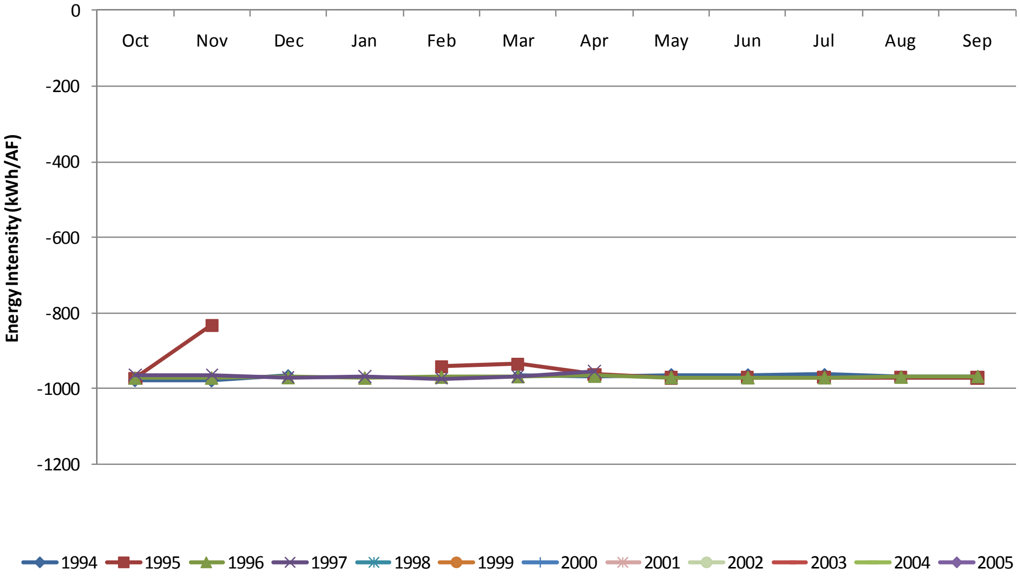


The Study Team determined the energy intensity of pumping operations at Castaic is -963.2 kWh/AF; scatter in the data reveals an error range of 5%, see Table 31. The value of energy intensity does not significantly change as over time, see Figure 49. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 31: Castaic Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
-963.2	5%	-917.2	-1009.2

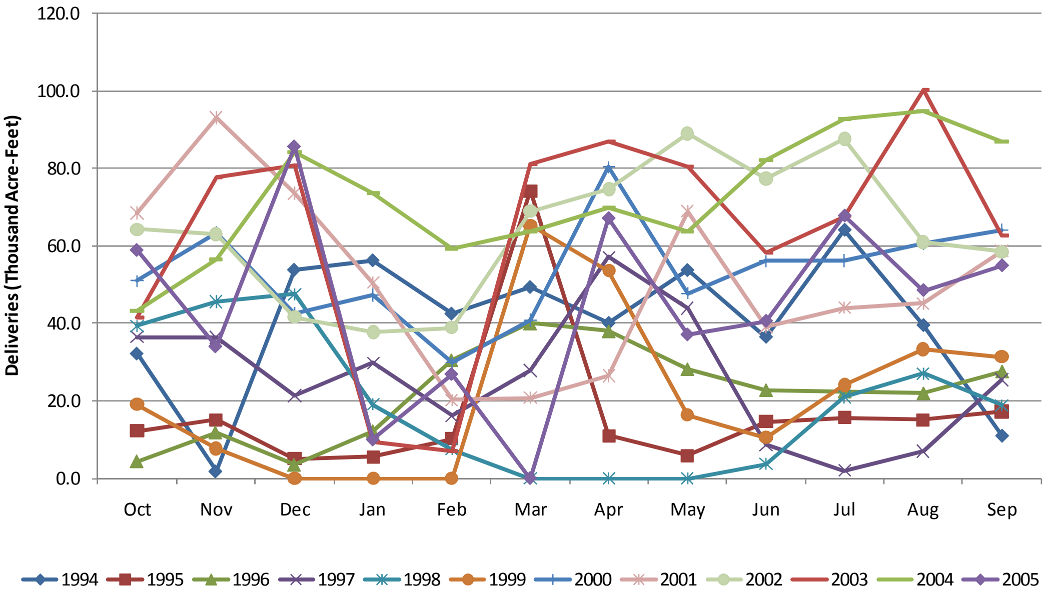
Figure 49: Castaic Energy Intensity Plot



C.2.14.3 Estimated Water Deliveries

Using data from Warne Pumping Plant as a proxy, the Study Team estimates Castaic Power Plant moved between 201,800 and 870,300 AF/year of water during the data collection period. Low flow tends to occur during the months of January and February and high flow tends to occur during the months of March through May, see Figure 50.

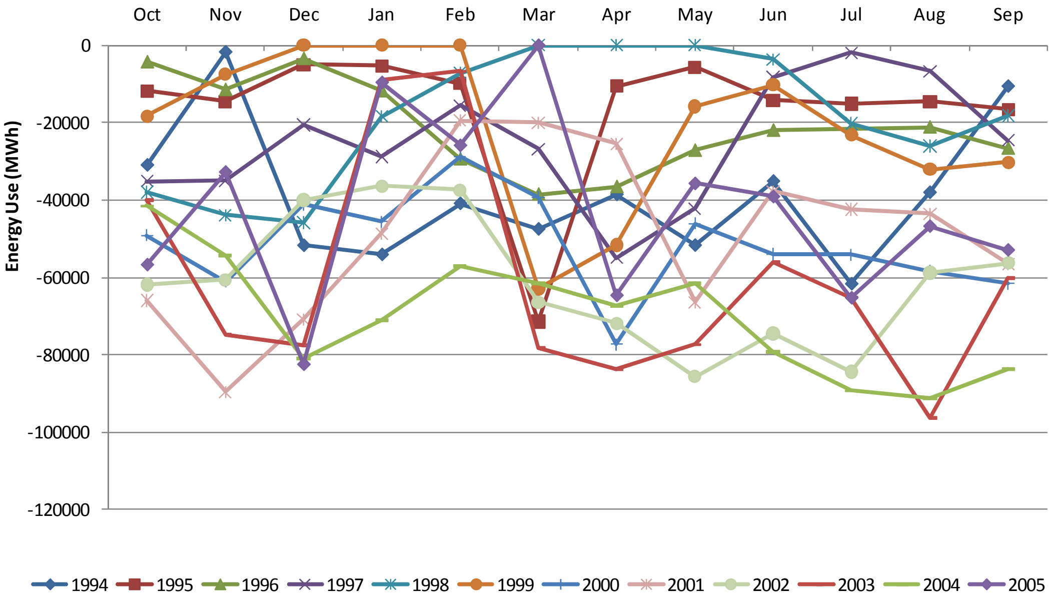
Figure 50: Estimated Castaic Deliveries



C.2.14.4 Estimated Net Energy Generation

The Study Team estimates historic net energy generation at Castaic Power Plant by multiplying energy intensity by estimated water deliveries. The Study Team estimates Castaic Power Plant's net generation was between 194 and 838 GWH/yr during the data collection period, see Figure 51 for details.

Figure 51: Estimated Castaic Net Energy Use



C.2.15 Alamo Power Plant

Table 32: Alamo Summary

<table>
<tr><td>Facility Name</td><td colspan="6">Alamo Power Plant</td><td colspan="2">Facility ID</td><td colspan="4">15</td></tr>
<tr><td>Owner</td><td colspan="6">State Water Project</td><td colspan="2">Facility Type</td><td colspan="4">Power Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="6">South Lahontan</td><td colspan="2">DEER Climate Zone</td><td colspan="4">14</td></tr>
<tr><td>Downstream From</td><td colspan="12">Edmonston Pumping Plant</td></tr>
<tr><td>Upstream From</td><td colspan="12">Pearblossom Pumping Plant</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="4">Other Wholesale Systems</td><td colspan="4">Storage</td><td colspan="4">Local Water Systems</td></tr>
<tr><td colspan="4">None</td><td colspan="4"></td><td colspan="4"></td></tr>
<tr><td rowspan="2">Facility Configuration</td><td colspan="3">Number of Generators</td><td colspan="3">Power Generation (MVA)</td><td colspan="3">Maximum Flow (CFS)</td><td colspan="3">Static Head (ft)</td></tr>
<tr><td colspan="3">1</td><td colspan="3">18</td><td colspan="3">n/a</td><td colspan="3">115-141</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="12">N/A</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="6">2003[1]</td><td colspan="2">Description of Last Major Retrofit</td><td colspan="4">Unit 1 replaced stator and rotor.</td></tr>
</table>

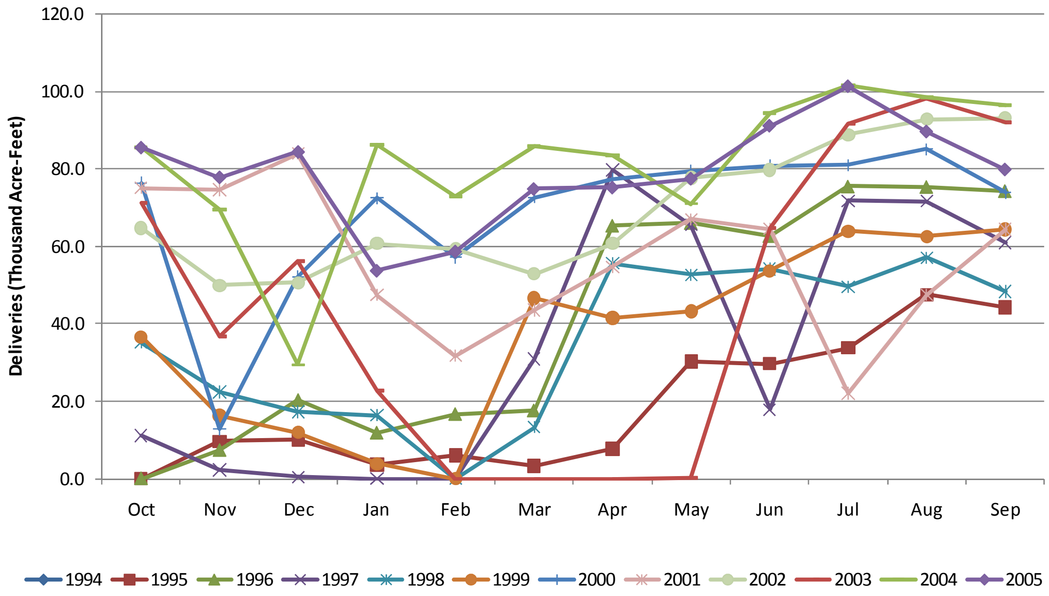
C.2.15.1 Description

Alamo Power Plant is the first facility in the SWP East Branch; it is used to recover energy from pumping operations at Edmonston pumping plant. The Alamo Power Plant has been restricted to produce a maximum of 4 MW in recent decades. The shaft connecting the turbine to the generator is bent. While not severe enough to shut down the whole plant, the bend limits the maximum capacity or loading on the generator. Only a limited amount of water can actually flow through the generator, the rest is bypassed and sent down the mountain to energy dissipaters. The plant contains one generating unit and operates at a static head ranging from 115-141 feet.

C.2.15.2 Water Flow

Alamo Power Plant moved between 225,600 and 974,300 AF/year of water during the data collection period.   Flow is low during the months of November through February and high during the months of July through September, see Figure 52.

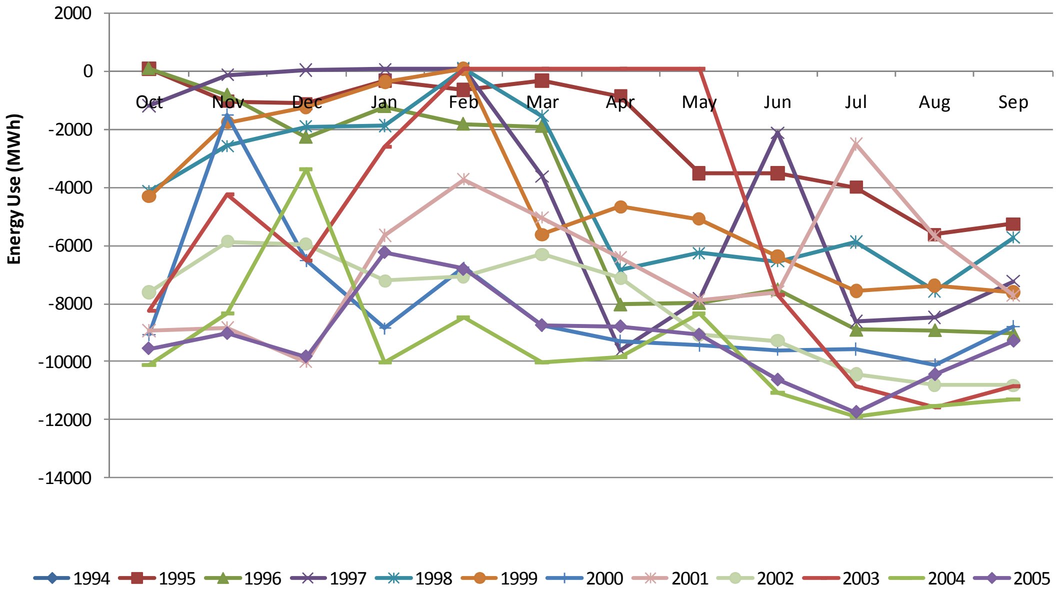
Figure 52: Alamo Deliveries



C.2.15.3 Energy Production

Alamo Power Plant’s annual energy production ranged between 26,180 and 114,340 MWh/year during the data collection period. Energy production is low during months of low flow indicated above and high during months of high flow, see Figure 53.

Figure 53: Alamo Energy Use



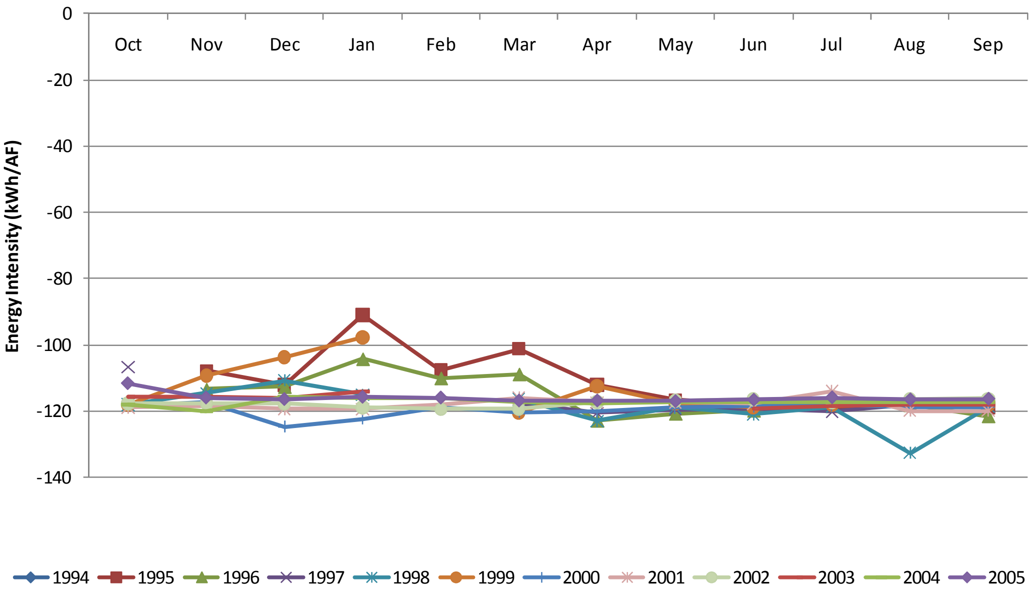
C.2.15.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Alamo is -116.6 kWh/AF; scatter in the data reveals an error range of 9%, see Table 33. The value of energy intensity does not significantly change as over time, see Figure 54. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 33: Alamo Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
-116.6	9%	-106.7	-126.6

Figure 54: Alamo Energy Intensity Plot



C.2.16Pearblossom Pumping Plant

Table 34: Pearblossom Summary

<table>
<tr><td>Facility Name</td><td colspan="8">Pearblossom Pumping Plant</td><td colspan="3">Facility ID</td><td colspan="4">16</td></tr>
<tr><td>Owner</td><td colspan="8">State Water Project</td><td colspan="3">Facility Type</td><td colspan="4">Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="8">South Lahontan</td><td colspan="3">DEER Climate Zone</td><td colspan="4">14</td></tr>
<tr><td>Downstream From</td><td colspan="15">Alamo Power Plant</td></tr>
<tr><td>Upstream From</td><td colspan="15">Mojave Siphon Power Plant</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="5">Other Wholesale Systems</td><td colspan="5">Storage</td><td colspan="5">Local Water Systems</td></tr>
<tr><td colspan="5">None</td><td colspan="5"></td><td colspan="5"></td></tr>
<tr><td rowspan="4">Facility Configuration</td><td colspan="3">Number of Pumps</td><td colspan="3">Power (HP)</td><td colspan="3">Speed (RPM)</td><td colspan="3">Maximum Flow (CFS)</td><td colspan="3">Static Head (ft)</td></tr>
<tr><td colspan="3">4</td><td colspan="3">22,500</td><td colspan="3">514</td><td colspan="3">290</td><td colspan="3">569</td></tr>
<tr><td colspan="3">2</td><td colspan="3">11,600</td><td colspan="3">720</td><td colspan="3">145</td><td colspan="3">569</td></tr>
<tr><td colspan="3">3</td><td colspan="3">30,000</td><td colspan="3">450</td><td colspan="3">375</td><td colspan="3">569</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="15">2575 CFS</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="8">2005[1]</td><td colspan="3">Description of Last Major Retrofit</td><td colspan="4">Unit 7 replaced due to failed pump mechanical seal.</td></tr>
</table>

1: From DWR Bulletin 132, 2006

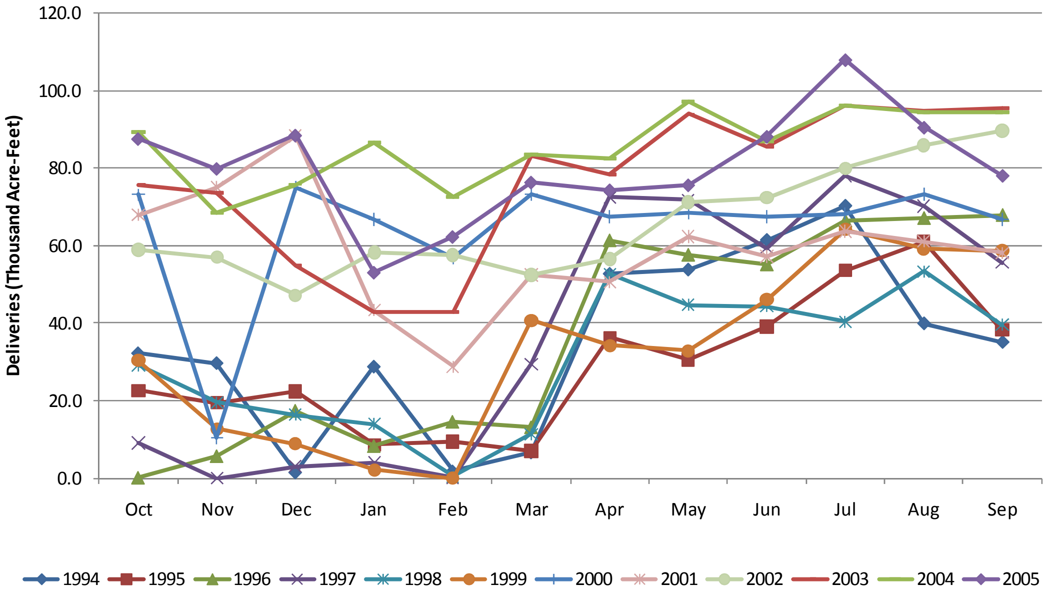
C.2.16.1 Description

Pearblossom Pumping Plant is the only pumping plant on the SWP East Branch, all other facilities are generation facilities. Water exiting this plant continues to flow to Mojave Siphon Power Plant. The plant contains nine fixed speed pumping units with a combined maximum capacity of 2575 CFS. The plant pumps water to a static head of 569 feet.

C.2.16.2 Water Flow

Pearblossom Pumping Plant pumped between 348,100 and 1,027,200 AF/year during the data collection period. Pumping is low during the months of January and February and high during the months of July and August, see Figure 55.

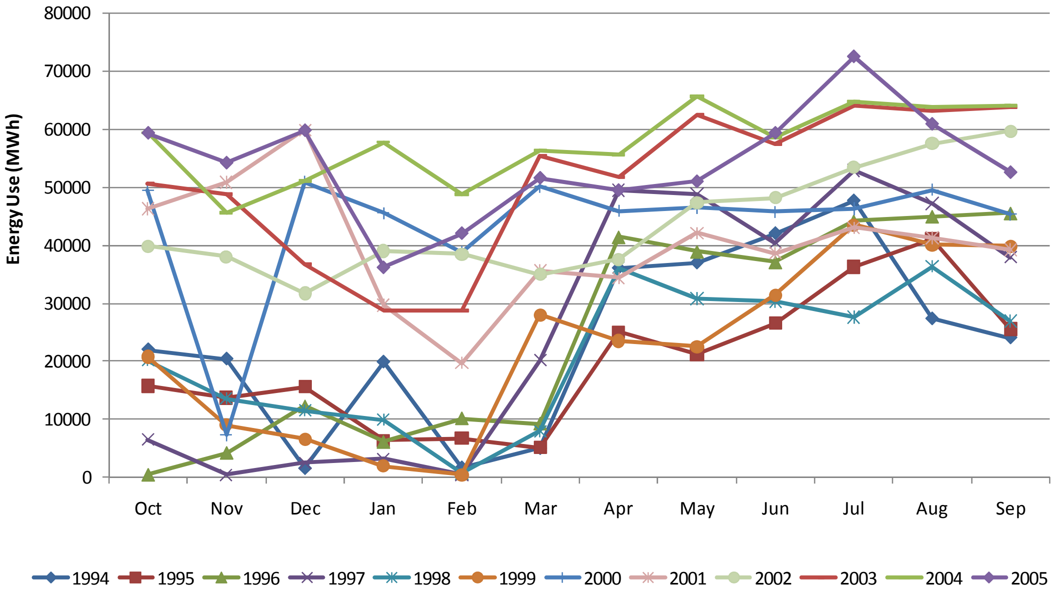
Figure 55: Pearblossom Deliveries



C.2.16.3 Energy Use

Pearblossom Pumping Plant's annual energy consumption ranged between 239,330 and 691,330 MWh/year during the data collection period. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 56.

Figure 56: Pearblossom Energy Use



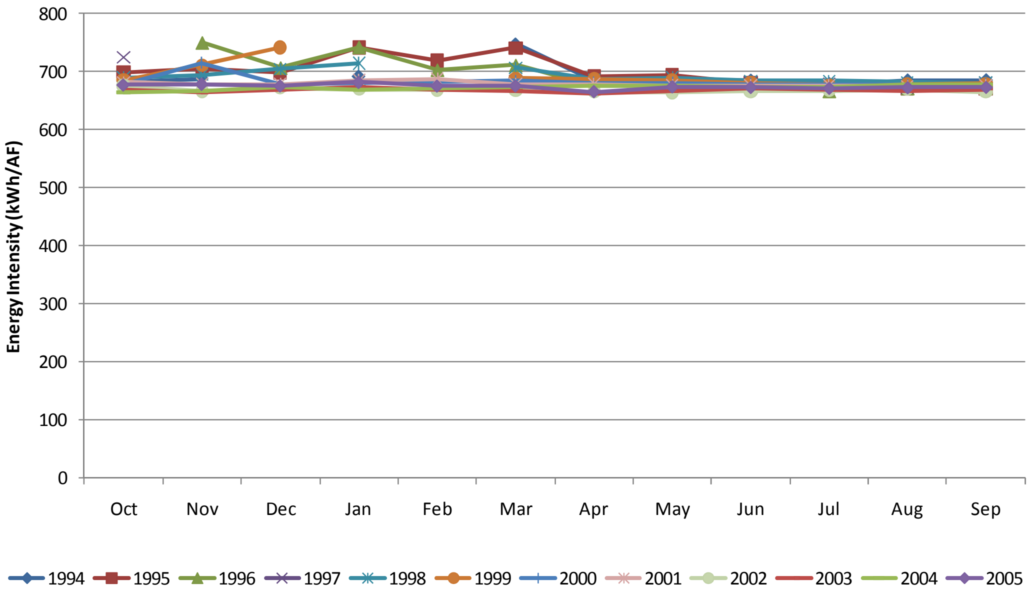
C.2.16.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Pearblossom is 682.9 kWh/AF; scatter in the data reveals an error range of 5%, see Table 35. The value of energy intensity does not significantly change as over time, see Figure 57. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 35: Pearblossom Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
682.9	5%	718.8	647.0

Figure 57: Pearblossom Energy Intensity Plot



C.2.17 Mojave Siphon Power Plant

Table 36: Mojave Siphon Summary

Facility Name	Mojave Siphon Power Plant		**Facility ID**	17	
Owner	State Water Project		**Facility Type**	Power Plant	
Hydrologic Region	South Lahontan		**DEER Climate Zone**	14	
Downstream From	Pearblossom Pumping Plant				
Upstream From	Devil Canyon Pumping Plant				
Points of Interconnection	**Other Wholesale Systems**	**Storage**	**Local Water Systems**		
	None	Silverwood Lake (in-conduit, SWP)			
Facility Configuration	**Number of Generators**	**Power Generation (MVA)**	**Maximum Flow (CFS)**	**Static Head (ft)**	
	3	11.5	960	81-136	
Maximum Plant Capacity	2880				
Date of Last Major Retrofit	2001[1]		**Description of Last Major Retrofit**	Furnish and install turbines.	

1: From DWR Bulletin 132, 2002

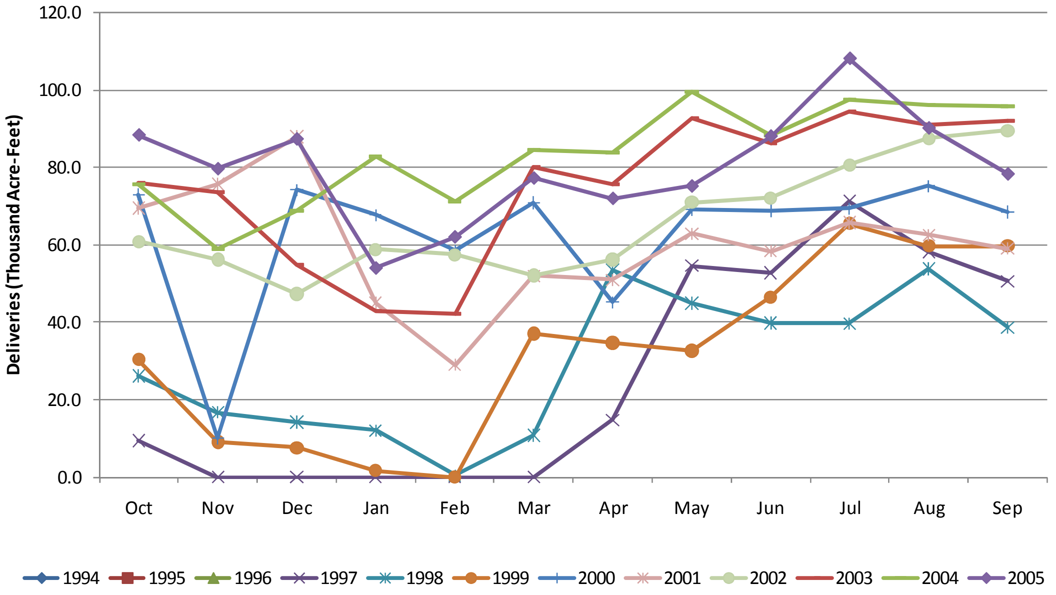
C.2.17.1 Description

Mojave Siphon Plant is a power plant in the SWP East Branch; it is used to recover energy from pumping operations at Edmonston and Pearblossom. The plant operates on a siphon part of the pipeline with water exiting at Silverwood Lake. The plant contains 3 fixed speed units with a combined maximum capacity of 2,880 CFS. The plant operates at a static head ranging from 81-136 feet.

C.2.17.2 Water Flow

Mojave Siphon Power Plant moved between 311,600 and 1,002,800 AF/year of water during the data collection period. Flow is low during the months of January and February and high during the months of July through September, see Figure 58.

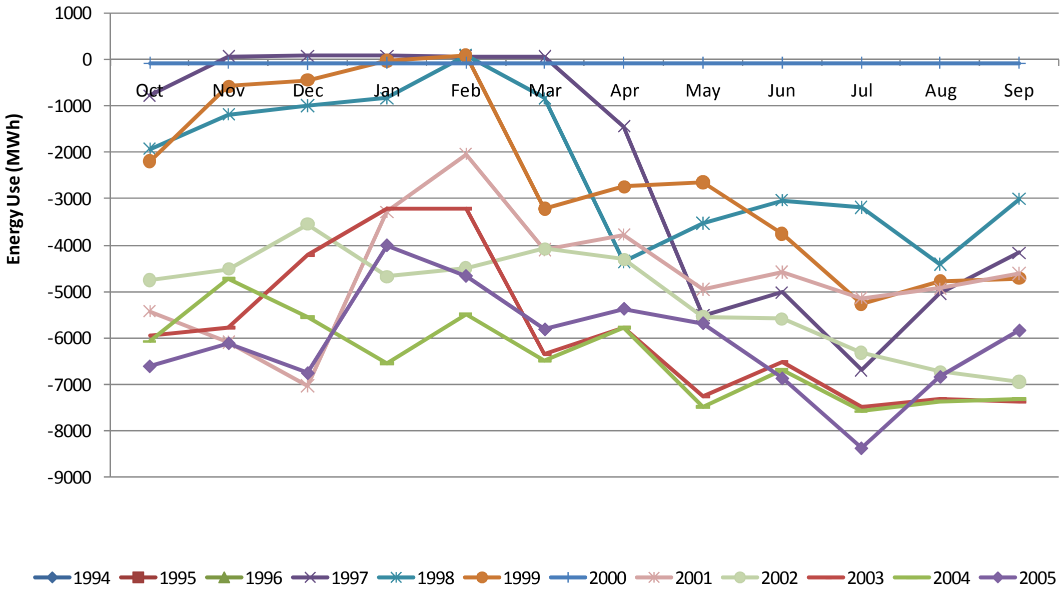
Figure 58: Mojave Siphon Deliveries



C.2.17.3 Energy Production

Mojave Siphon Power Plant's annual energy production ranged between 946 and 77,062 MWh/year generated during the data collection period. Energy production is low during months of low flow indicated above and high during months of high flow, see Figure 59.

Figure 59: Mojave Siphon Energy Use



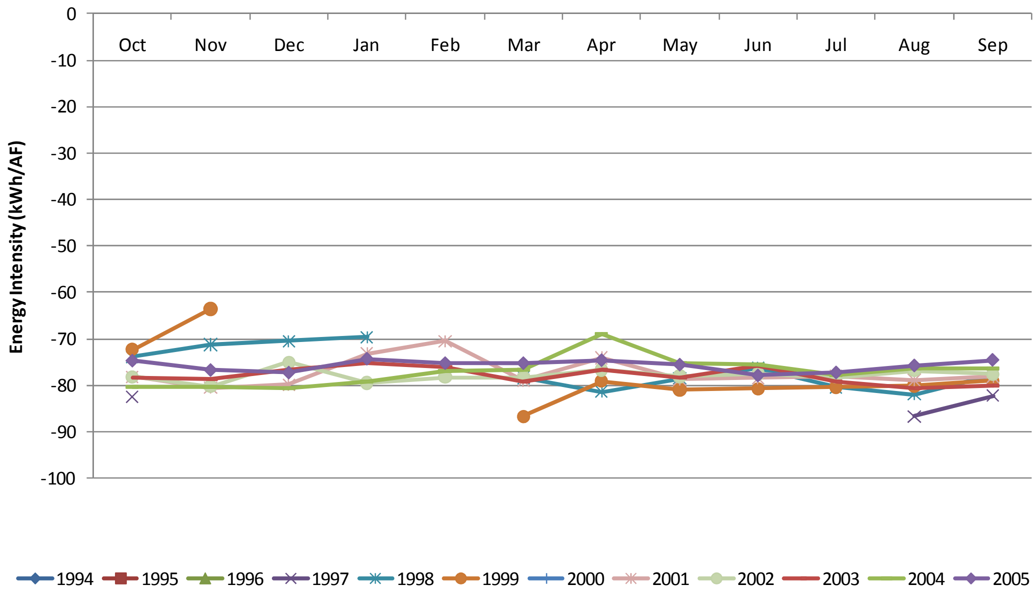
C.2.17.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Mojave Siphon is -77.4 kWh/AF; scatter in the data reveals an error range of 9%, see Table 37. The value of energy intensity does not significantly change as over time, see Figure 60. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 37: Mojave Siphon Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
-77.4	9%	-70.4	-84.5

Figure 60: Mojave Siphon Energy Intensity Plot



C.2.18Devil Canyon Power Plant

Table 38: Devil Canyon Summary

<table>
<tr><td>Facility Name</td><td colspan="6">Devil Canyon Power Plant</td><td colspan="2">Facility ID</td><td colspan="4">18</td></tr>
<tr><td>Owner</td><td colspan="6">State Water Project</td><td colspan="2">Facility Type</td><td colspan="4">Power Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="6">South Coast</td><td colspan="2">DEER Climate Zone</td><td colspan="4">16</td></tr>
<tr><td>Downstream From</td><td colspan="12">Mojave Siphon Plant</td></tr>
<tr><td>Upstream From</td><td colspan="12">Lake Perris, SWP East Branch Extension</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="4">Other Wholesale Systems</td><td colspan="4">Storage</td><td colspan="4">Local Water Systems</td></tr>
<tr><td colspan="4">MWD</td><td colspan="4">Lake Perris (terminal Reservoir, SWP.</td><td colspan="4"></td></tr>
<tr><td rowspan="2">Facility Configuration</td><td colspan="3">Number of Generators</td><td colspan="3">Power Generation (MVA)</td><td colspan="3">Maximum Flow (CFS)</td><td colspan="3">Static Head (ft)</td></tr>
<tr><td colspan="3">2</td><td colspan="3">63</td><td colspan="3">670</td><td colspan="3">1357</td></tr>
<tr><td></td><td colspan="3">2</td><td colspan="3">82.5</td><td colspan="3">800</td><td colspan="3">1300</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="12">2940</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="6">2001[1]</td><td colspan="2">Description of Last Major Retrofit</td><td colspan="4">Repaired turbine of unit 2 and modified turbine of unit 4</td></tr>
</table>

1: From DWR Bulletin 132, 2002

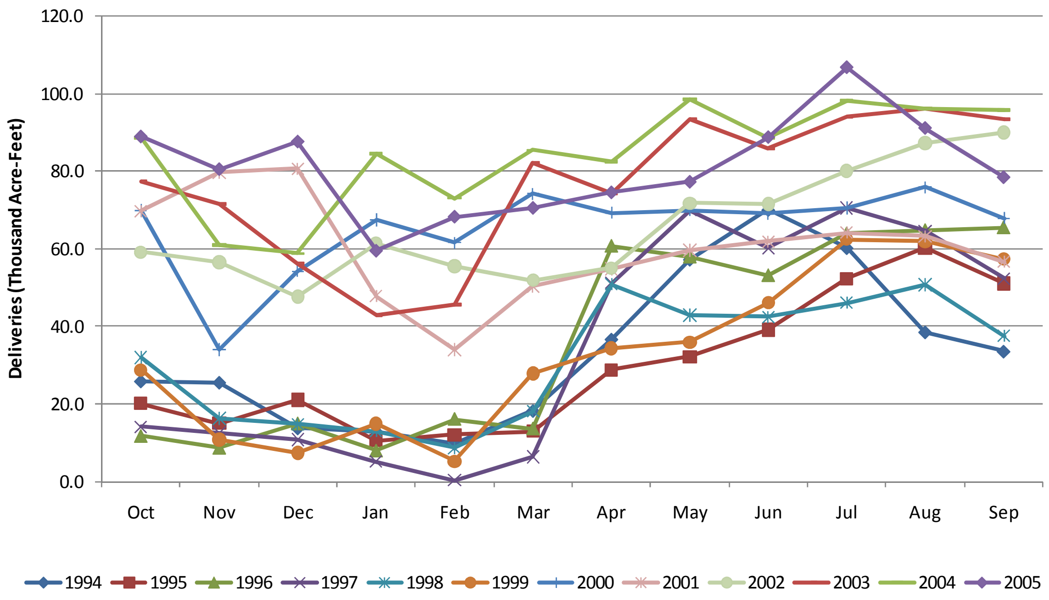
C.2.18.1 Description

Devil Canyon Power Plant is the last facility in the SWP East Branch. It receives water from Silverwood lake and send water to Lake Perris, the terminal reservoir in the East Branch. plant contains 4 units with a combined maximum capacity of 2,940 CFS. The plant operates at a static head ranging from 1300- 1357 feet.

C.2.18.2 Water Flow

Devil Canyon Power Plant moved between 355,200 and 1,010,200 AF/year of water during the data collection period. Flow is low during the months of January and February and high during the months of July and August, see Figure 61.

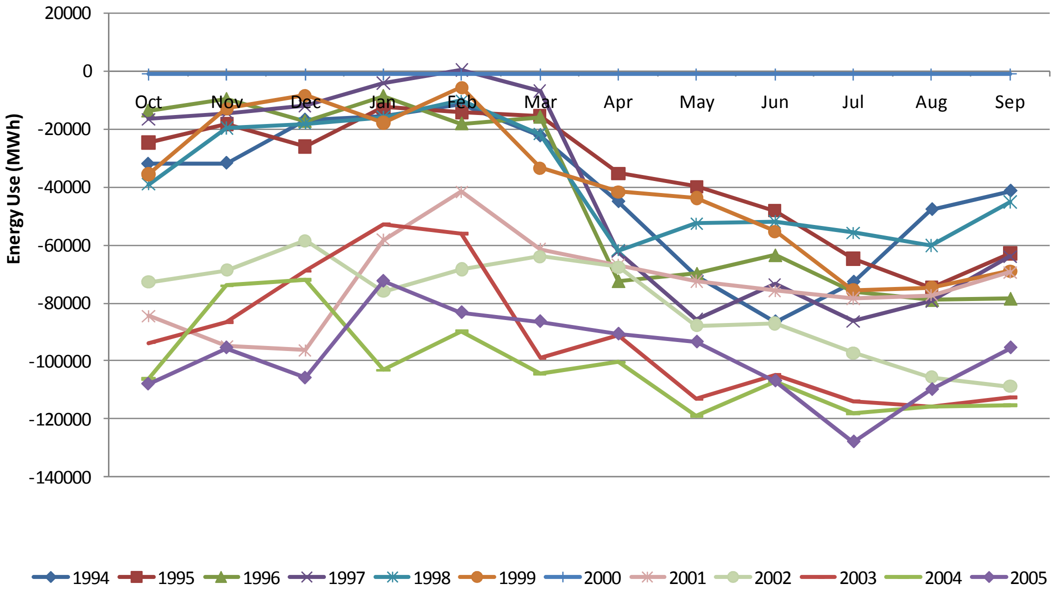
Figure 61: Devil Canyon Deliveries



C.2.18.3 Energy Production

Devil Canyon Power Plant's annual energy production ranged between 14,469 and 1,224,617 MWh/year generated during the data collection period. Energy production is low during months of low flow indicated above and high during months of high flow, see Figure 62.

Figure 62: Devil Canyon Energy Use



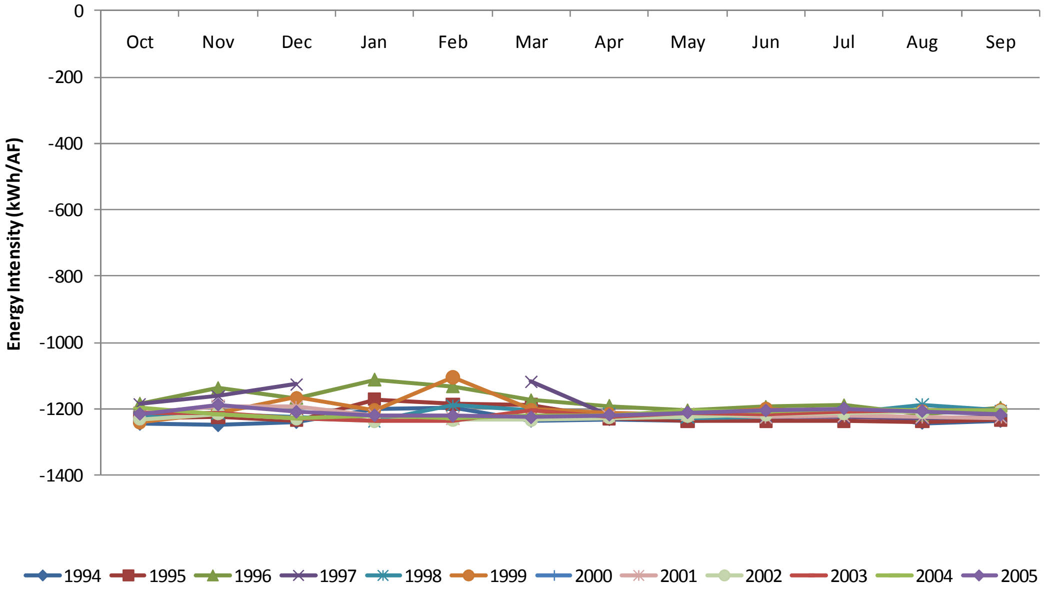
C.2.18.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Devil Canyon is -1,210.9 kWh/AF; scatter in the data reveals an error range of 4%, see Table 39. The value of energy intensity does not significantly change as over time, see Figure 63. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 39: Devil Canyon Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
-1210.9	4%	-1158.6	-1263.2

Figure 63: Devil Canyon Energy Intensity Plot



C.2.19Las Perillas Pumping Plant

Table 40: Las Perillas Summary

<table>
<tr><td>Facility Name</td><td colspan="2">Las Perillas Pumping Plant</td><td>Facility ID</td><td colspan="2">19</td></tr>
<tr><td>Owner</td><td colspan="2">State Water Project</td><td>Facility Type</td><td colspan="2">Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="2">Tulare Lake</td><td>DEER Climate Zone</td><td colspan="2">13</td></tr>
<tr><td>Downstream From</td><td colspan="5">Dos Amigos Pumping Plant</td></tr>
<tr><td>Upstream From</td><td colspan="5">Badger Hill Pumping Plant</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="2">Other Wholesale Systems</td><td colspan="2">Storage</td><td>Local Water Systems</td></tr>
<tr><td colspan="2">None</td><td colspan="2"></td><td></td></tr>
<tr><td rowspan="3">Facility Configuration</td><td>Number of Pumps</td><td>Power (HP)</td><td>Speed (RPM)</td><td>Maximum Flow (CFS)</td><td>Static Head (ft)</td></tr>
<tr><td>3</td><td>350</td><td>720</td><td>38</td><td>55</td></tr>
<tr><td>1</td><td>1000</td><td>600</td><td>122</td><td>55</td></tr>
<tr><td></td><td>2</td><td>1000</td><td>450</td><td>112</td><td>55</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="5">460 CFS</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="2">1999[1]</td><td>Description of Last Major Retrofit</td><td colspan="2">Installed new motor switchgears on all units.</td></tr>
</table>

1: From DWR Bulletin 132, 2000

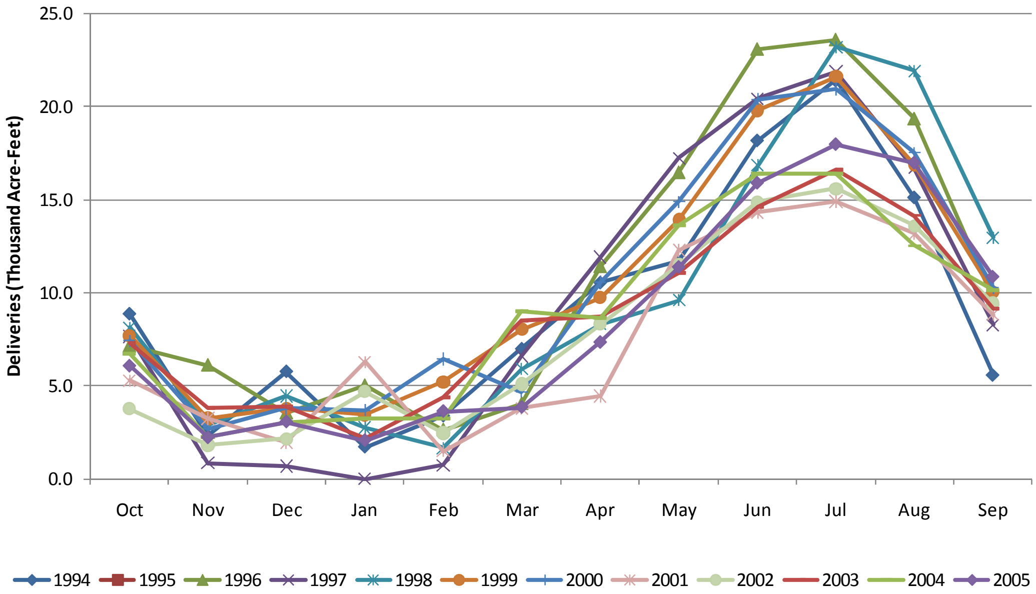
C.2.19.1 Description

Las Perillas Pumping Plant is the first facility in the Costal Branch Aqueduct of the State Water Project. It pumps water out of the California Aqueduct. Water exiting this plant continues to flow to Badger Hill Pumping Plant. The plant contains six fixed speed pumping units with a combined maximum capacity of 460 CFS. The plant pumps water to a static head of 55 feet.

C.2.19.2 Water Flow

Las Perillas Pumping Plant pumped between 89,900 and 131,900 AF/year of water during the data collection period. Pumping is low during the months of November through February and high during the months of July through August, see Figure 64.

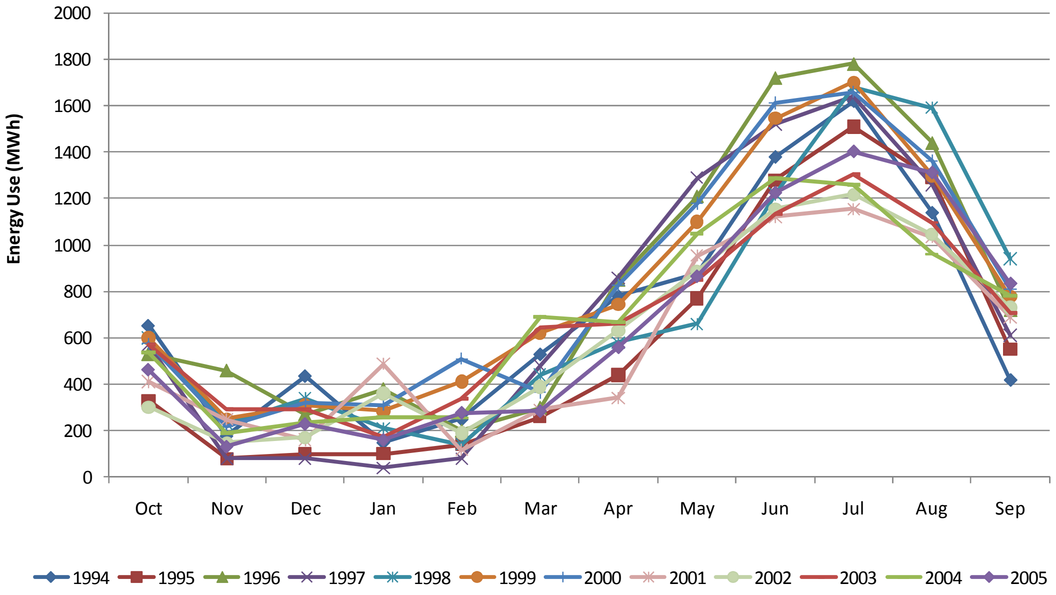
Figure 64: Las Perillas Deliveries



C.2.19.3 Energy Use

Las Perillas Pumping Plant's annual energy consumption ranged between 6,850 and 9,860 MWh/year during the data collection period. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 65.

Figure 65: Las Perillas Energy Use



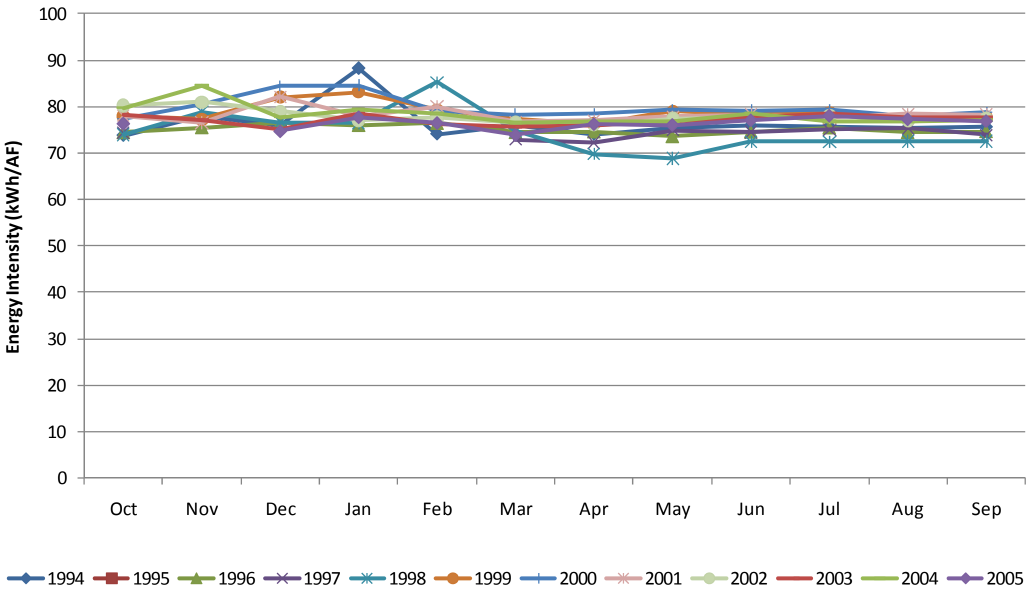
C.2.19.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Las Perillas is 77 kWh/AF; scatter in the data reveals an error range of 7%, see Table 41. The value of energy intensity does not significantly change as over time, see Figure 66. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 41: Las Perillas Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
77.0	7%	82.7	71.4

Figure 66: Las Perillas Energy Intensity Plot



C.2.20Badger Hill Pumping Plant

Table 42: Badger Hill Summary

<table>
<tr><td>Facility Name</td><td colspan="2">Badger Hill Pumping Plant</td><td>Facility ID</td><td colspan="2">20</td></tr>
<tr><td>Owner</td><td colspan="2">State Water Project</td><td>Facility Type</td><td colspan="2">Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="2">Tulare Lake</td><td>DEER Climate Zone</td><td colspan="2">13</td></tr>
<tr><td>Downstream From</td><td colspan="5">Las Perillas Pumping Plant</td></tr>
<tr><td>Upstream From</td><td colspan="5">Devil’s Den Pumping Plant</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="2">Other Wholesale Systems</td><td colspan="2">Storage</td><td>Local Water Systems</td></tr>
<tr><td colspan="2">None</td><td colspan="2"></td><td></td></tr>
<tr><td rowspan="4">Facility Configuration</td><td>Number of Pumps</td><td>Power (HP)</td><td>Speed (RPM)</td><td>Maximum Flow (CFS)</td><td>Static Head (ft)</td></tr>
<tr><td>3</td><td>1000</td><td>900</td><td>38</td><td>151</td></tr>
<tr><td>1</td><td>2750</td><td>600</td><td>116</td><td>151</td></tr>
<tr><td>2</td><td>3000</td><td>510</td><td>112</td><td>151</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="5">450 CFS</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="2">1999[1]</td><td>Description of Last Major Retrofit</td><td colspan="2">Installed new motor switchgears on all units and refurbished a pump.</td></tr>
</table>

1: From DWR Bulletin 132, 2000

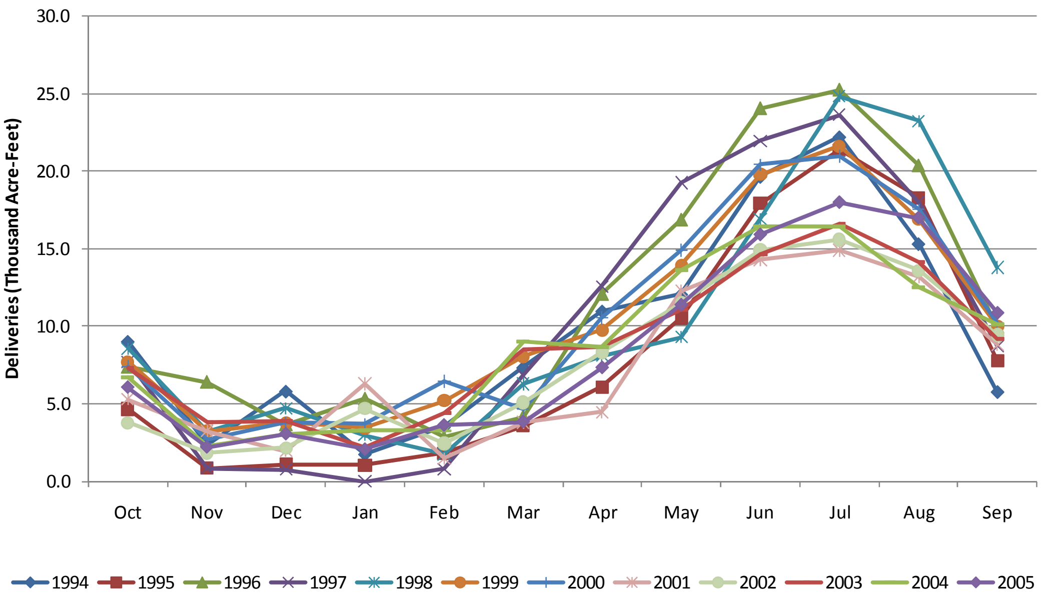
C.2.20.1 Description

Badger Hill Pumping Plant is the second facility in the Coastal Branch of the State Water Project. Water exiting this plant continues to flow to Devil's Den Pumping Plant. The plant contains six fixed speed pumping units with a combined maximum capacity of 450 CFS. The plant pumps water to a static head of 151 feet.

C.2.20.2 Water Flow

Badger Hill Pumping Plant pumped between 89,900 and 138,200 AF/year during the data collection period. Pumping is low during the months of November through February and high during the months of June through August, see Figure 67.

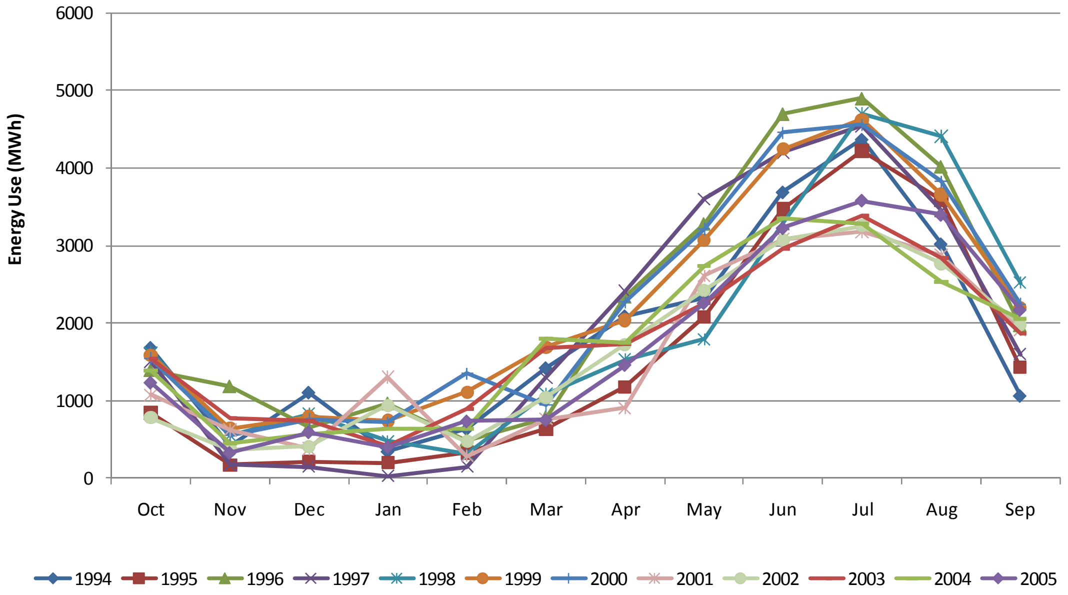
Figure 67: Badger Hill Deliveries



C.2.20.3 Energy Use

Badger Hill Pumping Plant's annual energy consumption ranged between 18,360 and 26,660 MWh/year during the data collection period. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 68.

Figure 68: Badger Hill Energy Use



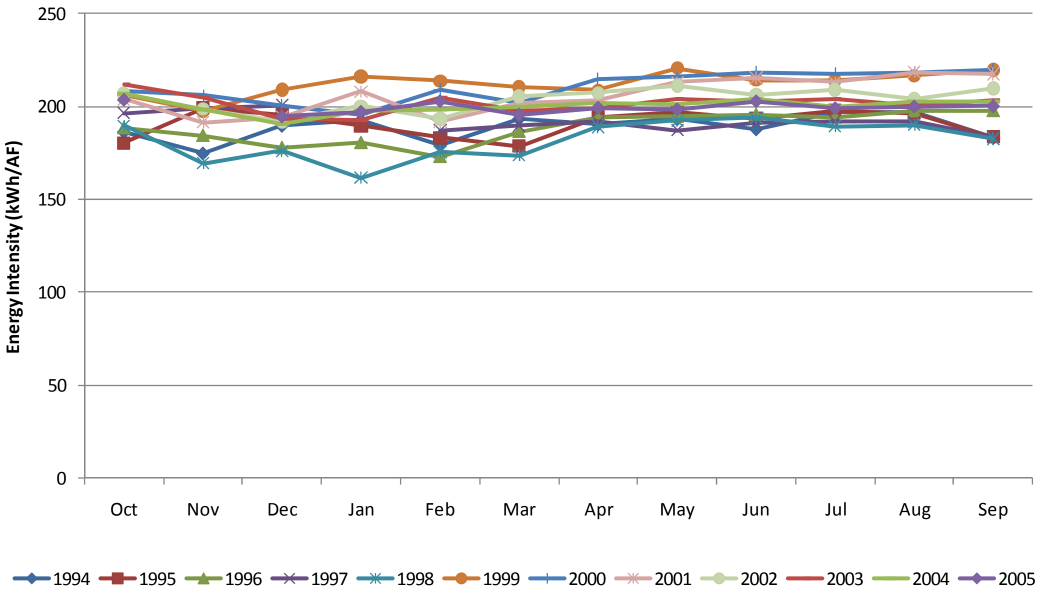
C.2.20.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Badger Hill is 198 kWh/AF; scatter in the data reveals an error range of 12%, see Table 43. The value of energy intensity does not significantly change as over time, see Figure 69. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 43: Badger Hill Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
198.0	12%	221.0	175.1

Figure 69: Badger Hill Energy Intensity Plot



C.2.21Devil’s Den Pumping Plant

Table 44: Devil’s Den Summary

<table>
<tr><td>Facility Name</td><td colspan="2">Devil’s Den Pumping Plant</td><td>Facility ID</td><td colspan="2">21</td></tr>
<tr><td>Owner</td><td colspan="2">State Water Project</td><td>Facility Type</td><td colspan="2">Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="2">Tulare Lake</td><td>DEER Climate Zone</td><td colspan="2">13</td></tr>
<tr><td>Downstream From</td><td colspan="5">Badger Hill Pumping Plant</td></tr>
<tr><td>Upstream From</td><td colspan="5">Bluestone Pumping Plant</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="2">Other Wholesale Systems</td><td colspan="2">Storage</td><td>Local Water Systems</td></tr>
<tr><td colspan="2">None</td><td colspan="2"></td><td></td></tr>
<tr><td rowspan="2">Facility Configuration</td><td>Number of Pumps</td><td>Power (HP)</td><td>Speed (RPM)</td><td>Maximum Flow (CFS)</td><td>Static Head (ft)</td></tr>
<tr><td>6</td><td>1750</td><td>1200</td><td>22.3</td><td>555</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="5">134 CFS</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="2">2004[1]</td><td>Description of Last Major Retrofit</td><td colspan="2">Replace pump bearings on unit 2 and unit 3.</td></tr>
</table>

1: From DWR Bulletin 132, 2005

C.2.21.1 Description

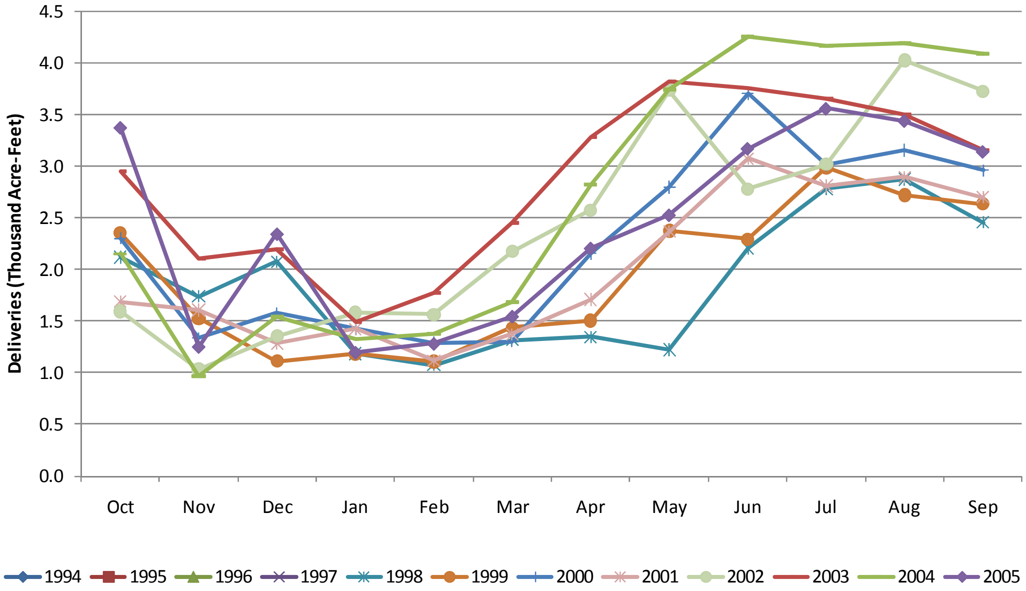
Devil’s Den Pumping Plant is the third facility in the Costal Branch of the State Water Project. It was completed in 1997 in a construction project to extend the Coastal Branch 100 miles; full operation began in 1998. Water exiting this plant continues to flow to Bluestone Pumping Plant. The plant contains six fixed speed pumping units with a combined maximum capacity of 134

CFS. Only 5 units can run at once, one unit is “reserve”. The plant pumps water to a static head of 555 feet.

C.2.21.2 Water Flow

Devil’s Den Pumping Plant pumped between 22,400 and 34,100 AF/year during 1997 to 2005. Pumping is low during the months of January and February and high during the months of June through September, see Figure 70.

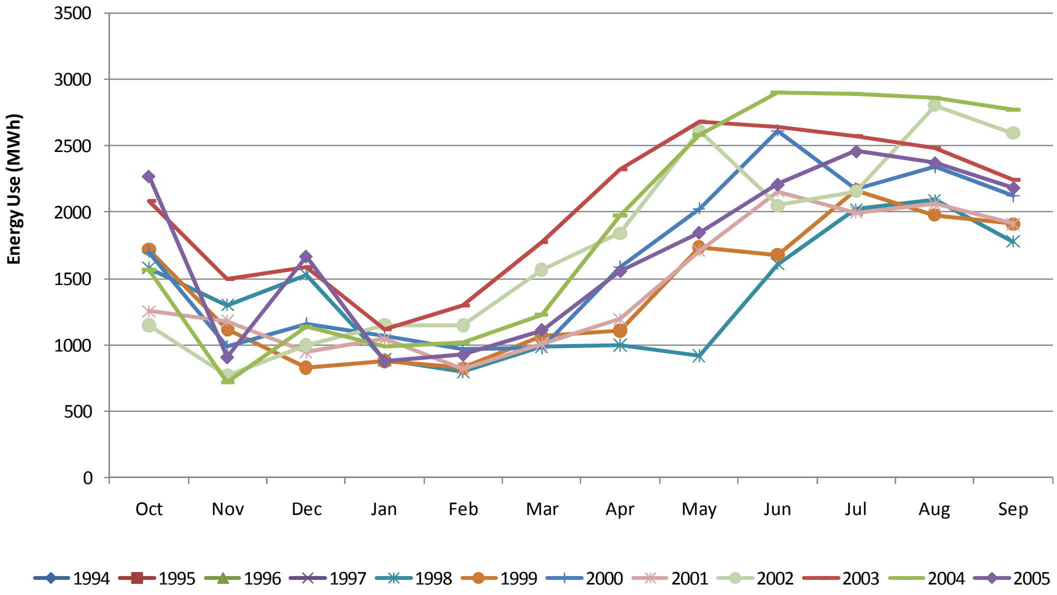
Figure 70: Devil’s Den Deliveries



C.2.21.3 Energy Use

Devil’s Den Pumping Plant’s annual energy consumption ranged between 16,510 and 24,292 MWh/year during 1997 to 2005. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 71.

Figure 71: Devil's Den Energy Use



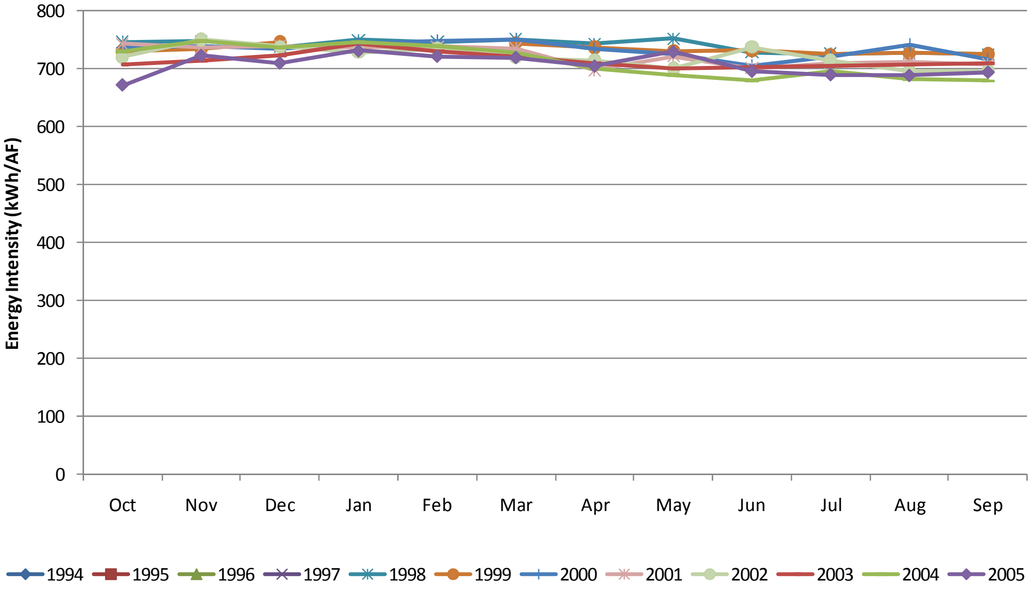
C.2.21.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Devil's Den is 723.2 kWh/AF; scatter in the data reveals an error range of 5%, see Table 45. The value of energy intensity does not significantly change as over time, see Figure 72. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 45: Devil's Den Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
723.2	5%	762.3	684.1

Figure 72: Devil's Den Energy Intensity Plot



C.2.22Bluestone Pumping Plant

Table 46: Bluestone Summary

Facility Name	Bluestone Pumping Plant	**Facility ID**	22		
Owner	State Water Project	**Facility Type**	Pumping Plant		
Hydrologic Region	Tulare Lake	**DEER Climate Zone**	13		
Downstream From	Badger Hill Pumping Plant				
Upstream From	Polonio Pass Pumping Plant				
Points of Interconnection	**Other Wholesale Systems**	**Storage**	**Local Water Systems**		
	None				
Facility Configuration	**Number of Pumps**	**Power (HP)**	**Speed (RPM)**	**Maximum Flow (CFS)**	**Static Head (ft)**
	6	1750	1200	22.3	555
Maximum Plant Capacity	134 CFS				
Date of Last Major Retrofit	1997[1]	**Description of Last Major Retrofit**	No major retrofits. Plant began pumping in 1997.		

1: From DWR Bulletin 132, 1998

C.2.22.1 Description

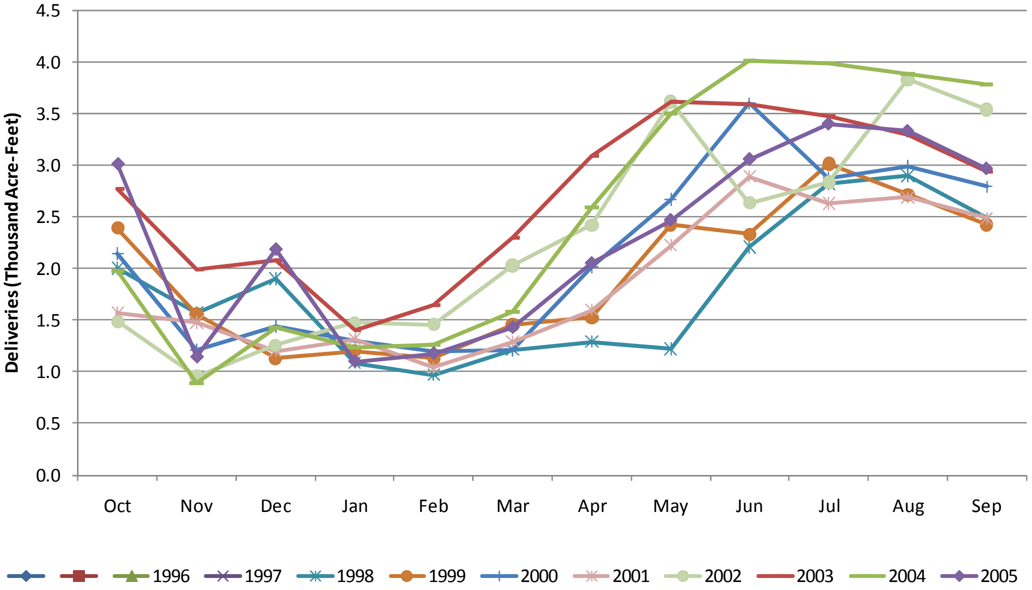
Bluestone Pumping Plant is the fourth facility in the Costal Branch of the State Water Project. It was completed in 1997 in a construction project to extend the Coastal Branch 100 miles; full operation began in 1998. Water exiting this plant continues to flow to Polonio Pass Pumping Plant. The plant contains six fixed speed pumping units with a combined maximum capacity of

134 CFS. Only 5 units can run at once, one unit is “reserve”. The plant pumps water to a static head of 555 feet.

C.2.22.2 Water Flow

Bluestone Pumping Plant pumped between 21,700 and 32,200 AF/year during 1997 to 2005. Pumping is low during the months of January and February and high during the months of June through September, see Figure 73.

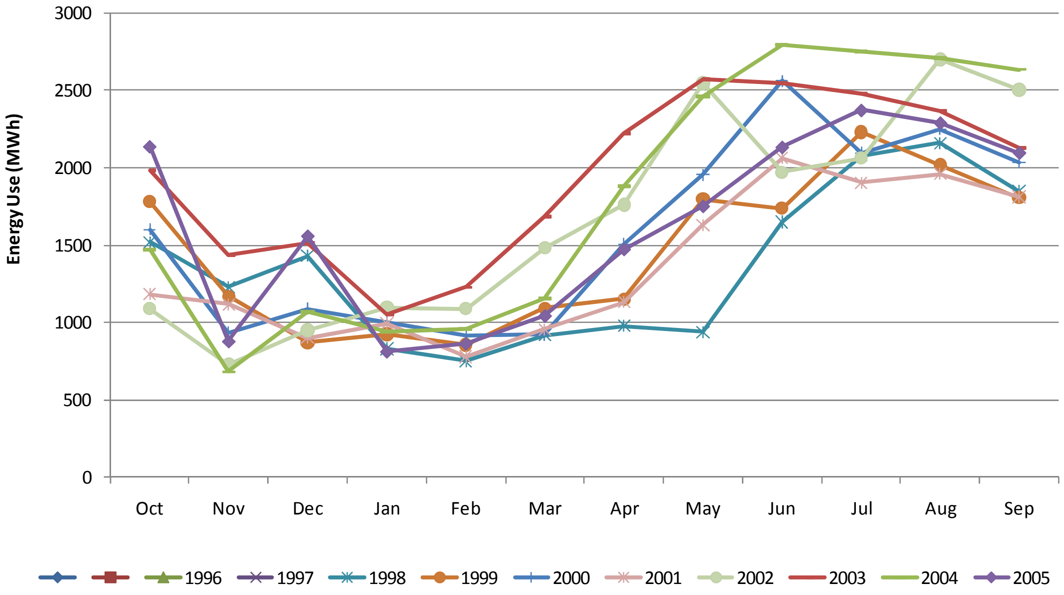
Figure 73: Bluestone Deliveries



C.2.22.3 Energy Use

Bluestone Pumping Plant’s annual energy consumption ranged between 16,340 and 23,226 MWh/year during 1997 to 2005. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 74.

Figure 74: Bluestone Energy Use



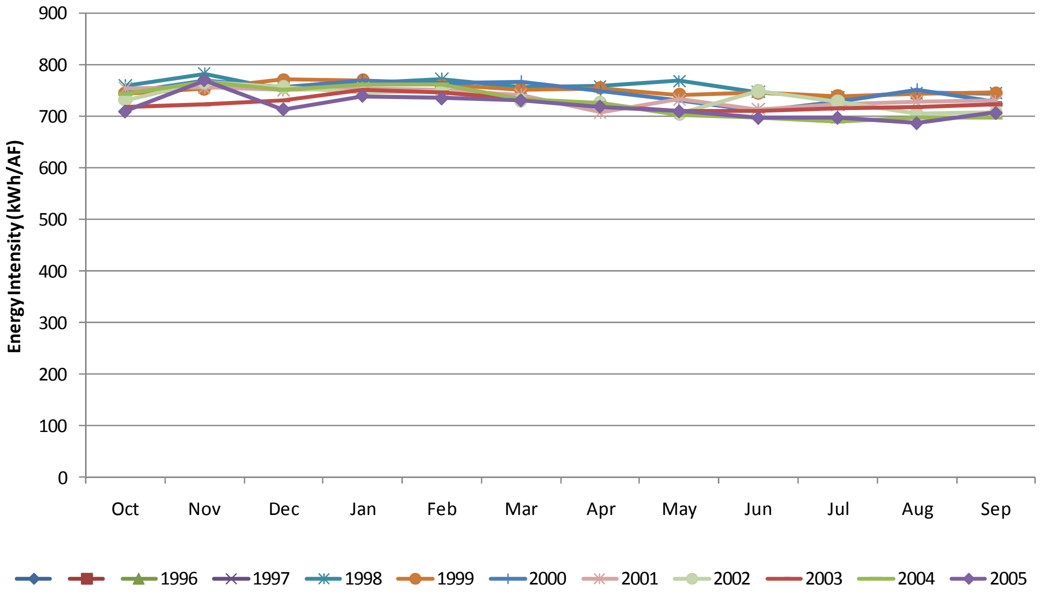
C.2.22.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Bluestone is 737 kWh/AF; scatter in the data reveals an error range of 6%, see Table 47. The value of energy intensity does not significantly change as over time, see Figure 75. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 47: Bluestone Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
737.0	6%	781.8	692.1

Figure 75: Bluestone Energy Intensity Plot



C.2.23Polonio Pass Pumping Plant

Table 48: Polonio Pass Summary

<table>
<tr><td>Facility Name</td><td colspan="6">Polonio Pass Pumping Plant</td><td colspan="3">Facility ID</td><td colspan="6">23</td></tr>
<tr><td>Owner</td><td colspan="6">State Water Project</td><td colspan="3">Facility Type</td><td colspan="6">Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="6">Tulare Lake</td><td colspan="3">DEER Climate Zone</td><td colspan="6">4</td></tr>
<tr><td>Downstream From</td><td colspan="15">Bluestone Pumping Plant</td></tr>
<tr><td>Upstream From</td><td colspan="15">n/a</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="5">Other Wholesale Systems</td><td colspan="5">Storage</td><td colspan="5">Local Water Systems</td></tr>
<tr><td colspan="5">None</td><td colspan="5"></td><td colspan="5"></td></tr>
<tr><td rowspan="2">Facility Configuration</td><td colspan="3">Number of Pumps</td><td colspan="3">Power (HP)</td><td colspan="3">Speed (RPM)</td><td colspan="3">Maximum Flow (CFS)</td><td colspan="3">Static Head (ft)</td></tr>
<tr><td colspan="3">6</td><td colspan="3">1750</td><td colspan="3">1200</td><td colspan="3">22.3</td><td colspan="3">555</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="15">134 CFS</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="6">1997</td><td colspan="3">Description of Last Major Retrofit</td><td colspan="6">Plant began pumping in 1997.</td></tr>
</table>

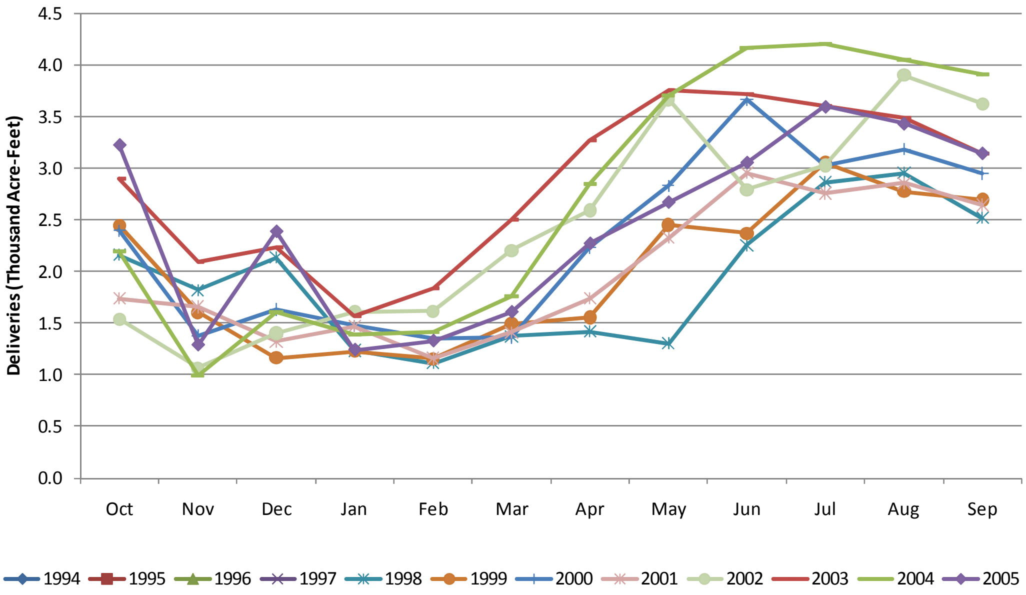
C.2.23.1 Description

Polonio Pass Pumping Plant is the final facility in the Costal Branch of the State Water Project. It was completed in 1997 in a construction project to extend the Coastal Branch 100 miles; full operation began in 1998. The plant contains six fixed speed pumping units with a combined maximum capacity of 134 CFS. Only 5 units can run at once, one unit is “reserve”. The plant pumps water to a static head of 555 feet.

C.2.23.2 Water Flow

Polonio Pass Pumping Plant pumped between 23,200 and 34,100 AF/year during 1997 to 2005. Pumping is low during the months of January and February and high during the months of June through September, see Figure 76.

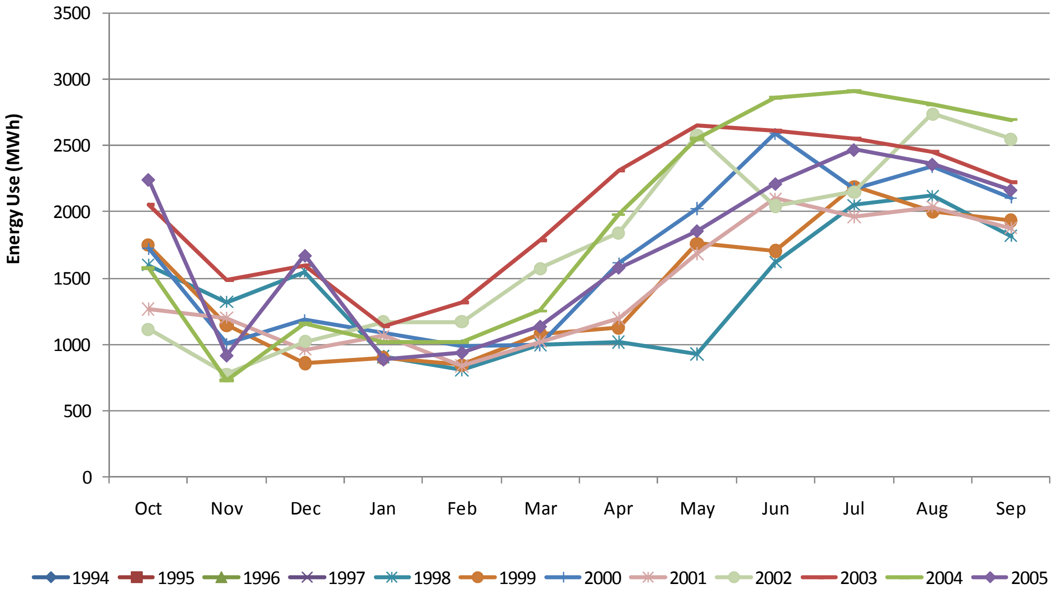
Figure 76: Polonio Pass Deliveries



C.2.23.3 Energy Use

Polonio Pass Pumping Plant’s annual energy consumption ranged between 16,750 and 24,184 MWh/year during 1997 to 2005. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 77.

Figure 77: Polonio Pass Energy Use



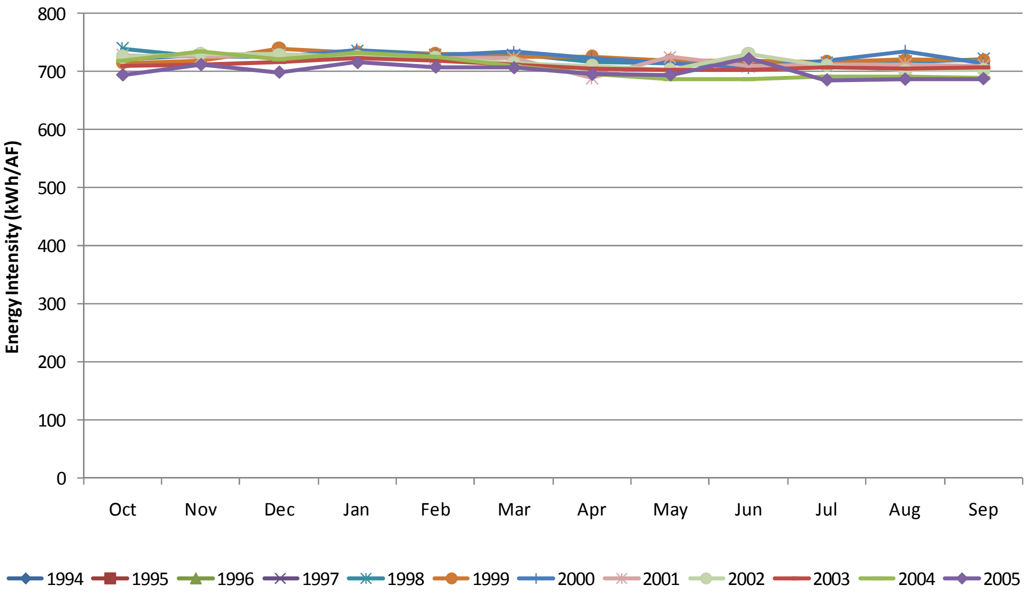
C.2.23.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Polonio Pass is 715.7 kWh/AF; scatter in the data reveals an error range of 4%, see Table 49. The value of energy intensity does not significantly change as over time, see Figure 78. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 49: Polonio Pass Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
715.7	4%	743.0	688.5

Figure 78: Polonio Pass Energy Intensity Plot



C.2.24 Greenspot Pumping Plant

Table 50: Greenspot Summary

<table>
<tr><td>Facility Name</td><td colspan="2">Greenspot Pumping Plant</td><td>Facility ID</td><td>24</td></tr>
<tr><td>Owner</td><td colspan="2">State Water Project</td><td>Facility Type</td><td>Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="2"></td><td>DEER Climate Zone</td><td></td></tr>
<tr><td>Downstream From</td><td colspan="5">Devil Canyon Pumping Plant</td></tr>
<tr><td>Upstream From</td><td colspan="5">Crafton Hills Pumping Plant</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="2">Other Wholesale Systems</td><td colspan="2">Storage</td><td>Local Water Systems</td></tr>
<tr><td colspan="2">None</td><td colspan="2"></td><td></td></tr>
<tr><td rowspan="2">Facility Configuration</td><td>Number of Pumps</td><td>Power (HP)</td><td>Speed (RPM)</td><td>Maximum Flow (CFS)</td><td>Static Head (ft)</td></tr>
<tr><td>4</td><td>3900</td><td>N/A</td><td>50</td><td>382</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="5">200 CFS</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="2">2004</td><td>Description of Last Major Retrofit</td><td colspan="2">Field operational testing was completed in 2004.</td></tr>
</table>

C.2.24.1 Description

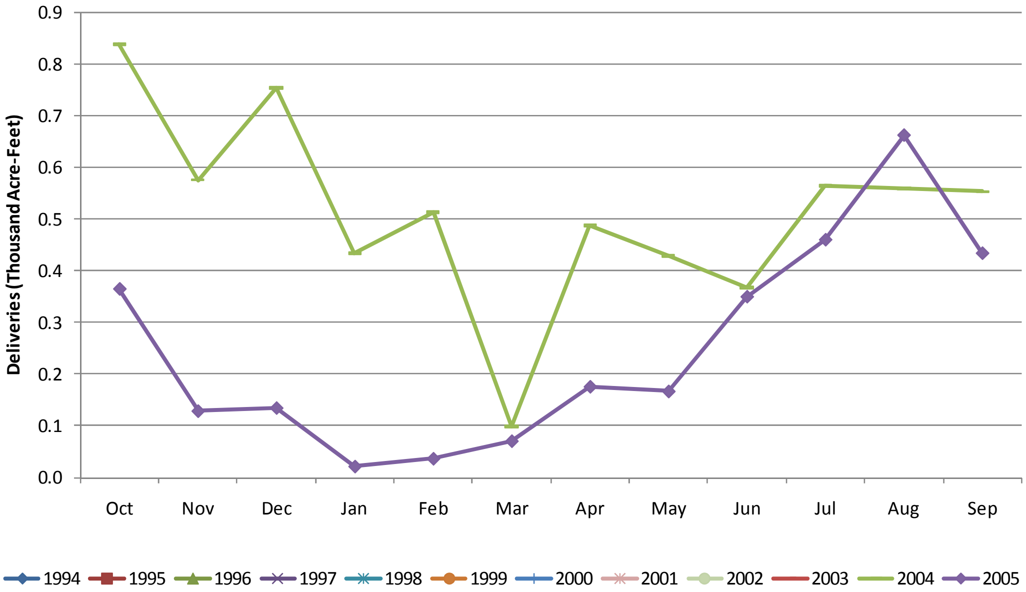
Greenspot Pumping Plant is the first facility in the East Branch Extension of the State Water Project. The East Branch Extension is the newest portion of the SWP becoming operational in 2004. Water exiting this plant continues to flow to Crafton Hills Pumping Station. The plant contains four pumps with a combined maximum flow of 200 CFS. The plant pumps water to a static head of 382 feet.

Only two years of data were available for this plant. For the purposes of the model, absent any additional information and data, the Study Team assumes operations in 2005 reflect operations in all water year types.

C.2.24.2 Water Flow

Greenspot Pumping Plant pumped between 3,000 and 6,200 AF/year during 2004 and 2005. Only two years of pumping information is available for this pumping plant, see Figure 79.

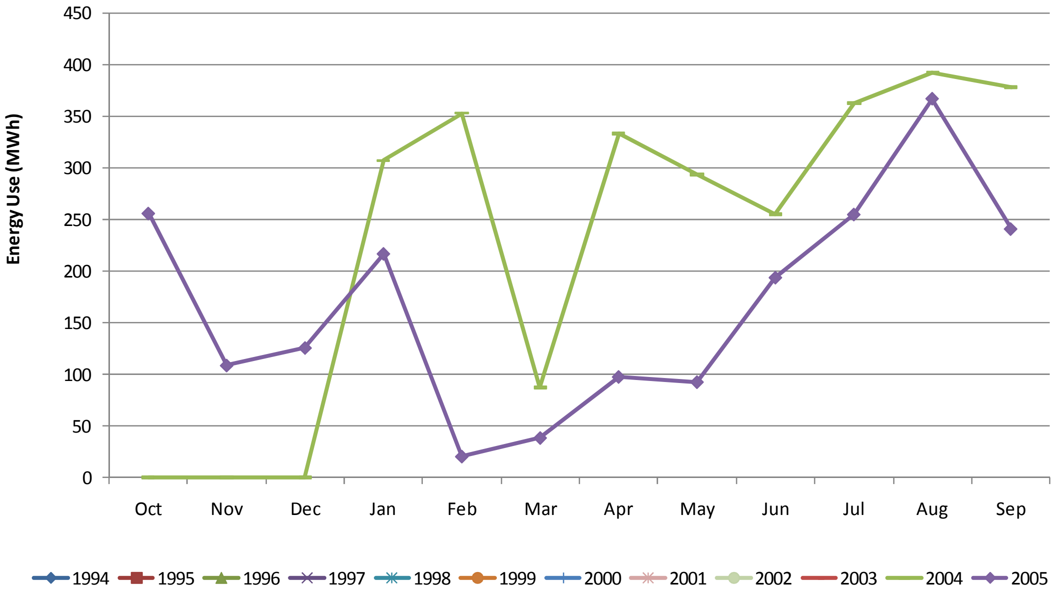
Figure 79: Greenspot Deliveries



C.2.24.3 Energy Use

Greenspot Pumping Plant's annual energy consumption ranged between 2,016 and 2,763 MWh/year during 2004 and 2005. Only two years of energy use information is available for this pumping plant, see Figure 80.

Figure 80: Greenspot Energy Use



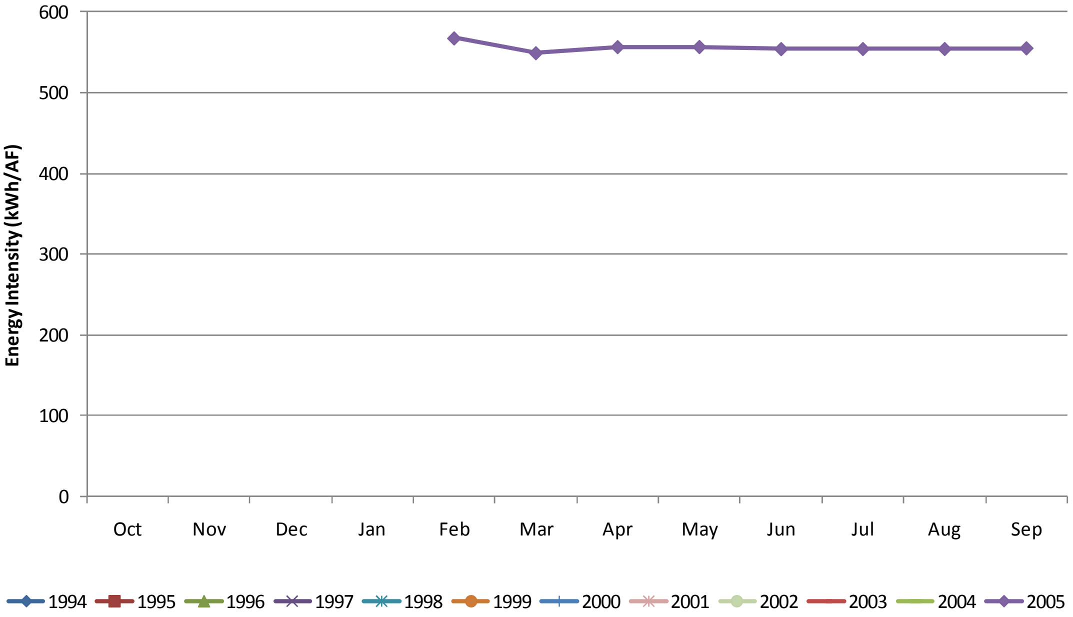
C.2.24.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Greenspot is 556.1 kWh/AF; scatter in the data reveals an error range of 2%, see Table 51. This calculation is based on data from February – December of 2005 when a clear pattern of “normal” operation emerged. Prior months exhibited erratic energy intensity due to abnormal operation conditions shortly after completion of construction. The value of energy intensity does not significantly change as over time, see Figure 81. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 51: Greenspot Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
556.1	2%	566.5	545.7

Figure 81: Greenspot Energy Intensity Plot



C.2.25Crafton Hills Pumping Plant

Table 52: Crafton Hills Summary

<table>
<tr><td>Facility Name</td><td colspan="7">Crafton Hills Pumping Plant</td><td colspan="3">Facility ID</td><td colspan="5">25</td></tr>
<tr><td>Owner</td><td colspan="7">State Water Project</td><td colspan="3">Facility Type</td><td colspan="5">Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="7"></td><td colspan="3">DEER Climate Zone</td><td colspan="5"></td></tr>
<tr><td>Downstream From</td><td colspan="15">Greenspot Pumping Plant</td></tr>
<tr><td>Upstream From</td><td colspan="15">Cherry Valley Pumping Plant</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="5">Other Wholesale Systems</td><td colspan="5">Storage</td><td colspan="5">Local Water Systems</td></tr>
<tr><td colspan="5">None</td><td colspan="5"></td><td colspan="5"></td></tr>
<tr><td rowspan="2">Facility Configuration</td><td colspan="3">Number of Pumps</td><td colspan="3">Power (HP)</td><td colspan="3">Speed (RPM)</td><td colspan="3">Maximum Flow (CFS)</td><td colspan="3">Static Head (ft)</td></tr>
<tr><td colspan="3">3</td><td colspan="3">4000</td><td colspan="3">N/A</td><td colspan="3">40</td><td colspan="3">613</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="15">120 CFS</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="7">2004</td><td colspan="3">Description of Last Major Retrofit</td><td colspan="5">Field operational testing was completed in 2004.</td></tr>
</table>

C.2.25.1 Description

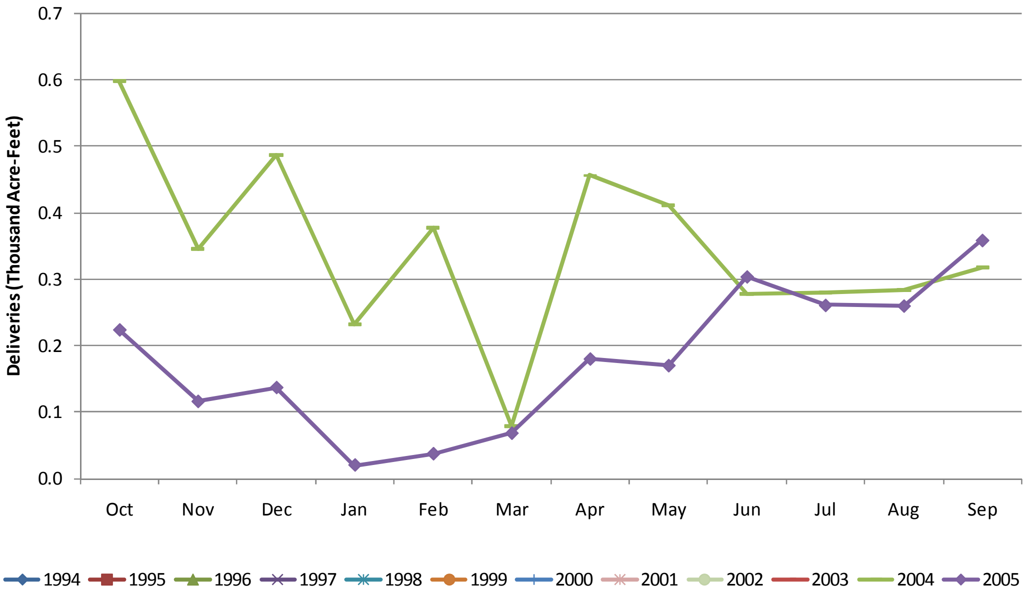
Crafton Hills Pumping Plant is the second facility in the East Branch Extension of the State Water Project. Water exiting this plant continues to flow to Cherry Valley Pumping Station. The plant contains three pumps with a combined maximum flow of 120 CFS. The plant pumps water to a static head of 613 feet.

Only two years of data were available for this plant. For the purposes of the model, absent any additional information and data, the Study Team assumes operations in 2005 reflect operations in all water year types.

C.2.25.2 Water Flow

Crafton Hills Pumping Plant pumped between 2,100 and 4,100 AF/year during 2004 and 2005. Only two years of pumping information is available for this pumping plant, see Figure 82.

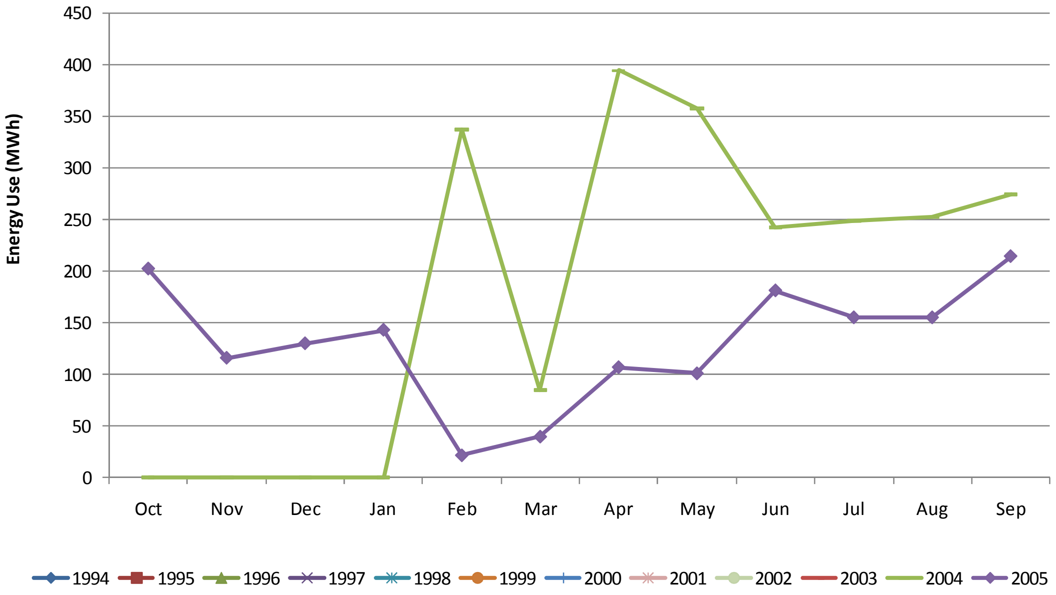
Figure 82: Crafton Hills Deliveries



C.2.25.3 Energy Use

Crafton Hills Pumping Plant's annual energy consumption ranged between 1,566 and 2,190 MWh/year during 2004 and 2005. Only two years of energy use information is available for this pumping plant, see Figure 83.

Figure 83: Crafton Hills Energy Use



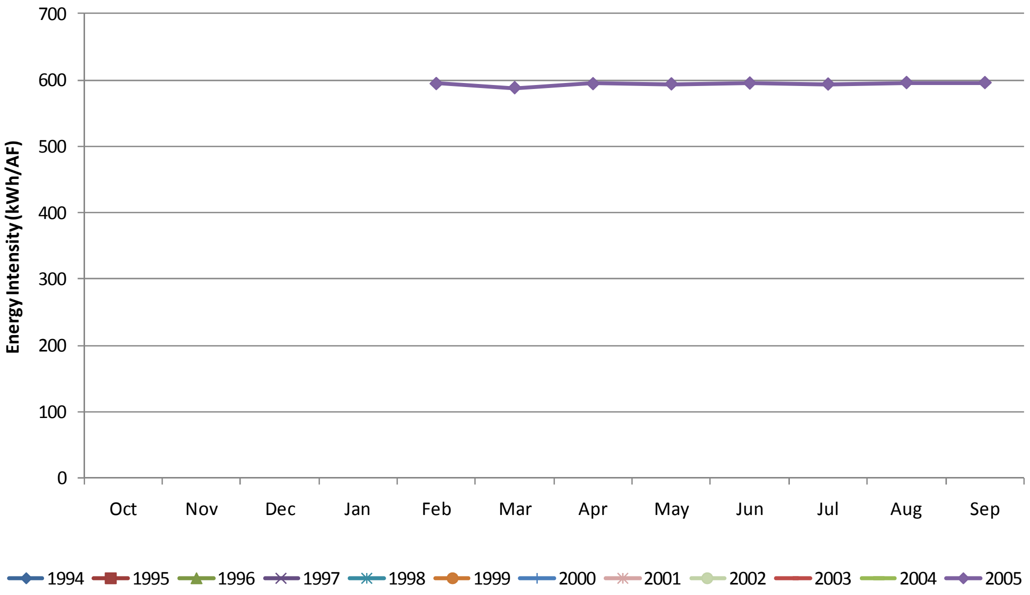
C.2.25.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Crafton Hills is 594.1 kWh/AF; scatter in the data reveals an error range of 1%, see Table 53. This calculation is based on data from February – December of 2005 when a clear pattern of "normal" operation emerged. Prior months exhibited erratic energy intensity due to abnormal operation conditions shortly after completion of construction. The value of energy intensity does not significantly change as over time, see Figure 84. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 53: Crafton Hills Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
594.1	1%	599.2	589.1

Figure 84: Crafton Hills Energy Intensity Plot



C.2.26Cherry Valley Pumping Plant

Table 54: Cherry Valley Summary

<table>
<tr><td>Facility Name</td><td colspan="12">Cherry Valley Pumping Plant</td><td colspan="6">Facility ID</td><td colspan="12">26</td></tr>
<tr><td>Owner</td><td colspan="12">State Water Project</td><td colspan="6">Facility Type</td><td colspan="12">Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="12"></td><td colspan="6">DEER Climate Zone</td><td colspan="12"></td></tr>
<tr><td>Downstream From</td><td colspan="30">Crafton Hills Pumping Plant</td></tr>
<tr><td>Upstream From</td><td colspan="30">N/A (Final</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="10">Other Wholesale Systems</td><td colspan="10">Storage</td><td colspan="10">Local Water Systems</td></tr>
<tr><td colspan="10">None</td><td colspan="10"></td><td colspan="10"></td></tr>
<tr><td rowspan="2">Facility Configuration</td><td colspan="6">Number of Pumps</td><td colspan="6">Power (HP)</td><td colspan="6">Speed (RPM)</td><td colspan="6">Maximum Flow (CFS)</td><td colspan="6">Static Head (ft)</td></tr>
<tr><td colspan="6">2</td><td colspan="6">300</td><td colspan="6">N/A</td><td colspan="6">16</td><td colspan="6">75</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="30">32 CFS</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="12">2004</td><td colspan="6">Description of Last Major Retrofit</td><td colspan="12">Field operational testing was completed in 2004.</td></tr>
</table>

C.2.26.1 Description

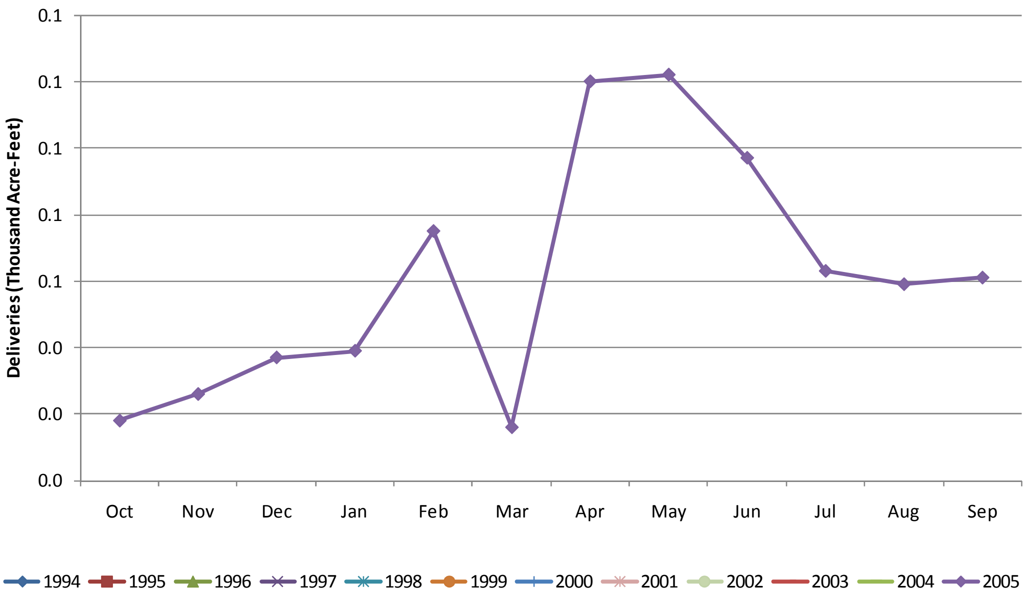
Cherry Valley Pumping Plant is the third and final facility in the East Branch Extension of the State Water Project. The plant contains three pumps with a combined maximum flow of 32 CFS. The plant pumps water to a static head of 75 feet.

Only one year of data was available for this plant. For the purposes of the model, absent any additional information and data, the Study Team assumes operations in 2005 reflect operations in all water year types.

C.2.26.2 Water Flow

Cherry Valley Pumping Plant pumped 0.7 AF/year during 2005. Only one year of pumping information is available for this pumping plant, see Figure 85.

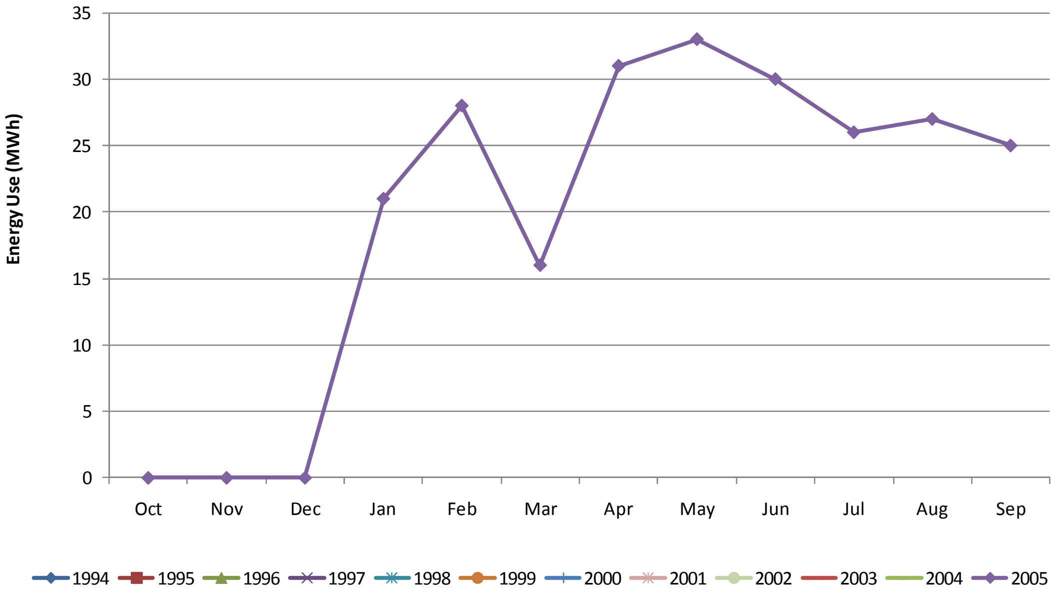
Figure 85: Cherry Valley Deliveries



C.2.26.3 Energy Use

Cherry Valley Pumping Plant's annual energy consumption was 237 MWh/year during 2005. Only one year of energy use information is available for this pumping plant, see Figure 86.

Figure 86: Cherry Valley Energy Use



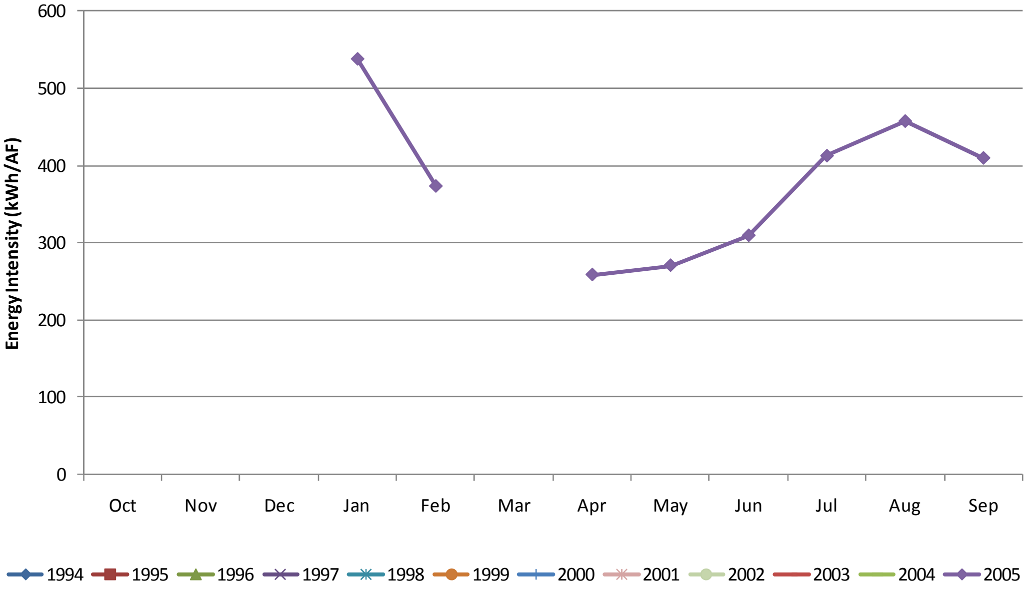
C.2.26.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Cherry Valley is 378.8 kWh/AF; scatter in the data reveals an error range of 51%, see Table 55. The value of energy intensity has a large error range due to the low sample of data available, see Figure 87. Variation may also be caused by abnormal operation of the plant in the year following its construction. Absent any additional information, this the best estimate of energy intensity the Study Team can obtain. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 55: Cherry Valley Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
378.8	51%	571.4	186.1

Figure 87: Cherry Valley Energy Intensity Plot



C.2.27 Sources

CDWR, 1963 to 2006, Bulletin 132 Management of the California State Water Project, Annual Bulletin from 1963 to 2006. http://www.water.ca.gov/swpao/bulletin.cfm

CDWR, 1990 to 2006, *State Water Project Monthly Operations Data*, Monthly Reports from 1990 to 2006. http://wwwoco.water.ca.gov/monthly/monthly.menu.html

Jim Blood, retired Chief Dispatcher of the State Water Project. Personal communication. October 2009.

California Sustainability Alliance. http://sustainca.org/content/state_water_project_facilities_map. Accessed December 2009.

C.3 Central Valley Project

The CVP delivers water to farms, homes, and industry in California's Central Valley as well as the major urban centers in the San Francisco Bay Area; it is also the a source of water for much of California's wetlands. In addition to delivering water for farms, homes, factories, and the environment, the CVP produces electric power and provides flood protection, navigation, recreation, and water quality benefits. It irrigates about 3 million acres of farmland (approximately one-third of the agricultural land in California) and supplies close to 1 million households. While the facilities are spread out over hundreds of miles, the project is financially and operationally integrated as a single large water project. The CVP reaches from the Cascade Mountains near Redding in the north to the Tehachapi Mountains near Bakersfield in the south, approximately 500 miles away. It is comprised of 20 dams and reservoirs, 11 power plants, and 500 miles of major canal as well as conduits, tunnels, and related facilities. The CVP delivered 6,227 TAF of water to long-term contractor in Water Year (WY) 2000 (a “normal” year). It provides about 600,000 acre-feet for municipal and industrial use, The CVP dedicates 800,000 acre-feet per year to fish and wildlife and their habitat and 410,000 acre-feet to State and Federal wildlife refuges and wetlands pursuant to the Central Valley Project Improvement Act (CVPIA).

The CVP began construction beginning in the late 1930’s pursuant to Emergency Relief Appropriation Act and Rivers and Harbors Act of 1937 for the purpose of contending problems with increasing salinity in the delta. The CVP is owned and operated by the US Bureau of Reclamation on behalf of its contractors. Deliveries are made to more than 250 contractors pursuant to long term contracts in which the contractors receiving the benefit of water delivered though CVP pay for allocated shares of capital and operating costs. Operating costs include the cost of energy used to transport water.

The CVP consists of 9 primary arteries: the Corning, Tehema-Colusa, Folsom South, Contra Costa, Delta-Mendota, San Luis, Coalinga, Madera, and Fraint-Kern Canals. The Corning Canal Corning Canal diverts water from the Tehama-Colusa Canal and delivers it 21 miles to Corning, CA. The Tehema-Colusa Canal delivers water to along a 122-mile canal in northern California to Tehama, Glenn, Colusa, and Yolo Counties. Folsom Canal delivers water from Folsom Lake along a 27 mile canal within Sacramento and San Joaquin counties. The Contra Costa Canal draws water from the Bay Delta and delivers it to Contra Costa Water District (CCWD) in a 47 mile canal; it is operated and maintained by CCWD. The Delta Mendota Canal stretches 117 miles south from Tracy Pumping Plant which draws water from the Bay Delta. The San Luis Canal is shared with SWP; a 102-mile portion of it is used by CVP to make deliveries to customers in the Central Valley. The Coalinga Canal is an 11.6 mile canal that branches off of the San Luis Canal in the southern part of Coalinga County. Madera Canal extends 36 miles from Millerton Lake in Central California to deliver water east towards Chowchilla. The Fraint-Kern Canal starts at Millerton Lake and extends 152 miles south to deliver water to Fresno, Tulare and Kern Counties. Six of these canals are illustrated in Figure 88. The CVP consists of approximately 610 miles of canals, rivers, and pipelines spanning from northern to central California, crossing three hydrologic regions and three DEER climate zones.

Figure 88: Central Valley Project Facility Diagram

Source: USBR 2009

The CVP is used for the following primary purposes:

1. Deliver water from Lake Shasta and Trinity Lake to its contractors
2. Flood control
3. Emergency deliveries of water along certain paths of interconnected water systems

The CVP is a major user of energy. The majority of energy used by CVP is to deliver water to customers along the Delta-Mendota Canal and San Luis Canal (shared with CVP). Deliveries to these customers require significant energy use by pump stations. Flows in other CVP canals are mostly gravity fed or use little energy for diversion pumps (with the exception of the Contra Costa Canal; however, it is operated by CCWD). For this reason, the Study Team focused on operations and energy consumption associated with making deliveries along the Delta Mendota Canal and San Luis Canal.

During WY 2000, a “normal” water year, the CVP delivered 6,227 TAF of water to contractors, 3,293 TAF of these deliveries were made via the Delta Mendota and San Luis Canal. The total annual amount of energy needed to convey all Delta Mendota and San Luis Canal water in was 1,148 GWh. Of this energy, 21% (241 GWh) is needed during summer months (June, July, August); the balance of energy consumption (79 %, 907 GWh) occurs during the other 9 months of the year. See Table 56 for water deliveries and energy consumption in other year types.

Of the energy needed to support CVP deliveries during a “normal” year, all is met through sources of self generation at hydro electric facilities. For the purposes of this study, none of the power generation by CVP is considered to be in-conduit hydropower. CVP is a net producer of power, the balance of power not needed is sold to CVP customers for further conveyance and pumping of water and to other long term contractors via the Western Area Power Authority (WAPA).

Table 56: Water Deliveries and Energy Use by the CVP

Water Year	Data Year	Total Water Delivered via CVP (TAF)	Delivered via Delta Mendota and San Luis Canals (TAF)	Energy Used by Delta Mendota and San Luis Canal Facilities (GWh)
Wet	1998	5,539	3,314	1,155
Above Normal	2000	6,227	3,293	1,148
Below Normal	2004	6,073	3,903	1,173

Dry	2002	5,888	3,502	1,089
Critical	2001	5,532	3,438	1,026

In order to support scenario analyses, the Study Team needed to determine an appropriate method of approximating the amount of energy needed to deliver contract water under a range of hydrologic conditions. For this purpose, the Study Team collected and analyzed historical monthly water deliveries and associated energy requirements for the period 1994-2005. The sources of these data for the CVP were: Central Valley Project Operations Office, Report of Operations Monthly Delivery Tables, Water Accounting Reports, and CVOO Report of Operations. For a detailed list of sources, see the end of this section.

C.3.1 Tracy Pumping Plant

Table 57: Tracy Summary

<table>
<tr><td>Facility Name</td><td colspan="2">Tracy Pumping Plant</td><td>Facility ID</td><td colspan="2">1</td></tr>
<tr><td>Owner</td><td colspan="2">Central Valley Project</td><td>Facility Type</td><td colspan="2">Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="2">San Joaquin River</td><td>DEER Climate Zone</td><td colspan="2">12</td></tr>
<tr><td>Downstream From</td><td colspan="5">Bay Delta</td></tr>
<tr><td>Upstream From</td><td colspan="5">Delta-Mendota Canal</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="2">Other Wholesale Systems</td><td colspan="2">Storage</td><td>Local Water Systems</td></tr>
<tr><td colspan="2">None</td><td colspan="2"></td><td></td></tr>
<tr><td rowspan="2">Facility Configuration</td><td>Number of Pumps</td><td>Power (HP)</td><td>Speed (RPM)</td><td>Maximum Flow (CFS)</td><td>Static Head (ft)</td></tr>
<tr><td>6</td><td>22,500</td><td>N/A</td><td>767</td><td>197</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="5">4602 CFS</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="2"></td><td>Description of Last Major Retrofit</td><td colspan="2"></td></tr>
</table>

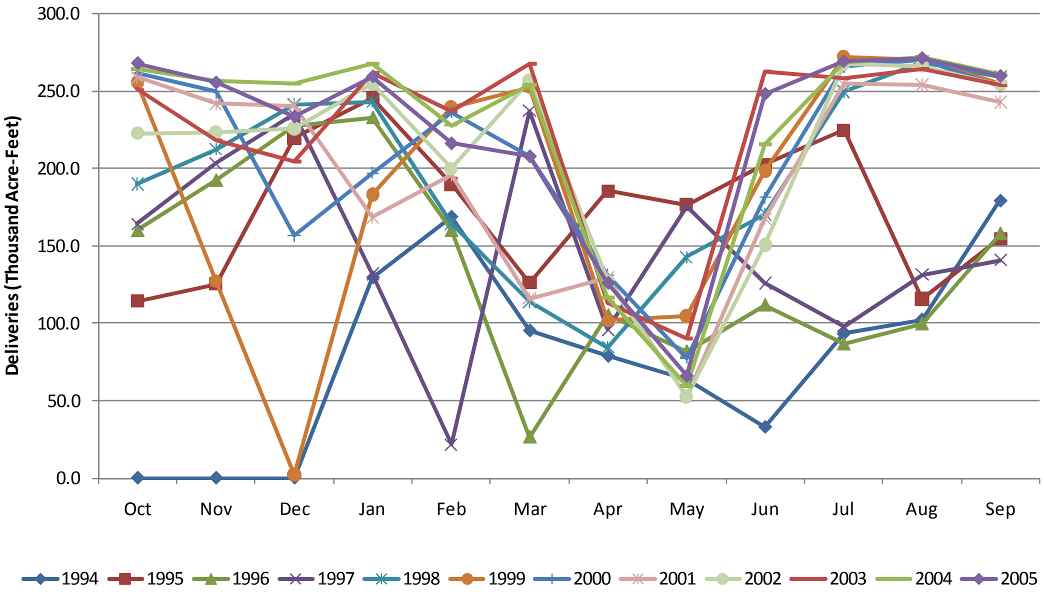
C.3.1.1 Description

Tracy Pumping Plant is the first facility in the Delta-Mendota Canal of the Central Valley Project. It pumps water out of the Bay Delta. The plant contains six pumping units with a combined maximum capacity of 4,602CFS. The plant pumps water to a static head of 197 feet. Tracy Pumping Plant has in the past pumped water for the SWP during emergencies or when Banks Pumping Plant is undergoing maintenance. This water can be transferred to the SWP’s California Aqueduct at O’Neil pump station.

C.3.1.2 Water Flow

Tracy Pumping Plant pumped between 1.6 and 2.7 million AF/year during the data collection period. Pumping is low during the months of April and May and generally high during the months of July through January, see Figure .

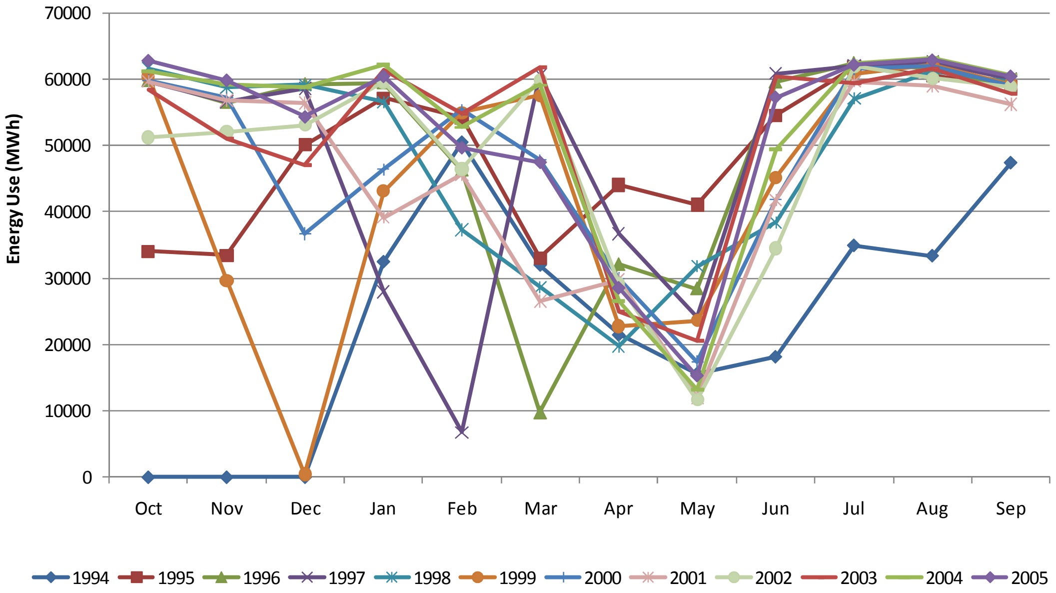
Figure 89: Tracy Deliveries



C.3.1.3 Energy Use

Tracy Pumping Plant's annual energy consumption ranged between 520,072 and 628,315 MWh/year during the data collection period. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 5.

Figure 90: Tracy Energy Use



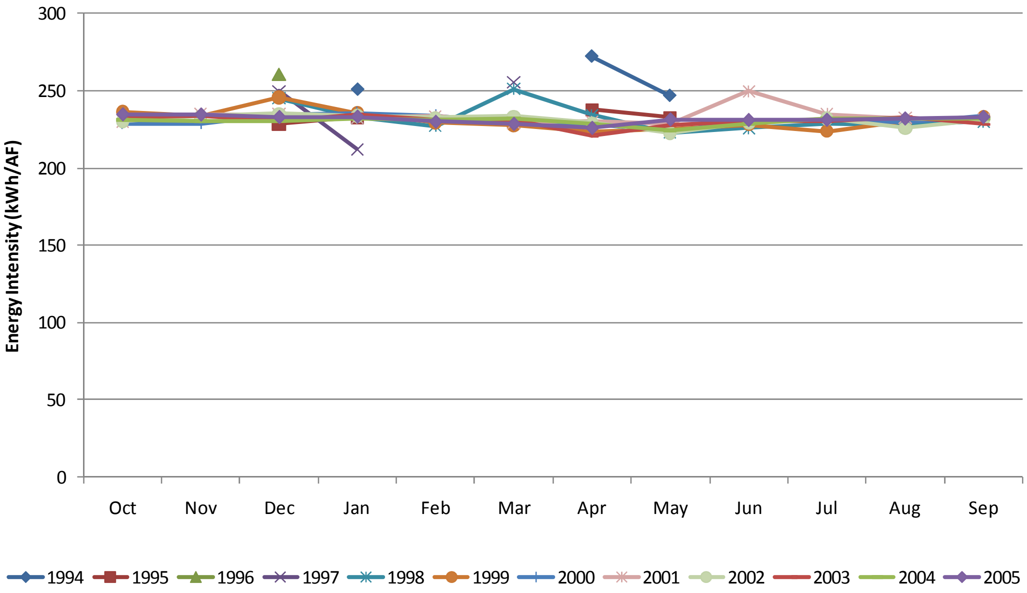
C.3.1.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations at Tracy is 232.7 kWh/AF; scatter in the data reveals an error range of 7%, see Table 4. The value of energy intensity does not significantly change as over time, see Figure 6. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 58: Tracy Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
232.7	7%	248.4	216.9

Figure 91: Tracy Energy Intensity Plot



C.3.2 O’Neill Pumping-Generating Plant

Table 59: O’Neill Summary

<table>
<tr><td>Facility Name</td><td colspan="7">O’Neill Pumping-Generating Plant</td><td colspan="3">Facility ID</td><td colspan="5">6</td></tr>
<tr><td>Owner</td><td colspan="7">CVP</td><td colspan="3">Facility Type</td><td colspan="5">Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="7">San Joaquin River</td><td colspan="3">DEER Climate Zone</td><td colspan="5">12</td></tr>
<tr><td>Downstream From</td><td colspan="15">Tracy Pumping Plant, Delta-Mendota Canal</td></tr>
<tr><td>Upstream From</td><td colspan="15">O’Neill Forebay, Gianelli Pumping Plant, Dos Amigos Pumping Plant</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="5">Other Wholesale Systems</td><td colspan="5">Storage</td><td colspan="5">Local Water Systems</td></tr>
<tr><td colspan="5">State Water Project</td><td colspan="5"></td><td colspan="5"></td></tr>
<tr><td rowspan="2">Facility Configuration</td><td colspan="3">Number of Units</td><td colspan="3">Power (HP)/ Generation (KW)</td><td colspan="3">Speed (RPM)</td><td colspan="3">Maximum Flow (CFS)</td><td colspan="3">Static Head (ft)</td></tr>
<tr><td colspan="3">6</td><td colspan="3">6,000 (P)
4,200 (G)</td><td colspan="3">N/A</td><td colspan="3">700</td><td colspan="3">45-53</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="15">4,200</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="7"></td><td colspan="3">Description of Last Major Retrofit</td><td colspan="5"></td></tr>
</table>

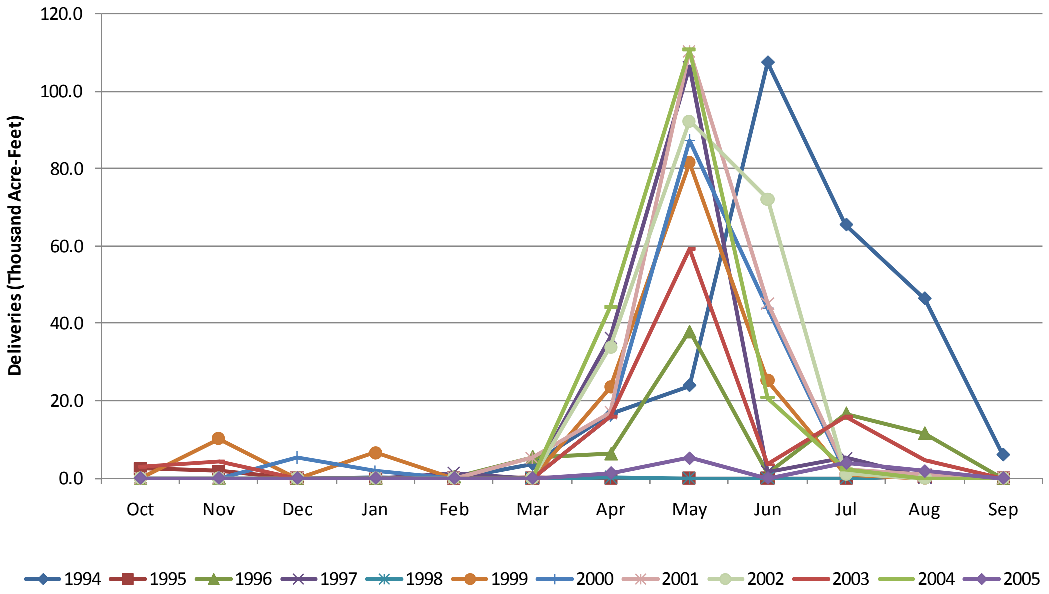
C.3.2.1 Description

O’Neill Pumping-Generating Plant connects CVP’s Delta-Mendota Canal to SWP’s California Aqueduct. It allows CVP to ultimately transfer water to San Luis Reservoir or deliver it down the California Aqueduct to CVP customers. The plant contains six pumping/generating units with a combined maximum capacity of 4,200 CFS. The plant pumps water to a static head of 45-53 feet.

C.3.2.2 Water Flow (Generating)

O'Neill generating operations moved between 800 and 269,600 AF/year of water during the data collection period. Water is not necessarily released through the generators every year, some years saw little flow. Flow is low during the months of August through March and high during the months of May and June, see Figure 92.

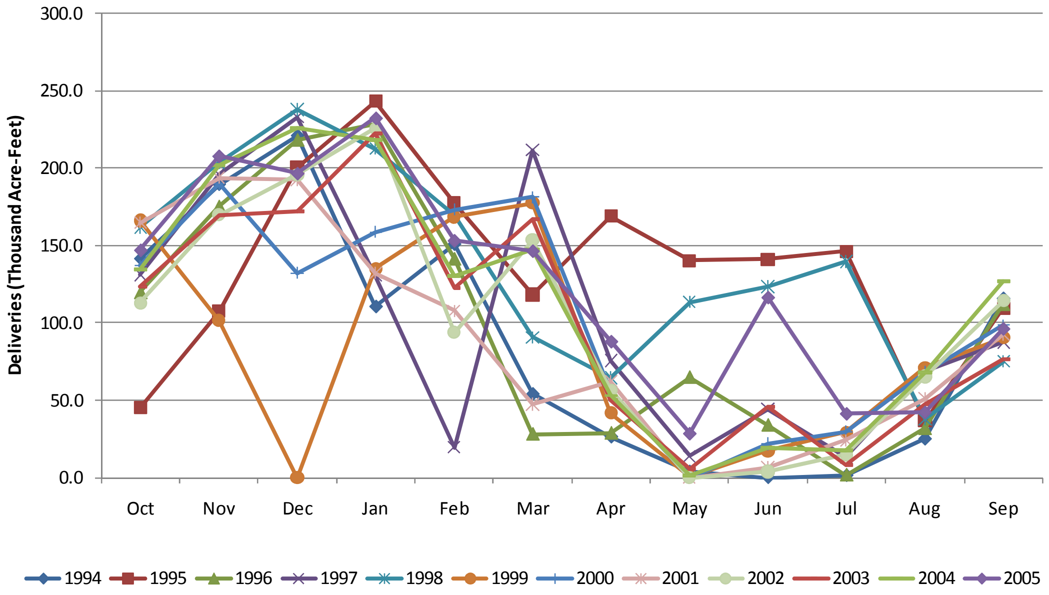
Figure 92: O'Neill Deliveries (Generating)



C.3.2.3 Water Flow (Pumping)

O'Neill pumping operations saw between 998,400 and 1,632,900 AF/year during the data collection period. Flow is generally low during the months of April through August and generally high during the months of November through January, see Figure 93.

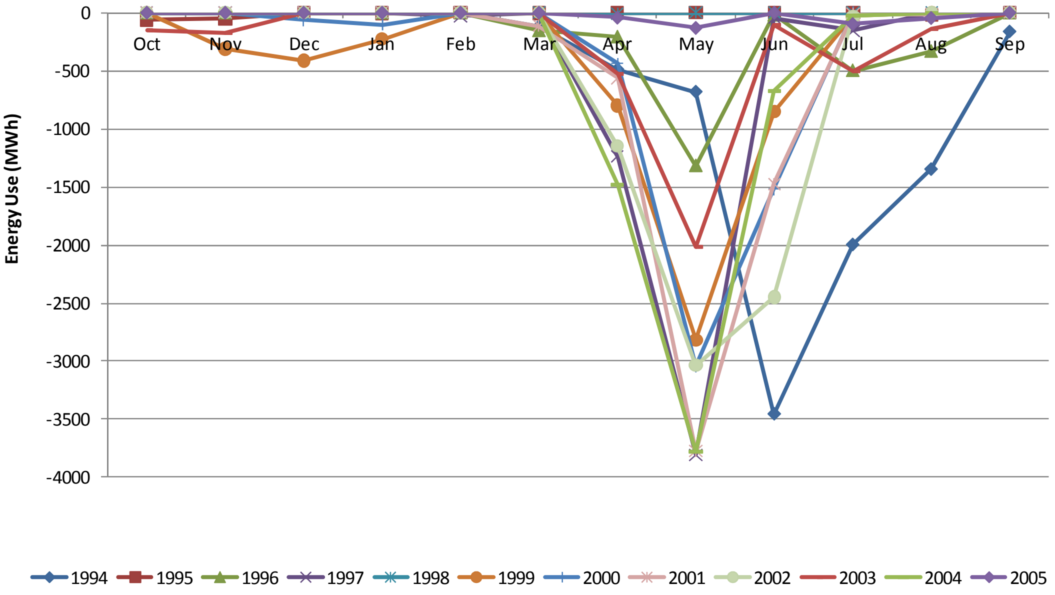
Figure 93: O'Neill Deliveries (Pumping)



C.3.2.4 Energy Production (Generating)

O'Neill generated between 5 and 8,259 MWh/year of energy during the data collection period. Energy production is low during months of low flow indicated above and high during months of high flow, see Figure 94.

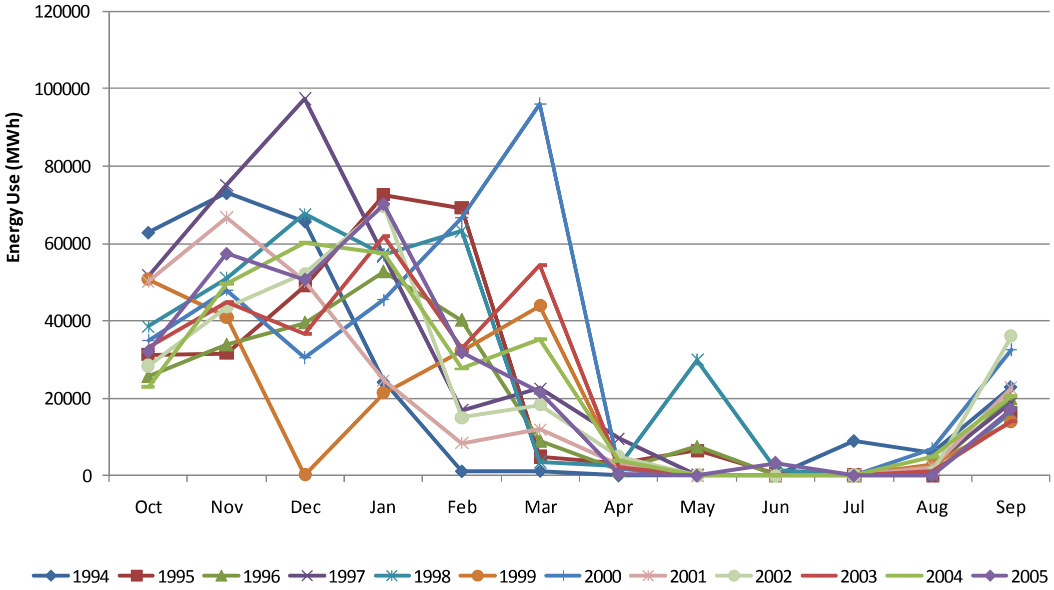
Figure 94: O'Neill Energy Use (Generating)



C.3.2.5 Energy Use (Pumping)

O'Neill Pumping annual energy consumption ranged between 209,228 and 363,124 MWh/year during the data collection period. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 95.

Figure 95: O'Neill Energy Use (Pumping)



C.3.2.6 Energy Intensity (Generating)

The Study Team determined the energy intensity of generating operations at Gianelli is -32.2 kWh/AF; scatter in the data reveals an error range of 15%, see Table 60. The energy intensity has a relatively large error range due to the limited number of data points, see Figure 96. For the purposes of the model, the energy intensity of this facility will be one constant number.

Figure 96: O'Neill Energy Intensity Plot (Generating)

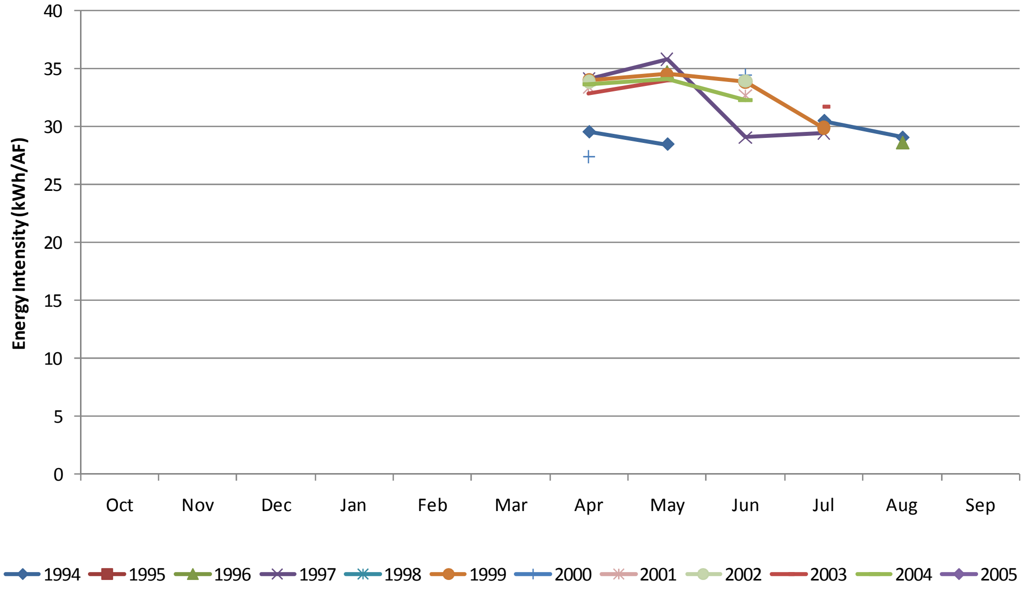


Table 60: O'Neill Energy Intensity (Generating)

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
-32.2	15%	-27.3	-37.1

C.3.2.7 Energy Intensity (Pumping)

The Study Team determined the energy intensity of pumping operations at Gianelli is 59.5 kWh/AF; scatter in the data reveals an error range of 6%, see Table 61. The value of energy intensity does not significantly change as over time, see Figure 97. For the purposes of the model, the energy intensity of this facility will be one constant number.

Figure 97: O'Neill Energy Intensity Plot (Pumping)

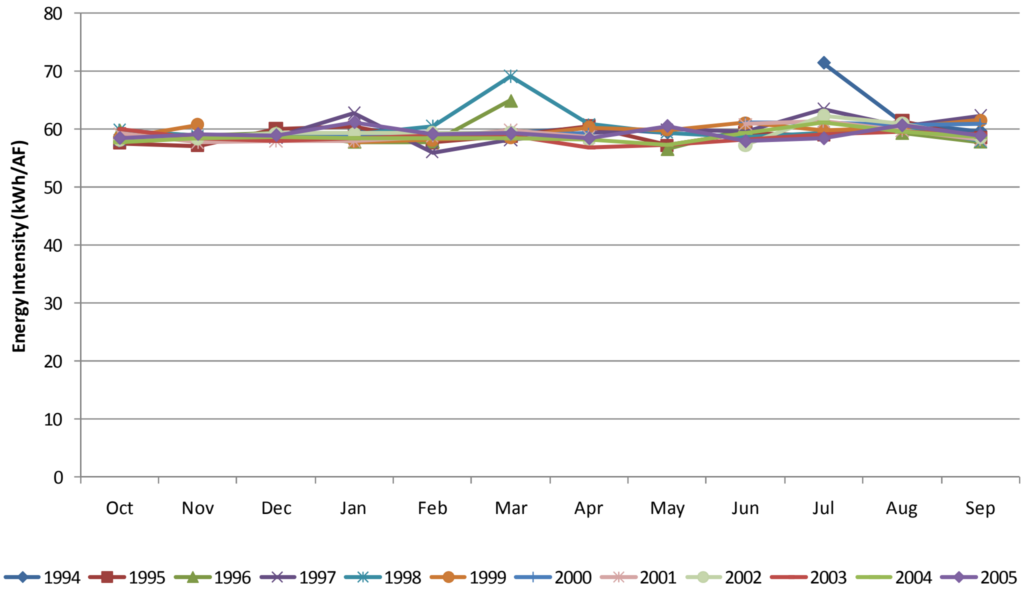


Table 61: O'Neill Energy Intensity (Pumping)

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
59.5	6%	63.3	55.6

C.3.3 Banks Pumping Plant

Table 62: Banks Summary

<table>
<tr><td>Facility Name</td><td colspan="2">Banks Pumping Plant</td><td colspan="2">Facility ID</td><td>1</td></tr>
<tr><td>Owner</td><td colspan="2">SWP</td><td colspan="2">Facility Type</td><td>Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="2">San Joaquin River</td><td colspan="2">DEER Climate Zone</td><td>12</td></tr>
<tr><td>Downstream From</td><td colspan="5">Clifton Court Forebay</td></tr>
<tr><td>Upstream From</td><td colspan="5">Bethany Reservoir</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="2">Other Wholesale Systems</td><td colspan="2">Storage</td><td>Local Water Systems</td></tr>
<tr><td colspan="2">State Water Project</td><td colspan="2">Bethany Reservoir (in-conduit, SWP)</td><td></td></tr>
<tr><td rowspan="4">Facility Configuration</td><td>Number of Pumps</td><td>Power (HP)</td><td>Speed (RPM)</td><td>Maximum Flow (CFS)</td><td>Static Head (ft)</td></tr>
<tr><td>2</td><td>11,500</td><td>400</td><td>375</td><td>236-252</td></tr>
<tr><td>5</td><td>34,500</td><td>225</td><td>1130</td><td>236-252</td></tr>
<tr><td>4</td><td>34,500</td><td>200</td><td>1076</td><td>236-252</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="5">10,700 CFS</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="2">2004[1]</td><td colspan="2">Description of Last Major Retrofit</td><td>Unit 6 motor rewound.</td></tr>
</table>

1: From DWR Bulletin 132, 2005

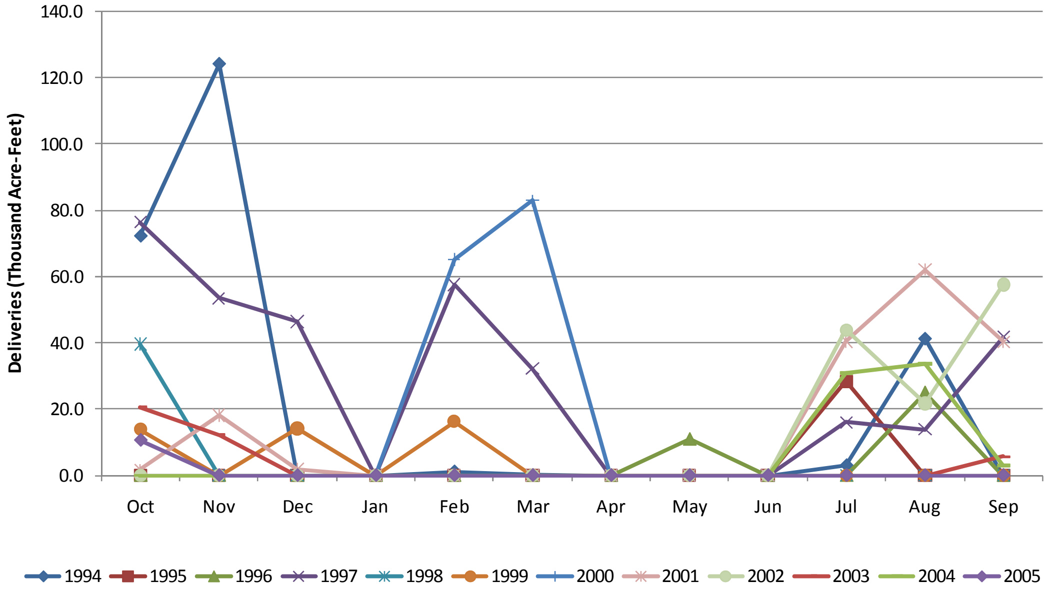
C.3.3.1 Description

Banks Pumping Plant is owned by the SWP, but conveys water at times for the CVP under a joint operations agreement. It is the first pumping plant in the SWP's California Aqueduct; it pumps water out of the Delta at Clifton Court Forebay and into Bethany Reservoir. Banks Pumping Plant is used by CVP CVP's Tracy Pumping Plant is out of service; CVP's use of Banks is limited. Currently flow through the pumps at Banks is limited by regulations protecting Delta fisheries. The plant contains eleven fixed speed pumping units with a combined maximum capacity of 10,700 CFS. The plant pumps water to a static head ranging from 236 to 252 feet.

C.3.3.2 Water Flow

Banks Pumping Plant pumped between 10,600 and 337,500 AF/year for CVP use during the data collection period. During the collection period, several months had no pumping and the most consistent pumping occurred in the months of July through October, see Figure 98.

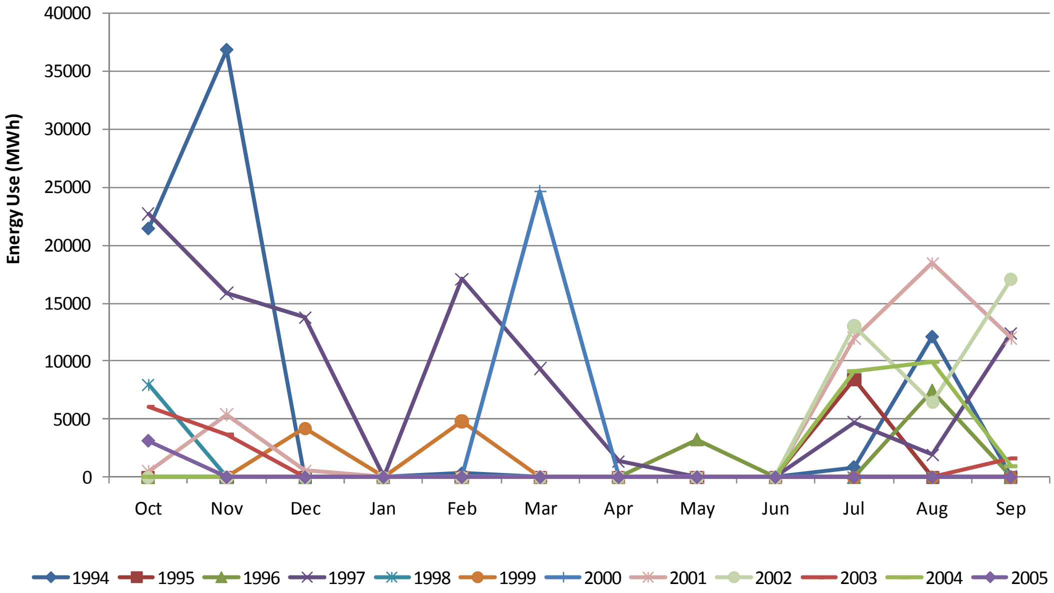
Figure 98: Banks Deliveries



C.3.3.3 Energy Use

Banks Pumping Plant's annual energy consumption ranged between 3,144 and 99,208 MWh/year during the data collection period. This energy is that which is used to move CVP water only. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 99.

Figure 99: Banks Energy Use



C.3.3.4 Energy Intensity

This facility is shared with the State Water Project, thus the Study team will rely on the energy intensity analysis performed on this facility using SWP data. This analysis can be found in the State Water Project Section of this appendix. See Table 4 for the energy intensity analysis results.

Table 63: Banks Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
284.7	6%	300.8	268.6

C.3.4 Dos Amigos Pumping Plant

Table 64: Dos Amigos Summary

<table>
<tr><td>Facility Name</td><td colspan="2">Dos Amigos Pumping Plant</td><td>Facility ID</td><td colspan="2">1</td></tr>
<tr><td>Owner</td><td colspan="2">SWP and CVP</td><td>Facility Type</td><td colspan="2">Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="2">San Joaquin River</td><td>DEER Climate Zone</td><td colspan="2">12</td></tr>
<tr><td>Downstream From</td><td colspan="5">O’Neil Forebay</td></tr>
<tr><td>Upstream From</td><td colspan="5">Las Perillas Pumping Plant</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="2">Other Wholesale Systems</td><td colspan="2">Storage</td><td>Local Water Systems</td></tr>
<tr><td colspan="2">State Water Project</td><td colspan="2"></td><td></td></tr>
<tr><td rowspan="3">Facility Configuration</td><td>Number of Pumps</td><td>Power (HP)</td><td>Speed (RPM)</td><td>Maximum Flow (CFS)</td><td>Static Head (ft)</td></tr>
<tr><td>3[1]</td><td>40,000</td><td>120[1]</td><td>2550</td><td>107-125</td></tr>
<tr><td>3</td><td>40,000</td><td>120</td><td>2600</td><td>107-125</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="5">15,450 CFS</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="2">2001[2]</td><td>Description of Last Major Retrofit</td><td colspan="2">Repair pump and motor on unit 1 and unit 4.</td></tr>
</table>

1: Variable capacity pumps, flow rating represents maximum flow

2: From DWR Bulletin 132, 2002

C.3.4.1 Description

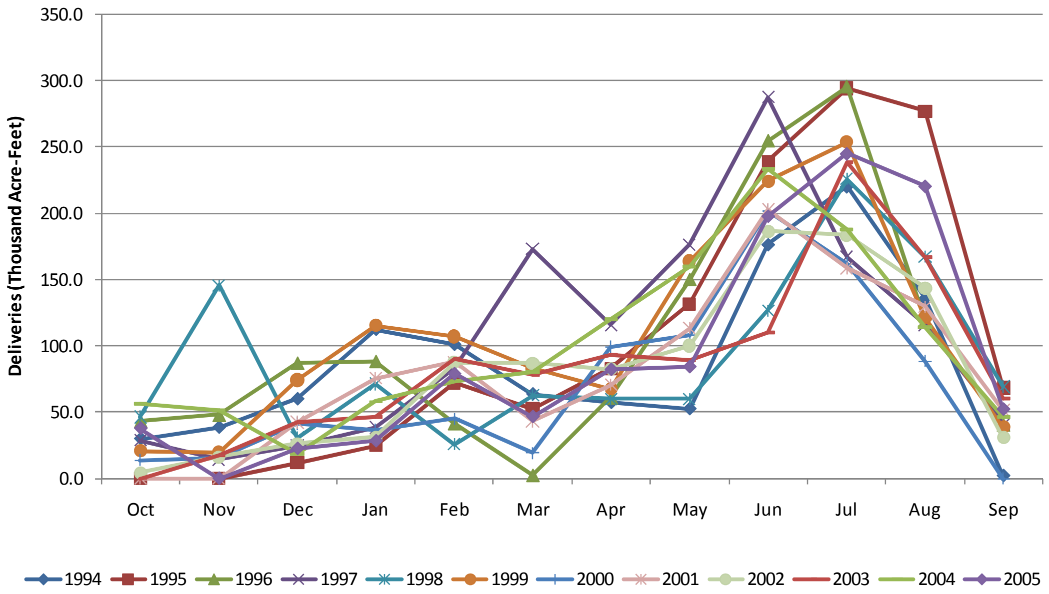
Dos Amigos is shared by SWP and CVP. It is the second pumping plant in SWP’s California Aqueduct, it is downstream from O’Neil forebay and upstream from the Las Perillas Pumping

Plant. Dos Amigos has three pumps that are variable capacity units. The original intent for operating this plant was to have the variable capacity units constantly running, and turn on and off the fixed capacity units as needed. The variable capacity units would then be adjusted to meet the required demand. The plant contains three fixed speed pumping units and three variable speed pumping units with a combined maximum capacity of 15,450 CFS. The plant pumps water to a static head ranging from 107 to 125 feet.

C.3.4.2 Water Flow

Dos Amigos Pumping Plant pumped between 831,200 and 1,289,400 AF/year for CVP use during the data collection period.   During the collection period, several months had no pumping and the most consistent pumping occurred in the months of July through October, see Figure 100.

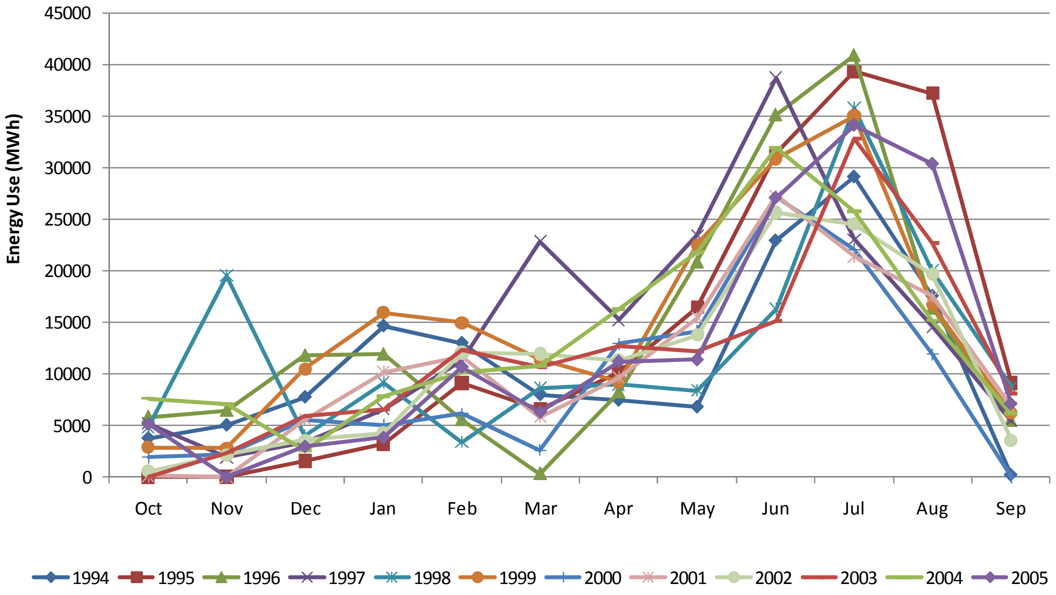
Figure 100: Dos Amigos Deliveries



C.3.4.3 Energy Use

Dos Amigos Pumping Plant’s annual energy consumption ranged between 111,787 and 179,140 MWh/year during the data collection period. This energy is that which is used to move CVP water only. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 101.

Figure 101: Dos Amigos Energy Use



C.3.4.4 Energy Intensity

This facility is shared with the State Water Project, thus the Study team will rely on the energy intensity analysis performed on this facility using SWP data. This analysis can be found in the State Water Project Section of this appendix. See Table 65: Dos Amigos Energy Intensity for the energy intensity analysis results.

Table 65: Dos Amigos Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
135.6	6%	144.3	126.8

C.3.5 Gianelli Pumping-Generating Plant

Table 66: Gianelli Summary

<table>
<tr><td>Facility Name</td><td colspan="2">Gianelli Pumping-Generating Plant</td><td>Facility ID</td><td colspan="2">6</td></tr>
<tr><td>Owner</td><td colspan="2">SWP and CVP</td><td>Facility Type</td><td colspan="2">Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="2">San Joaquin River</td><td>DEER Climate Zone</td><td colspan="2">12</td></tr>
<tr><td>Downstream From</td><td colspan="5">O’Neil Pumping Plant</td></tr>
<tr><td>Upstream From</td><td colspan="5">San Luis Reservoir</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="2">Other Wholesale Systems</td><td colspan="2">Storage</td><td>Local Water Systems</td></tr>
<tr><td colspan="2">Connected to CVP via O’Neil Forebay and San Luis Reservoir</td><td colspan="2">San Luis Reservoir (off-canal storage, SWP)</td><td></td></tr>
<tr><td rowspan="3">Facility Configuration</td><td>Number of Units</td><td>Power (HP)</td><td>Speed (RPM)</td><td>Maximum Flow (CFS)</td><td>Static Head (ft)</td></tr>
<tr><td>6</td><td>34,000 (P)
63,000 (G)</td><td>120/150</td><td>3470/2300 (G/P)</td><td>99-327</td></tr>
<tr><td>2</td><td>34,000 (P)
63,000 (G)</td><td>120</td><td>3470/2300 (G/P)</td><td>99-327</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="5">21,620 CFS (G), 13,800 (P)</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="2">2005[1]</td><td>Description of Last Major Retrofit</td><td colspan="2">Refurbish pump/turbine on unit 4.</td></tr>
</table>

1: From DWR Bulletin 132, 2006

C.3.5.1 Description

Gianelli Pumping/Generating station is shared by SWP and CVP; storage in San Luis Reservoir, to which this facility pumps, is also shared. CVP operates Gianelli Pumping/Generating station in conjunction with San Luis Reservoir as a seasonal storage facility. San Luis Reservoir and Gianelli are not and cannot be operated as a pump-storage facility, see SWP section on this facility for details.

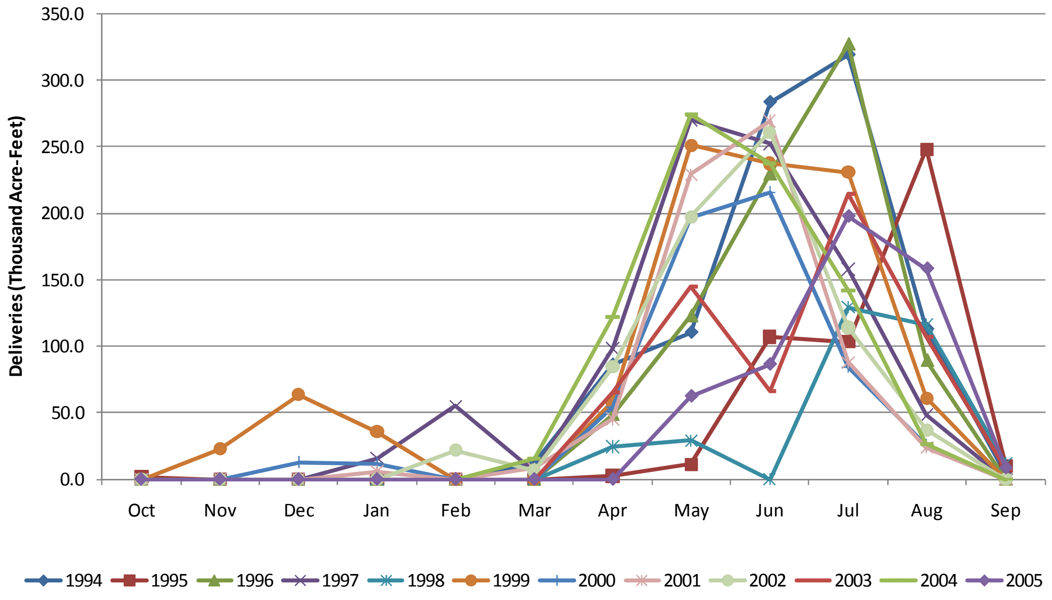
The eight units at Gianelli are reversible units capable of pumping and generating. Six of the units are dual speed units; they have the ability to operate a two different RPM's ultimately determined by the elevation of San Luis Reservoir. Jim Blood informed the Study Team that as the reservoir elevation drops below a certain level, the speed of the unit is changed to provide the best pumping or generating efficiency.

The changing reservoir level affects the energy required to pump or the amount of energy that can be generated. At higher reservoir levels, pumping requires more energy but generators can produce more energy. This trend seen in the data provided to the study team.

C.3.5.2 Water Flow (Generating)

Gianelli Generating operations moved between 310,700 and 959,800 AF/year of water for CVP use during the data collection period. Flow is low during the months of September through November and high during the months of May through July, see Figure 102.

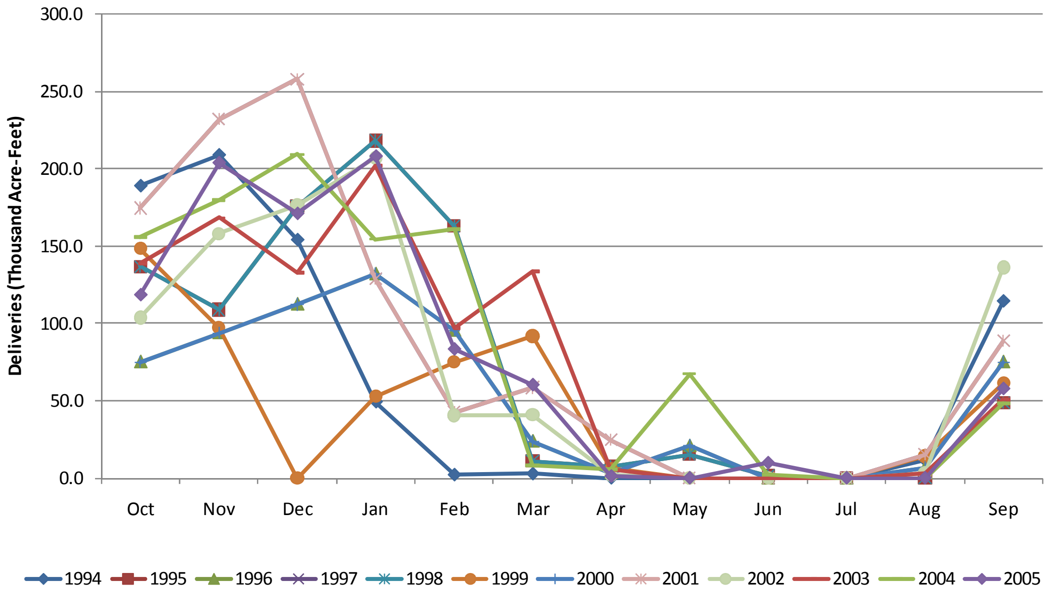
Figure 102: Gianelli Deliveries (Generating)



C.3.5.3 Water Flow (Pumping)

Gianelli Pumping operations moved between 546,900 and 1,022,500 AF/year of water for CVP use during the data collection period. Flow is low during the months of April through August and high during the months of November through January, see Figure 103. Flows for pumping were high while flows for generating were low. This illustrates the seasonal storage functionality of San Luis Reservoir. Water is pumped into the reservoir during wet months and held until it's released in the dry months when it is needed.

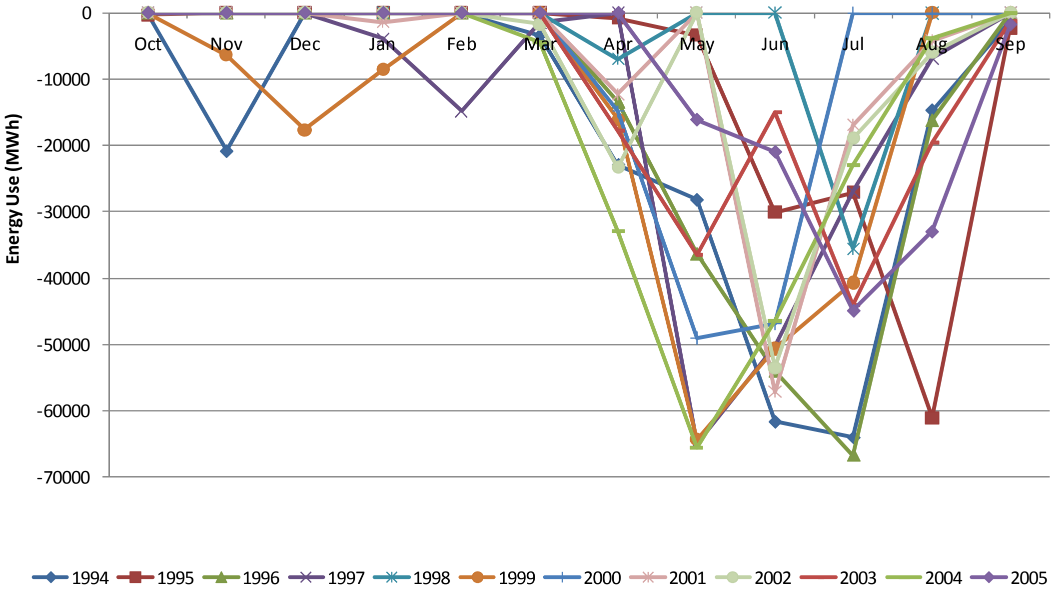
Figure 103: Gianelli Deliveries (Pumping)



C.3.5.4 Energy Production (Generating)

Gianelli Generating Plant's annual energy production ranged between 42,523 and 216,873 MWh/year during the data collection period. This energy is that which is generated by moving CVP water only. Energy production is low during months of low flow indicated above and high during months of high flow, see Figure 104.

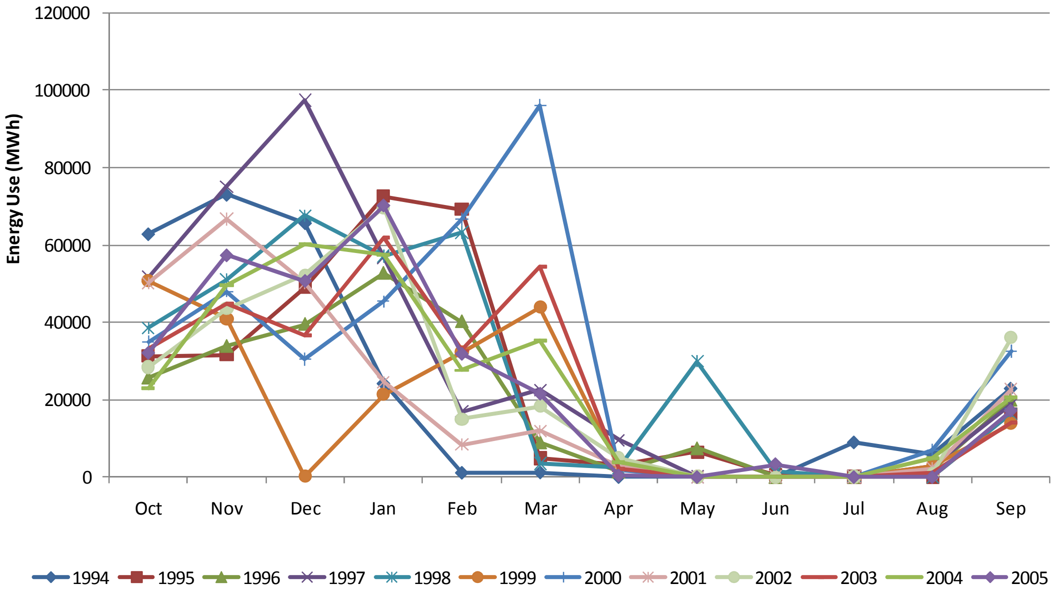
Figure 104: Gianelli Energy Use (Generating)



C.3.5.5 Energy Use (Pumping)

Gianelli Pumping Plant's annual energy consumption ranged between 209,228 and 363,124 MWh/year during the data collection period. This energy is that which is used to move CVP water only. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 105.

Figure 105: Gianelli Energy Use (Pumping)



C.3.5.6 Energy Intensity (Generating)

This facility is shared with the SWP, thus the Study team will rely on the energy intensity analysis performed on this facility using SWP data. This analysis can be found in the State Water Project Section of this appendix. See Table 67 for the energy intensity analysis results for generating operations.

Table 67: Gianelli Energy Intensity (Generating)

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
-233.8	39%	-143.7	-323.9

C.3.5.7 Energy Intensity (Pumping)

This facility is shared with the State Water Project, thus the Study team will rely on the energy intensity analysis performed on this facility using SWP data. This analysis can be found in the State Water Project Section of this appendix. See Table 68 for the energy intensity analysis results for pumping operations.

Table 68: Gianelli Energy Intensity (Pumping)

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
338.1	41%	476.4	199.9

C.3.6 Sources

"Central Valley Project and State Water Project Canals" August 31, 2009, US Bureau of Reclamation. February 1, 2010, http://www.usbr.gov/projects/Project.jsp?proj_Name=Central%20Valley%20Project

Central Valley Project Operations Office, 1985 to current. Report of Operations Monthly Delivery Tables. http://www.usbr.gov/mp/cvo/deliv.html. (Used for 1994 water year to 1997 water year)

Central Valley Project Operations Office, 1998 to current. Water Accounting Reports. http://www.usbr.gov/mp/cvo/pmdoc.html. (Used for 1998 water year to 2000 water year)

Central Valley Project Operations Office, 2001 to 2008. CVOO Report of Operations. http://www.usbr.gov/mp/cvo/index.html. (Used for 2001 water year to 2008 water year)

CDWR, 1990 to 2006, *State Water Project Monthly Operations Data*, Monthly

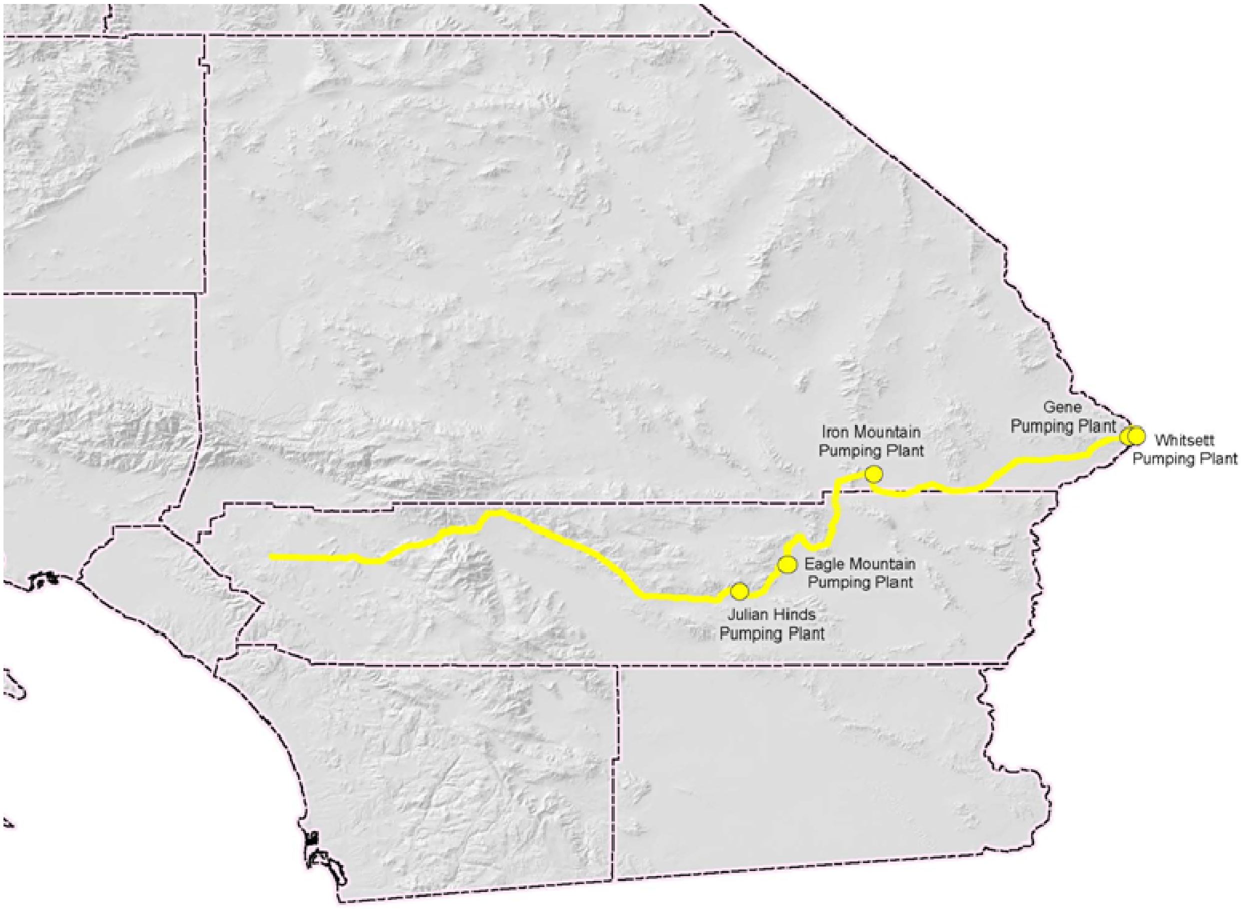
Reports from 1990 to 2006. http://wwwoco.water.ca.gov/monthly/monthly.menu.html (Used for 1994 water year data for SWP and CVP shared facilities)

C.4 Colorado River Aqueduct

The Colorado River Compact of 1922 allocated 7.5 million acre-feet to the states of the lower Colorado River, and shortly after, the Boulder Canyon Project Act of 1928 allocated 4.4 million acre-feet to California[1]. Metropolitan Water District (MWD) was formed in 1928 through an act of state legislature with 11 member agencies, with the intent of obtaining water from the Colorado River though the Colorado River Aqueduct. In 1931, $220 million in bonds were passed to fund the Colorado River Aqueduct, and in 1941, the aqueduct began delivering water from Lake Havasu near the Parker Dam to MWD's service area. The CRA now serves as one of the two main sources of water for MWD[2].

The CRA utilizes approximately 330 miles of aqueduct and pipeline crossing two hydrologic regions and three DEER climate zones, Figure 106 illustrates the CRA and its facilities. The main aqueduct is nearly 240 miles and ranges from the Parker Dam on the Colorado River in the east to Lake Mathews in the West. Between 1952 and 1961 the aqueduct was expanded to its current capacity of nearly 1.3 million acre-feet per year to accommodate additional transfers to San Diego County. Of this 1.3 million acre-feet, MWD's annual allocation is up to 660,000 acre-feet. Increasing diversions made by Arizona and Nevada could potentially cause MWD's total diversion to decline to its fourth priority right of 550,000 acre-feet. Palo Verde Irrigation District, the Yuma Project, Imperial Irrigation District and Coachella Valley Water District hold the first three priority rights to divert up to 3.85 million acre-feet a year.

Figure 106: Colorado River Aqueduct Facility Diagram



The CRA is a major user of energy. During WY 2000, a "normal" water year, the CRA delivered 1,299 TAF. The total annual amount of energy needed to convey that water in the CRA was 2,557 GWh. Of this energy, 25.6 % (353 GWh) was needed during summer months (June, July, August); the balance of energy consumption (74.4%, 1904GWh) occurred during the other 9 months of the year. Table 69 contains water deliveries and energy consumption data for other historic water year types.

Of the energy needed to support CRA deliveries during any water year type, all is purchased under wholesale power contracts. Power is obtained from Boulder Canyon Project (Hoover Power Plant), Parker Power Plant, power exchanges with SCE and DWR, purchase or sale arrangements with members of the Western Systems Power Pool and energy purchases from SCE. A 230 KV transmission line owned by MWD connects all five pumping plants to electrical substations near Hoover and Parker Dam power plants. This transmission line is used to supply each pumping plant with purchased power and is connected to WAPA and SCE transmission systems.

Table 69: Water Deliveries and Energy Use by the CRA

Water Year	Data Year	Water Delivered via CRA (TAF)	Energy Used for Water Deliveries (GWh)
Wet	1998	1,085	2,136
Above Normal	2000	1,299	2,557
Below Normal	2004	720	1,416
Dry	2002	1,277	2,543
Critical	2001	1,264	2,506

In order to support scenario analyses, the Study Team needed to determine an appropriate method of approximating the amount of energy needed to deliver contract water under a range of hydrologic conditions. The only data available to the study team for the period of time in question (1994 through 2005) were the total deliveries through the CRA and the total energy usage by all five pumping plants combine. This data will be analyzed as the total energy intensity to convey water from the Colorado River to MWD. The sources of these data for the CRA were: energy and water flow data provided by MWD staff; interviews with Jon Lambeck, Operations Planning Unit Manager at MWD; and supplemental reports from MWD.[1]

The results of our findings and recommendations are documented below.

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[1] MWD. *Power Integrated Resource Plan For Metropolitan's Colorado River Aqueduct Power Operations*. October 2006

C.4.1 Colorado River Aqueduct

Table 70: CRA Summary

<table>
<tr><td>Facility Name</td><td colspan="2">Colorado River Aqueduct</td><td>Facility ID</td><td colspan="2">1</td></tr>
<tr><td>Owner</td><td colspan="2">MWD</td><td>Facility Type</td><td colspan="2">System of five pump stations</td></tr>
<tr><td>Hydrologic Region</td><td colspan="2">Colorado River</td><td>DEER Climate Zone</td><td colspan="2">14 and 15</td></tr>
<tr><td>Downstream From</td><td colspan="5">Lake Havasu along the Colorado River</td></tr>
<tr><td>Upstream From</td><td colspan="5">Lake Mathews</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="2">Other Wholesale Systems</td><td colspan="2">Storage</td><td>Local Water Systems</td></tr>
<tr><td colspan="2"></td><td colspan="2">Lake Mathews</td><td></td></tr>
<tr><td rowspan="6">Facility Configurations</td><td>Pump Station Name</td><td>Number of Pumps</td><td>Typical Power Requirement (MW)[a]</td><td>Maximum Flow (CFS)[a]</td><td>Static Head (ft)[b]</td></tr>
<tr><td>Whitsett (Intake)</td><td>9</td><td>53.5</td><td>1800</td><td>291</td></tr>
<tr><td>Gene</td><td>9</td><td>55.7</td><td>1800</td><td>303</td></tr>
<tr><td>Iron Mountain</td><td>9</td><td>26.5</td><td>1800</td><td>144</td></tr>
<tr><td>Eagle Mountain</td><td>9</td><td>80.4</td><td>1800</td><td>438</td></tr>
<tr><td>Julian Hinds</td><td>9</td><td>81.0</td><td>1800</td><td>441</td></tr>
<tr><td>Maximum Aqueduct Capacity</td><td colspan="5">1,800 CFS</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="2">1984-1993</td><td>Description of Last Major Retrofit</td><td colspan="2">Replace bearings, motor windings and impellers. Achieved a 5-7% efficiency improvement.</td></tr>
</table>

a) With 8 pumps operating
b) Updated by MWD staff citing: *A Guide to the Colorado River Aqueduct,* September 2008.

C.4.1.1 Description

The CRA uses five pump stations located along the aqueduct to transport water; there are no energy recovery systems. The pump stations are known as: Whitsett (Intake) Pumping Plant, Gene, Iron Mountain, Eagle Mountain, and Julian Hinds. All pumping plants stations have 9 fixed speed pumps of equal capacity.

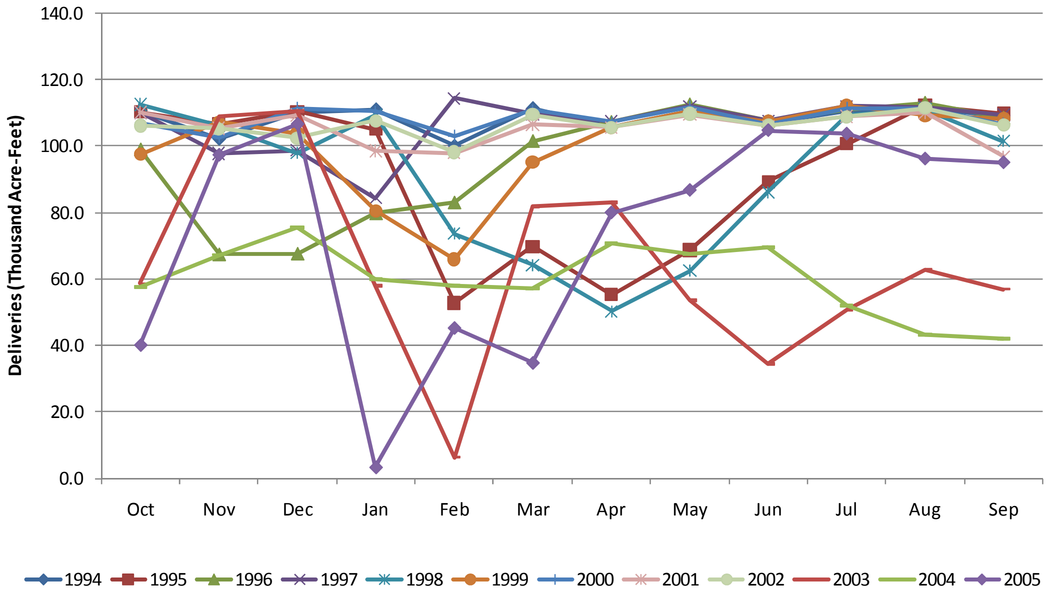
The pumping plants at Intake and Gene pump water into reservoirs. Operations at these plants are driven by reservoir levels and these stations are manually controlled by onsite operators. All 9 pumps at the plants could be in operation at the same time; they are not constrained by the capacity of the pipelines. Gates at each reservoir regulate the flow exiting the reservoirs and entering the next portion of the aqueduct.

The remaining pumping plants at Iron Mountain, Eagle Mountain and Julian Hinds are limited in their pumping capacity. The limitation is set by the physical size of the aqueduct which allows flows up to 1800 CFS. This restriction allows only 8 of the 9 pumps to operate simultaneously; if all 9 were operating the aqueduct would overflow. The remaining pump acts as a reserve pump, though no single pump is dedicated for this purpose. After water is released from the Copper Basin Reservoir downstream from the Gene Pumping Plant, there is no storage until the terminal reservoir at Lake Mathews. Thus all water leaving Copper Basin must continue through the three remaining plants without stopping until it reaches Lake Mathews. These final three pumping plants are operated in unison to ensure flow at each is matched and the aqueduct does not overflow.

C.4.1.2 Water Flow

CRA Pumping Plants pumped between 720,100 and 1,299,200 AF/year during the data collection period. The timing and amount of pumping vary year to year with no clear pattern emerging, see Figure .

Figure 107: CRA Historic Deliveries



Recent operations do not necessarily reflect this historic data. The Quantification Settlement Agreement (QSA) in 2003 had the effect of reducing the annual total flows through the CRA. MWD indicated after the QSA the average base amount received through the CRA was and still is approximately 800,000 AF/year. MWD is aggressively seeking additional supplies that can be brought through the CRA to make up for the recent reductions. MWD negotiates with other recipients of Colorado River water for access to their unutilized allocations, though the amount available varies year to year. In 2009 MWD pumped 1.1 million AF through the CRA; the additional amount came primarily from reductions in agricultural uses by other Colorado River water recipients.

MWD does not believe there is a need to estimate further reductions on the base CRA supplies (800 TAF/yr) since it would likely only happen under very unusual circumstances. Other recipients would see reductions in their base supply before further reductions would be seen by MWD. MWD staff suggested a range of annual pumping via the CRA that could be used in the model when projecting into the future, see Table 71.

Table 71: Suggested Range of Annual CRA Flow

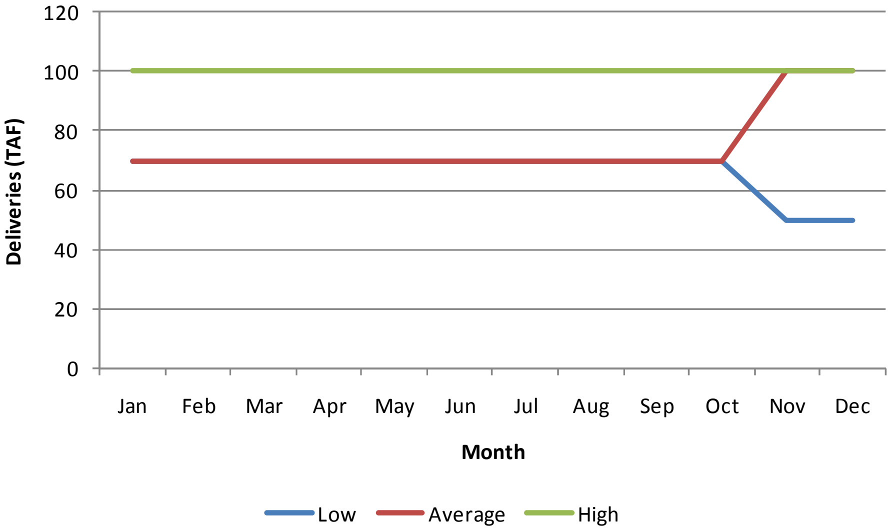
Case	Annual Flow (AF/yr)	Notes
Average	900,000	Assumes 100 TAF of water transfers can be obtained (staff indicates this is typical)
Low	800,000	Assumes no water transfers are obtained
High	1,200,000	Assumes 400 TAF of water transfers, possible in a year where water is relatively abundant

MWD receives water via the SWP and the CRA. Deliveries on the CRA are operated to provide the majority of supply during the first 8 months of the calendar year. When compared to deliveries by the SWP (low in the early months and peaking in the summer) it may seem that the CRA is operated to supply water to MWD customers when SWP deliveries are low. However, MWD operates the CRA completely independent of SWP deliveries. The complimentary load profiles occur as a consequence of water delivery schedules that seek to maximize water supplies. Allocations of Colorado River water are tracked over a calendar year basis while allocations of SWP water are tracked over the California water year basis (October – September). In the early part of the calendar year SWP deliveries tend to be low as the SWP's full supply is uncertain and the SWP operates to conserve as much water as possible.

CRA deliveries are scheduled in an effort to maximize water supply from the Colorado River. Higher priority recipients of Colorado River water (such as Imperial Irrigation District) typically wait until the end of the calendar year to decide if they have surplus Colorado River water available for sale; these decisions are typically made in November or December. If surplus water is available and is purchased by MWD, MWD must pump it prior to the end of the calendar year. Thus in years where large transfers are made, water flow in the CRA is higher in November and December than in any other months of the calendar year. To ensure there is enough capacity in the CRA to receive potential transfers in these months, MWD schedules the majority of its base allocation to be pumped during the months of January through September to leave additional capacity for transfers at the end of the year. Should transfers not become available, flows in November and December are lower than in the other months of the year because MWD must reduce pumping to adhere to its yearly allocation.

Based on this information the Study Team developed several typical monthly flow patterns to use in lieu of historic data. These profiles are illustrated in Figure 108 and will be used in the model to represent the range of future imports via the CRA.

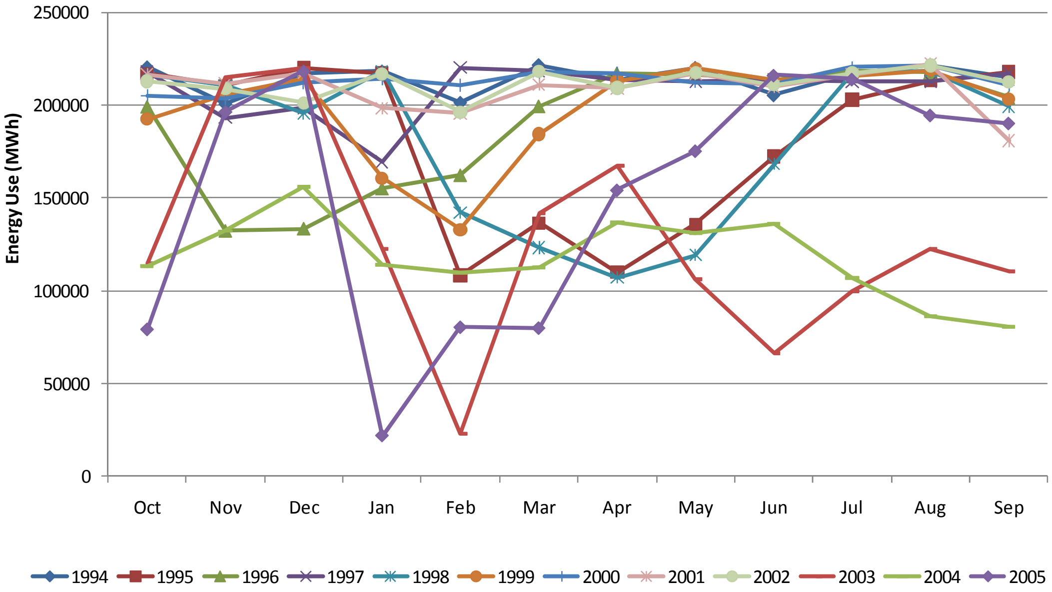
Figure 108: CRA Typical Monthly Deliveries for use in Model



C.4.1.3 Energy Use

CRA Pumping Plant's annual energy consumption ranged between 1,416,133 and 2,572,387 MWh/year during the data collection period. Energy use is low during months of low flow indicated above and high during months of high flow, see Figure 5. Energy use attributed to the CRA in the model will be calculated based on energy intensity and the selected CRA flow (Low, Average, High).

Figure 109: CRA Energy Use



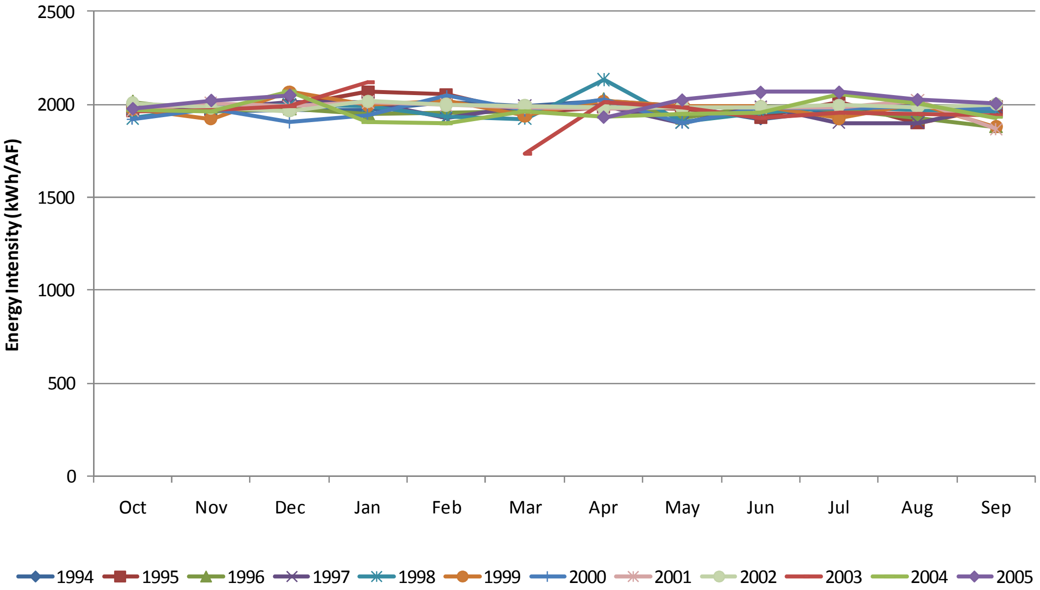
C.4.1.4 Energy Intensity

The Study Team determined the energy intensity of pumping operations along the CRA is 1976.1 kWh/AF; scatter in the data reveals an error range of 5%, see Table 4. The value of energy intensity does not significantly change as over time, see Figure 6. For the purposes of the model, the energy intensity of the CRA will be one constant number.

Table 72: CRA Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
1976.1	5%	2074.1	1878.1

Figure 110: CRA Energy Intensity Plot



C.4.2 Sources

Western Water Assessment. *Colorado River- Law and Policy* http://wwa.colorado.edu/colorado_river/law.html

MWD. *Power Integrated Resource Plan For Metropolitan's Colorado River Aqueduct Power Operations*. October 2006

Jon Lambeck, Operations Planning Unit Manager – MWD. Personal communication. Multiple occasions from December 2009 – January 2010.

CRA Water and Energy Data received via communication with MWD Staff. March 2009.

C.5 Metropolitan Water District of Southern California

The Metropolitan Water District of Southern California (MWD) is the nation's largest provider of treated water. It was formed in 1928 through an act of California State legislature with 11 member agencies, with the intent of increasing the water reliability in the area through the construction of the Colorado River Aqueduct (CRA). Today, MWD moves more than 1.5 billion gallons of water on a daily basis through its distribution system, delivering supplies to 26 member agencies. Those agencies, in turn, sell that water to more than 300 sub-agencies or directly to consumers. In all, 19 million Southern Californians rely on MWD for some or all of the water they use. These people live within MWD’s six-county service area, which encompasses 5,200 square miles in Los Angeles, Orange, Riverside, San Bernardino, San Diego and Ventura counties. MWD imports its water from two sources—the Colorado River and the State Water Project (SWP). The SWP brings supplies south from the Sacramento-San Joaquin Delta, while the Colorado River Aqueduct (CRA) moves water from the east from the Colorado River along the California-Arizona border. MWD built and owns the CRA and is responsible for system operations and maintenance. A series of canals, siphons, pipelines and five pumping plants move the water west to MWD’s service area. MWD’s regional distribution system connects to Lake Perris and Castaic Lake, which are terminal reservoirs for the East and West Branches of the state-owned and operated SWP as well as the SWP operated Devil Canyon Afterbay and the Santa Ana Pipeline .

MWD’s distribution system consists of multiple canals and pipelines. MWD has approximately 750 miles of raw and treated water distribution pipelines spanning 6 counties in the Southern California area, within one hydrologic region, and spanning five DEER climate zones. Additionally MWD manages hundreds of miles of power transmission lines, five water treatment plants, nine reservoirs, and sixteen hydroelectric plants. Figure 111 illustrates the main components of MWD’s distribution system.

Figure 111: Metropolitan Water District of Southern California – Major Pipelines and Facilities

Source: MWD 2008

MWD has the following primary responsibilities:

1. Provide an adequate, reliable supply of water to member agencies from the SWP and CRA
2. Manage the operation of the CRA

During WY 2000, a “normal” water year, MWD delivered 2,622 TAF of water to member agencies. Relatively little energy is used to distribute this water; significant amounts of energy are generated through deliveries. MWD’s imports arrive at high elevations and deliveries are made to member agencies at lower elevations allowing energy generation. During WY 2000, 41.6 GWh was generated through in-conduit hydropower facilities as a process of delivering the water. Power is mostly sold under long term power contracts. Table 73 shows water deliveries and power generation in other water year types.

Table 73: Water Deliveries and Energy Use by the MWD

Water Year	Data Year	Water Delivered via MWD (TAF)	Energy Generated from Water Deliveries (GWh)
Wet	1998	1,565	25.7
Above Normal	2000	2,622	41.6
Below Normal	2004	2,222	46.5
Dry	2002	2,617	42.8
Critical	2001	2,458	31.5

Little energy consumption is necessary for water distribution within MWD's service area; however power is generated. As energy consumption by MWD's distribution system was relatively small, this study focuses on MWD's in-conduit hydropower generation. In order to support scenario analyses, the Study Team needed to determine an appropriate method of approximating the amount of energy produced to deliver contract water under a range of hydrologic conditions. For this purpose, the Study Team collected and analyzed historical monthly water imports to MWD and associated energy generation for the period 1994-2005. The sources of these data for the MWD were: water and energy data provided by MWD staff and interviews with Jon Lambeck, Operations Planning Unit Manager at MWD.

The results of our findings and recommendations are documented below.

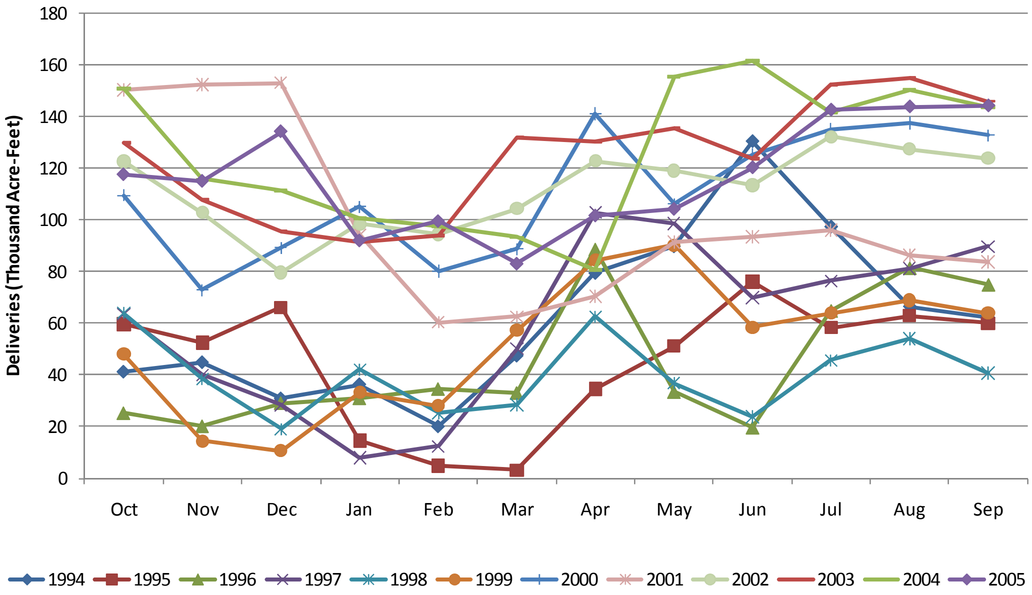
C.5.1 SWP Imports

MWD imports water from the State Water Project. It takes delivery at Castaic Lake, the terminus of the West Branch, and at several locations on the East Branch.

C.5.1.1 Water Flow

MWD received between 481,000 and 1,502,000 AF/year from the SWP during the data collection period. Deliveries are low during the months of January through March and high during the months of July through September, see Figure 112.

Figure 112: SWP Imports to MWD



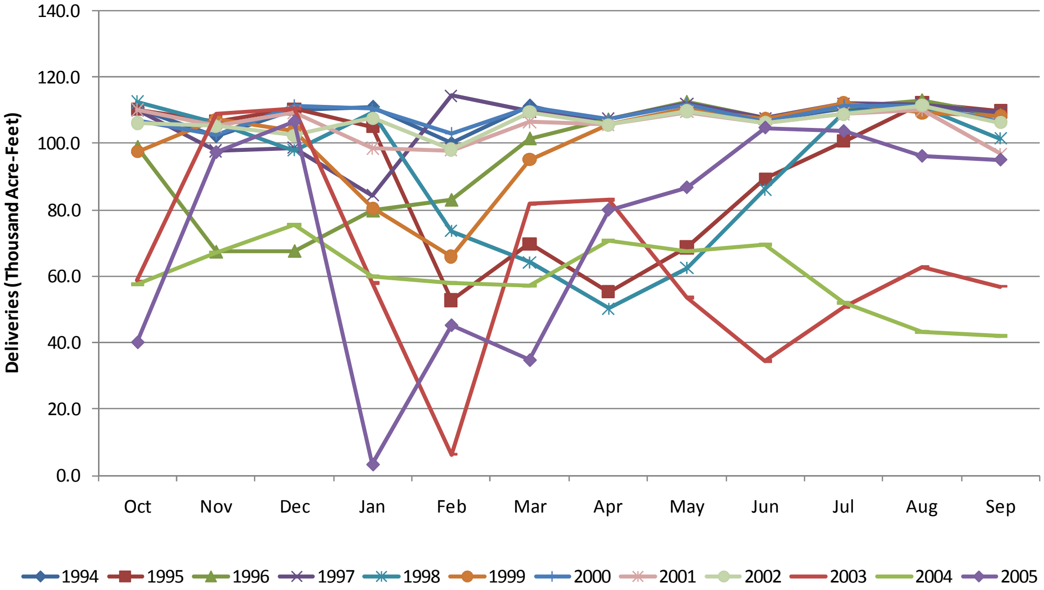
C.5.2 CRA Imports

MWD imports water from the Colorado River via the Colorado River Aqueduct. The aqueduct terminates at Lake Mathews in MWD's service territory. More information on the CRA can be found in the Colorado River Aqueduct profile.

C.5.2.1 Water Flow

MWD received between 720,100 and 1,299,200 AF/year from CRA during the data collection period. The timing and amount of water received vary year to year with no clear pattern emerging, see Figure .

Figure 113: CRA Imports to MWD



C.5.3 MWD Storage

MWD has significant storage operations in-region as well as in various other areas of the state. In-region surface storage operations include capacity in Diamond Valley Lake [800 TAF], storage agreements with DWR in Castaic and Perris Lakes, and local storage in Lake Matthews. MWD also has some groundwater storage in-region. Other storage options include: carryover storage in San Luis Reservoir (agreement with DWR); water banking with Arvin Edison and Semitropic Water Storage Districts; and groundwater storage agreements with Desert Water and Coachella Valley Water District, and 400 TAF of storage in Lake Mead. Lake Mead can be used to store water from surplus exchanges with other recipients of Colorado River water. Despite ample storage capacity, storage levels are currently low, Diamond Valley Lake and Lake Mead are approximately half full. In 2006, MWD had about 2.6 MAF of water in storage, as of early 2010 it was approximately 1.6 - 1.7 MAF. As a response to the shortfall in water supply, MWD currently reduced deliveries to its members by 10% to retail and 20% to wholesale customers. In such shortfalls MWD is not required to locate additional supplies for member agencies; however MWD continues to seek additional sources of water on behalf of its members.

C.5.4 MWD Power Plants

MWD owns and operates 16 pipeline hydropower plants in the Los Angeles area; these are listed in Table 74. All plants except Diamond Valley are under long term contracts to sell the power they generate. Long term contracts are with LADWP, SCPPA, SCE, DWR, and PG&E. All power plants are connected to the grid via LADWP or SCE electrical systems. Power generated at Diamond Valley is currently sold on the short term market.

MWD recently retired three generators at Diamond Valley Lake (DVL) to lower the facility's nameplate capacity to its current 29.7 MW. This places it under the 30 MW capacity limit to allow it to be designated as a renewable source under the California Energy Commission (CEC) rules for renewable hydroelectric power under California's Renewable Portfolio Standard. DVL has recently received this designation from the CEC. The power generated can now be sold under contract to parties interested in procuring qualifying renewable energy. The downgrade in capacity means that MWD has reduced operating options if some of the remaining generators are out of service. This could result in water being released without producing any power. The retirement of the three generators and reduction in nameplate capacity (operationally, MWD could not generate more than 30 MWs) was driven by the regulation that hydropower plants with a nameplate capacity greater than 30MW cannot be designated as renewable.

Table 74: MWD Hydropower Plants

Plant Name	Water Type	County	Feed Waters	Nameplate Capacity (Megawatts)	Initial Year of Operation
Diamond Valley Lake	Raw	Riverside	SWP+CRA	29.7	2001
Etiwanda	Raw	San Bernardino	SWP	23.9	1994
Red Mountain on SD Aqueduct pipeline #5	Raw	San Diego	SWP+CRA	5.9	1985
Valley View	Raw	Orange	SWP+CRA	4.1	1985
Coyote Creek	Treated	Orange	SWP+CRA	3.1	1984
Rio Hondo	Treated	Los Angeles	SWP+CRA	1.9	1984
Corona	Raw	Riverside	CRA	2.9	1983
Perris	Raw	Riverside	SWP	7.9	1983
Temescal	Raw	Riverside	CRA	2.9	1983
Sepulveda Canyon	Treated	Los Angeles	SWP	8.5	1982
Venice	Treated	Los Angeles	SWP	10.1	1982
Foothill Feeder	Raw	Los Angeles	SWP	9	1981
San Dimas	Raw	Los Angeles	SWP	9.9	1981
Yorba Linda	Raw	Orange	SWP+CRA	5.1	1981
Lake Mathews	Raw	Riverside	CRA	4.9	1980
Greg Avenue	Treated	Los Angeles	SWP	1	1979

Water demand by MWD customers ultimately governs the flow though each power plant. All plants have water flow design rating range; the generation equipment can be damaged if it operates outside of those limits. If flows are too high, excessive vibration or cavitation can cause damage. Conversely if the water flow is too low, excessive vibration or cavitation can occur or there may not be enough force in the water flow to adequately turn the turbine and generator. MWD works to manage operations and coordinate flows through power plants with member agencies to keep flow within the limits of each plant. For example MWD can ask member agencies if they can shift timing of water deliveries to allow for generation. However, most member agencies do not have the facilities to be this flexible in their water demands.

When water flows required by water demand exceed the plant's rated flow range, water bypasses the plants though energy dissipaters and no power is generated. MWD was not able to provide data to the Study Team on total flow through each power plant or the amount of water that bypassed plants. For this reason, monthly power generation cannot be easily tied to water flows.

Drought conditions and other cutbacks in water deliveries can cause many of MWD's generators to be offline as less water is available to run the generators. The reduction in power generation depends on the feed water to each power plant. If SWP deliveries are reduced significantly, power generated by plants fed by SWP water also decreases. Currently SWP supplies are significantly reduced and most of the power plants that feed off the SWP water are not producing energy. However, plants fed by the Colorado River waters are still producing power. Total power generation by MWD depends on the source of imported water, the demands of its Member Agencies and the flow pattern in the distribution system. MWD could have the same total demand for water in two cases, but if the source waters are a different mix in each case, MWD may have two completely different power generation levels. Feed water for each power plant is listed in Table 74.

MWD power plants produce a relatively flat profile for energy corresponding to water deliveries. Fifteen of the sixteen MWD power plants cannot operate as peaking power plants since they do not have a reservoir below the plant to create a storage buffer.

The Study Team discussed options to relate power generation to water flow with Jon Lambeck. A suggested approach was to relate the total power generation by all power plants fed by SWP water to total SWP imports. Similarly, plants fed by CRA waters could be related to CRA imports and plants fed by both CRA and SWP could be related to total CRA and SWP imports. The subsequent analysis using a yearly time step is seen below.

C.5.4.1 Power Generation Intensity

The Study Team calculated power generation intensity on a yearly basis. Water flows at each individual plant were not available. Thus, the Study Team related imported water flow to power generation by a collective group of plants fed by those imports. Data on the feed waters (imports to MWD) were available at the point of delivery to MWD. These imports can be stored in reservoirs before flowing through power plants. Data on power generation was available at each individual plant. The physical separation of the locations where water and energy data were collected complicate analysis at a monthly basis. Thus a yearly basis was used.

Figure 114 illustrates the yearly imports to MWD from the SWP, CRA, and the total of SWP and CRA. Figure 115 illustrates the yearly power generation by MWD power plants fed by SWP, CRA, and a combination of SWP and CRA waters. Figure 116 calculates the power generation intensity of each group of power plants on a yearly basis. Table 75 summarizes the average generation intensity used by the Study Team to estimate future power generation by MWD. For the purposes of the model, the generation intensity of each set of powerplants will be one constant number.

Figure 114: Yearly Water Imports to MWD by Source

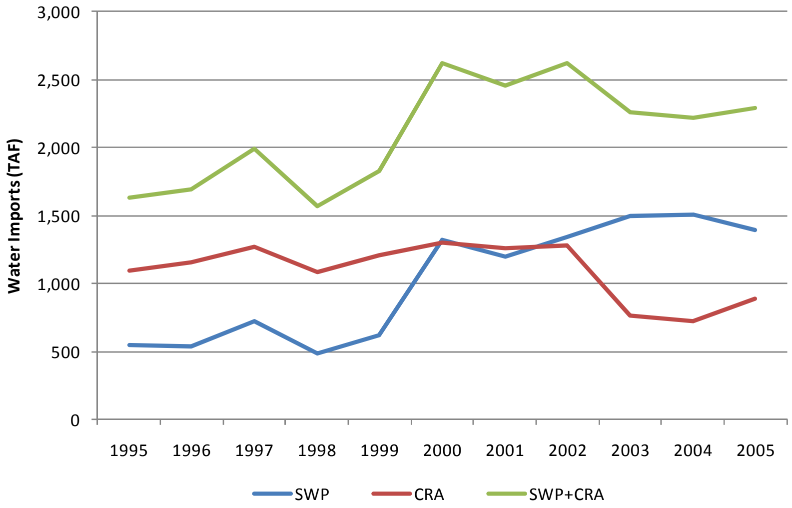


Figure 115: Generation at MWD Facilities by Feed Water Source

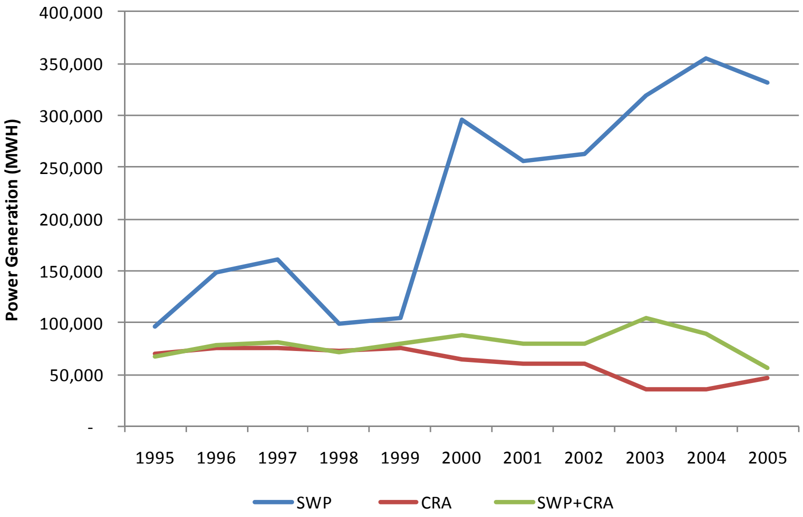


Figure 116: Generation Intensity at MWD Facilities by Feed Water Source

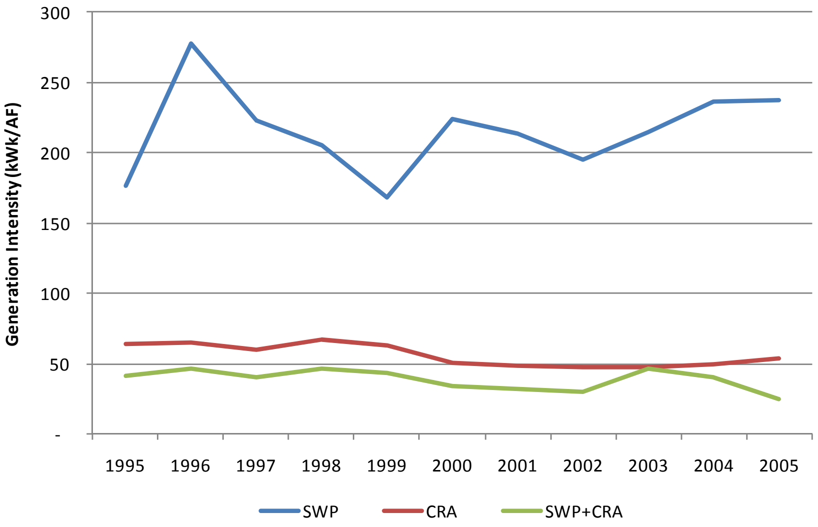


Table 75: Average Generation Intensity at MWD Facilities

Feed Water Source	Generation Intensity (kWh/AF)	Error Range
SWP	216	28%
CRA	56	28%
SWP+CRA	39	38%

C.5.5 Sources

MWD. *Profile, A summary of the delivery and distribution system, facilities and equipment.* November, 2008.

Jon Lambeck, Operations Planning Unit Manager – MWD. Personal communication. November 2009 – February 2010.

MWD Water and Energy Data received via communication with Jon Lambeck. March 2009 and November 2009.

C.6 San Francisco Public Utilities Commission

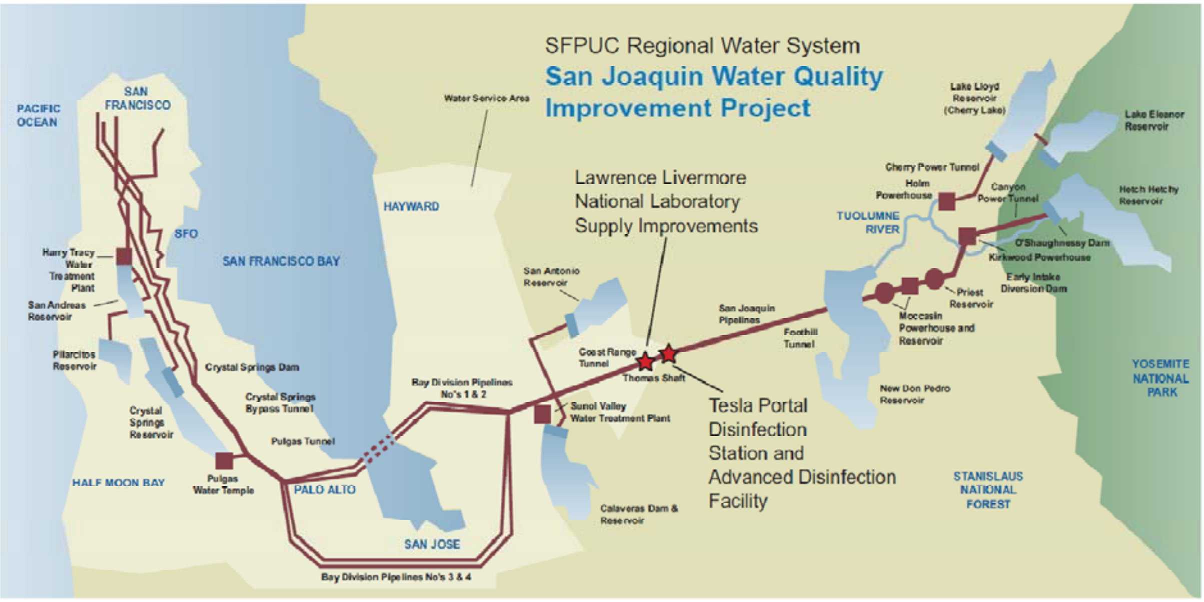
The SFPUC provides water to both retail and wholesale water customers. A population of over 2.5 million people within the counties of San Francisco, San Mateo, Santa Clara, Alameda and Tuolumne rely entirely or in part on the water supplied by the SFPUC. The SFPUC's retail water customers include the residents, business and industries located within the corporate boundaries of the City and County of San Francisco (City). In addition to these customers, retail water service is also provided to other customers located outside of the City, such as Treasure Island, the Town of Sunol, San Francisco International Airport, Lawrence Livermore Laboratory, Castlewood and Groveland Community Services District. The SFPUC sells water to 27 current wholesale water customers. The current population of San Francisco is estimated to be approximately 800,000. The population of San Francisco is projected to increase to 938,800 by the year 2030. This increase amounts to an annual growth rate of approximately 0.64% for the next 25 years. The population for the wholesale customers within the service area is expected to increase over the next thirty years increasing from 1,653,618 (2001) to 1,925,283 (2030).

Approximately 96 percent of San Francisco's demand is provided by the SFPUC Retail Water System (RWS), which is made up of a combination of runoff into local Bay Area reservoirs and diversions from the Tuolumne River through the Hetch Hetchy Water and Power Project (HHWP). The RWS supplies are distributed within San Francisco through SFPUC's in-City distribution system. A small portion of San Francisco's water demand is met through locally-produced groundwater and secondary-treated recycled water. The SFPUC currently serves an average of approximately 265 million gallons per day (mgd) to 2.5 million users in Tuolumne, Alameda, Santa Clara, San Mateo and San Francisco counties. In 2007-2008, the SFPUC wholesale customers collectively purchased two-thirds of their total water supply (approximately 195 million gallons per day) from the SFPUC regional water system. Their remaining demands were met through a combination of groundwater, recycled water, water conservation, and other sources of supplies such as the State Water Project and supplies delivered from Santa Clara Valley Water District.

The SFPUC water conveyance system consists of four primary arteries: San Joaquin Pipelines No. 1, 2 and 3, Bay Division Pipelines No. 1 and 2, Bay Division Pipelines No. 3 and 4, and the "Peninsula Pipelines". The San Joaquin Pipelines stretch from Hetch Hetchy Reservoir to the Sunol Valley, they are used to convey water and few deliveries are made off the pipeline. Bay Division Pipelines No. 1 and 2 stretch from the Irvington Tunnel in Fremont across the San Francisco Bay to Palo Alto; this water bypasses the South Bay. Bay Division Pipelines No. 3 and 4 traverse from Irvington Tunnel in Fremont to Palo Alto via San Jose; they are used to make deliveries to wholesale customers in the South Bay. The "Peninsula Pipelines" stretch from Palo Alto to San Francisco; deliveries to wholesale and several retail customers are made along the pipelines, which ultimately serves retail customers in the City. The SFPUC Regional Water System (RWS) consists of approximately 160 miles of pipelines and tunnels spanning from

Yosemite National Park to Crystal Springs Reservoir, crossing 2 hydrologic regions and 4 DEER climate zones.   Figure 117 illustrates the system.

Figure 117: San Francisco Public Utilities Commission Regional Water System



Source: SFPUC 2007

The SFPUC RWS is used to deliver water from Hetch Hetchy, Calaveras, San Antonio, and Peninsula reservoirs to its contractors and the City and County of San Francisco.

During WY 2000, a “normal” water year, the SFPUC delivered 306 TAF of water to customers. The total annual amount of energy needed to convey all water in the SFPUC RWS was 28 GWh. Of this energy, 26.7 % (7.5 GWh) was needed during summer months (June, July, August); the balance of energy consumption (73.3 %, 20.5 GWh) occurred during the other 9 months of the year.

During WY 2000, the SFPUC produced 449.5 GWh from water that is used for water deliveries, it exceeds the energy needed to support all SFPUC/Water Enterprise activities and the balance (421.5 GWh) supports the City and County of San Francisco’s Municipal load requirements or sold to Modesto Irrigation District, Turlock Irrigation District, and several other public utility or government customers. For the purposes of this study, none of the energy generation by the SFPUC is considered in-conduit hydropower.

Table 76 shows the total water delivered by the SFPUC in five water year types and the associated energy used for the conveyance of that water.

Table 76: Water Deliveries and Energy Use by the SFPUC

Water Year	Data Year	Water Delivered via SFPUC RWS (TAF)	Energy Used for Water Deliveries (GWh)
Wet	1998	253.8	24.7
Above Normal	2000	305.6	28.0
Below Normal	2004	294.8	29.9
Dry	2002	317.2	28.3
Critical	2001	309.5	28.0

In order to support scenario analyses, the Study Team needed to determine an appropriate method of approximating the amount of energy needed for water deliveries under a range of hydrologic conditions. For this purpose, the Study Team collected and analyzed historical monthly water deliveries and associated energy requirements for the period 1994-2005. The sources of these data for the SFPUC were: water and electric data sent to the Study Team by SFPUC Staff and communication with Alexis Dufour, P.E., Water Operations Analyst, SFPUC - Water Enterprise.

The SFPUC supplied water deliveries and energy consumption data to the Study Team. Energy consumption was mostly provided on an individual facility basis, however this could not be done for the water flow because of incomplete records over the study period. Instead, water deliveries made to three service areas (East and South Bay, Peninsula, and the City of San Francisco) were provided. Additional information from SFPUC indicated which facilities were associated with each service area. The Study team could only link the total energy consumption by a group of facilities within a service area to the water delivered in that service area. For this reason, energy intensity results vary dramatically within each service area.

The results of our findings and recommendations are documented below.

C.6.1 East of Pulgas Valve Lot Facilities

Table 77: East of Pulgas Valvel Lot Facilities Summary

Facility Name	East of Pulgas Valve Lot Facilities	**Facility ID**	1
Owner	SFPUC	**Facility Type**	Collection of Facilities
Hydrologic Region	San Francisco	**DEER Climate Zone**	4 and 12
Downstream From	Hetch Hetchy Reservoir, Calaveras Reservoir, San Antonio Reservoir		
Upstream From	Peninsula Facilities		
Points of Interconnection	**Other Wholesale Systems**	**Storage**	**Local Water Systems**
	SWP, SCVWD		SFPUC Wholesale Customers

C.6.1.1 Description

The East of Pulgas Valve Lot Facilities is a group of facilities located between Pulgas Valve Lot in the South Bay service area and Moccasin in the Sierra foothills, which includes: Moccasin to Alameda East Portal facilities, Sunol Valley Water Treatment Plant (SVWTP), San Antonio Pump Station (SAPS), Alameda West Portal to Pulgas valve lot, and SCVWD/SFPUC intertie facilities. The power usage at SVWTP and SAPS are measured at the same meter, thus energy data for these facilities are combined.

The South Bay area receives water from either Hetch Hetchy Reservoir or two local reservoirs, Calaveras and San Antonio. Most of the water that flows through the South Bay area is unfiltered water directly from Hetch Hetchy. A smaller amount of water is obtained from the two south bay reservoirs and this water must be treated at the SVWTP. SFPUC typically sets the San Joaquin Pipeline rate and adjusts supply to meet demand using the SVWTP and the HTWTP. The San Joaquin Pipelines has a maximum capacity to deliver approximately 290 MGD for from Hetch Hetchy.

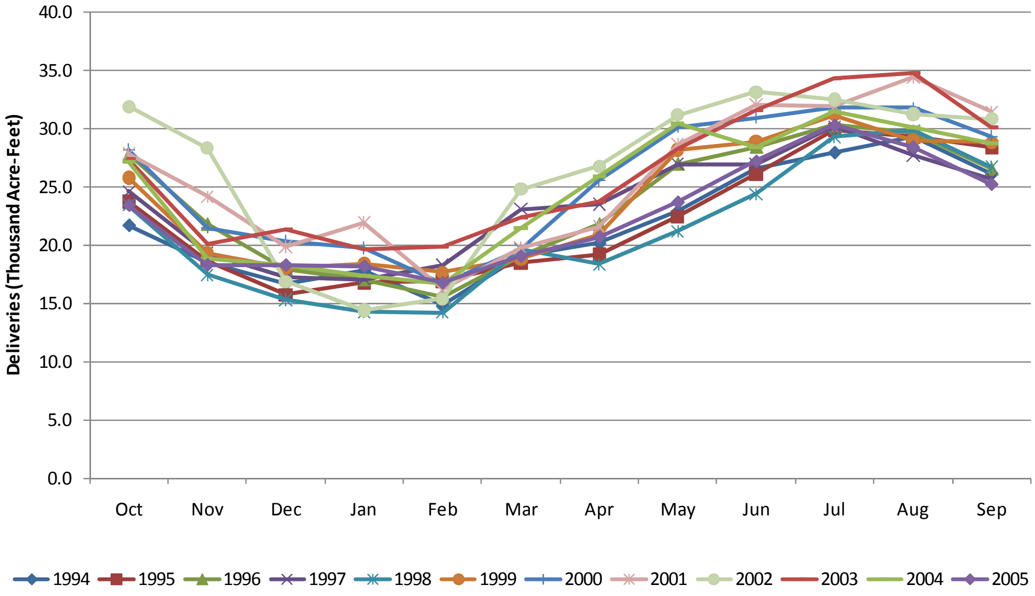
Calaveras and San Antonio reservoirs are located at an elevation above the SVWTP; water is fed to the plant via gravity flow. Additionally SVWTP is at an elevation above the San Joaquin Pipeline, treated water can be put into the pipeline without any need for pumping. Sometimes the SVWTP draws on the San Antonio Reservoir, this water flows by gravity to the SVWTP until reservoir level falls to 445 ft. Below that level, SAPS is used to pump water from San

Antonio to the SVWTP, however this did not happen very often over the study period. The pump station has a 160 MGD utilizing several engines driven and electric driven pumps.

C.6.1.2 Water Flow

Facilities East of Pulgas delivered between 253,800 and 317,200 AF/year during the data collection period. Deliveries are low during the months of December through February and high during the months of July through September, see Figure 118. Water deliveries include all water delivered to customers in the South Bay and a portion of the water destined for delivery in the Peninsula and City.

Figure 118: East and South Bay Deliveries

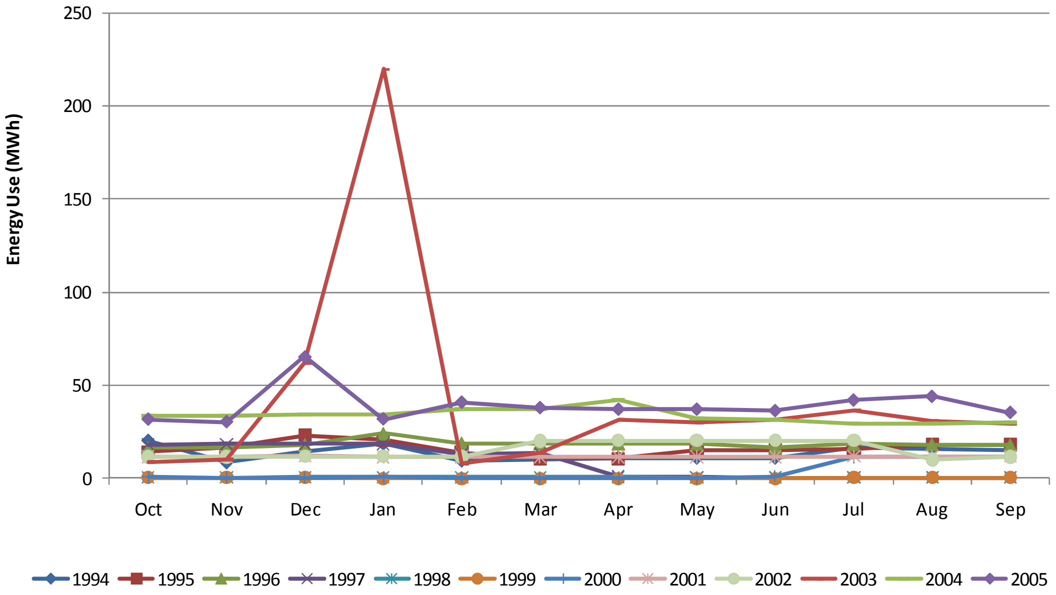


C.6.1.3 Energy Use

Annual Energy consumption by east of Pulgas Valve Lot Facilities ranged between 3.7 and 512.9 MWh/year during the data collection period, see Figure 5. The large variations in monthly and annual energy use are attributed to the intermittent operation of various facilities depending on available supply and demand needs.

As previously mentioned, the energy consumption for SVWTP and SAPS was provided to the Study Team combined into one dataset. As energy use for treatment is excluded from this study while energy use for conveyance is included, the Study Team needed to analyze the dataset in closer detail. Most of the time water flows from Calaveras and San Antonio reservoirs to SVWTP by gravity. This implies that most of the energy used in by the combined SVWTP and SAPS is used by the treatment plant (SVWTP). Based on the information provided, the Study Team excluded the combined energy use for SVWTP and SAPS from this study.

Figure 119: East of Pulgas Valve Lot Facilities Energy Use



C.6.1.4 Energy Intensity

The Study Team determined the average energy intensity of conveyance operations is 0.7 kWh/AF; scatter in the data reveals a spread around the average of 186%, see Table 4. While energy intensity varies significantly over time (Figure 6), its value is relatively low, almost zero. Variation is due to intermittent use of various facilities at different times during the data collection period. Variation in the energy intensity will cause little overall change in the total energy consumption attributed to conveyance by the entire SFPUC system. For the purposes of the model, the energy intensity of this group of facilities will be one constant number equal to the 12-year average of 0.7 kWh/AF.

Figure 120: East of Pulgas Valvel Lot Facilities Energy Intensity Plot

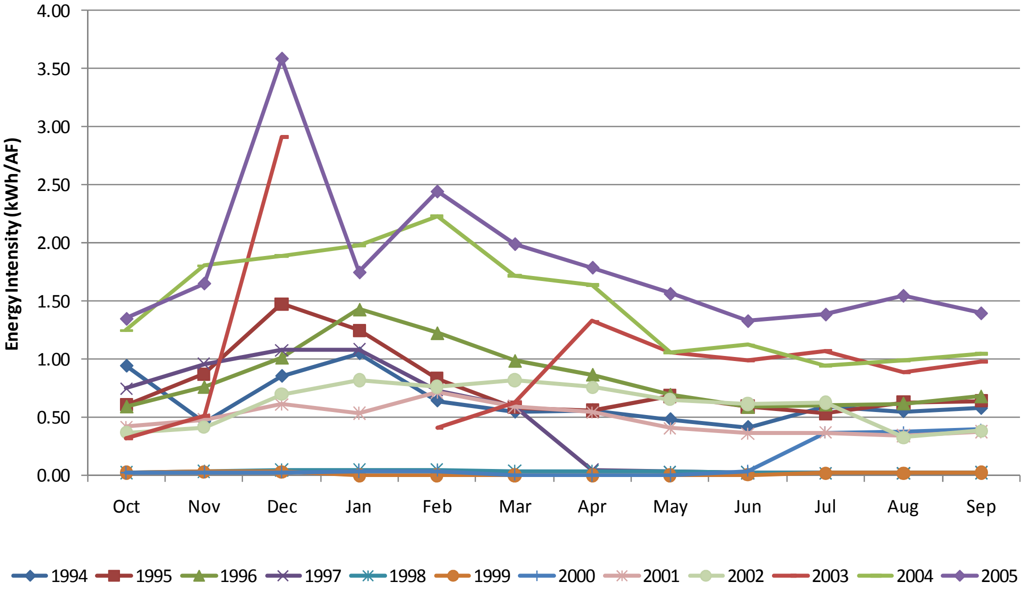


Table 78: East of Pulgas Valve Lot Facilities Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)[a]
0.7	186%	2.0	0.0

a) Truncated at 0, a negative values is not possible as it would imply power generation

C.6.2 Peninsula Facilities

Table 79: Peninsula Summary

Facility Name	Peninsula	**Facility ID**	1
Owner	SFPUC	**Facility Type**	Collection of Pump Stations and Valve Lots
Hydrologic Region	San Francisco	**DEER Climate Zone**	3
Downstream From	East of Pulgas Valve Lot Facilities		
Upstream From	City Facilities		
Points of Interconnection	**Other Wholesale Systems**	**Storage**	**Local Water Systems**
	None	Crystal Springs Reservoir, San Andreas Reservoir	SFPUC wholesale customers

C.6.2.1 Description

The Peninsula Facilities are a group of facilities located in the San Francisco Peninsula service area. The facilities located in this area include: Pulgas pump station, Pulgas Dechloramination facility, Polhemus to Millbrae Yard valve lots, Crystal Springs Pump Station, Harry Tracy Water Treatment Plant and Baden Pump Station.

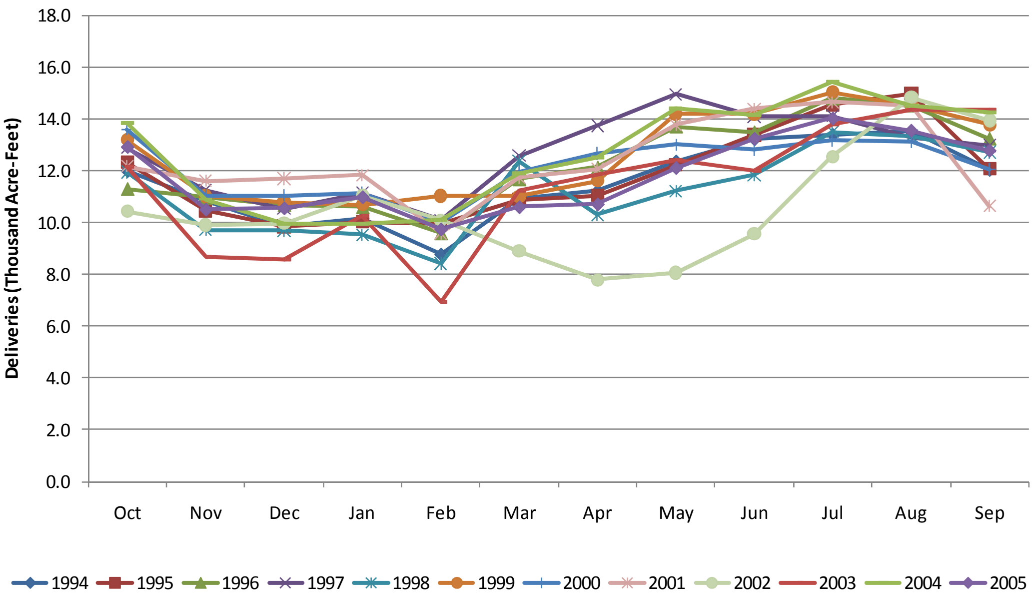
These facilities move water from three main sources: the South Bay (Hetch Hetchy water and SVWTP treated water), Crystal Springs Reservoir, and San Andreas Reservoirs. The Raker Act, which governs the ultimate use of Hetch Hetchy water, stipulates that SFPUC is to use as much of the local water (Calaveras, San Antonio, Crystal Springs and San Andreas) that is practical for delivery to the ultimate customer. If water from Crystal Springs is used as supply for San Francisco, it must first be pumped to the higher elevation San Andreas Reservoir. Crystal Springs pump station is used to transfer water out of Crystal springs reservoir. Baden pump station and Lake Merced Pump station both pump treated water to transport it from HTWTP to San Francisco’s water distribution system.

Depending on the availability and use of local water, availability of Hetch Hetchy Water, and overall system demands, the Peninsula Facilities can be operated in a variety of ways that greatly changes the energy used for the water conveyance in this region.

C.6.2.2 Water Flow

Peninsula Facilities delivered between 127,200 and 152,000 AF/year during the data collection period. Deliveries are low during the months of November through February and high during the months of July and August, see Figure 121. Water deliveries include all water delivered to customers in the Peninsula and all water destined to be delivered to the City.

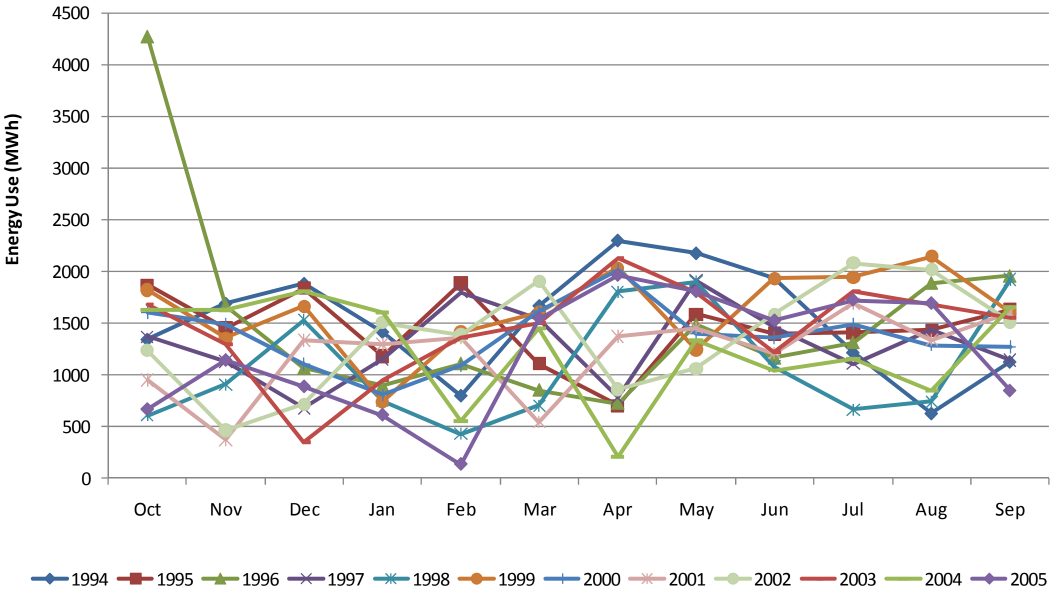
Figure 121: Peninsula Facilities Deliveries



C.6.2.3 Energy Use

The Peninsula Facilities annual energy consumption ranged between 13,067 and 19,517 MWh/year during the data collection period, see Figure 122. Variation is due to intermittent use of various facilities at different times during the data collection period. Water is conveyed to and from different reservoirs at different times of the year. Additionally year to year supply availability requires the system to be operated differently. The ultimate combination of different operating conditions at different times during the data collection period causes significant scatter in energy use.

Figure 122: Peninsula Facilities Energy Use



C.6.2.4 Energy Intensity

The Study Team determined the energy intensity of conveyance operations is 113.9 kWh/AF; scatter in the data reveals a spread of 71 % around the average, see Table 80. The value of energy varies over time, as seen in Figure 123. Variation is due to intermittent use of various facilities required by operations. For the purposes of the model, the energy intensity of this group of facilities will be one constant number equal to the 12-year average of 113.9 kWh/AF.

Figure 123: Peninsula Facilities Energy Intensity Plot

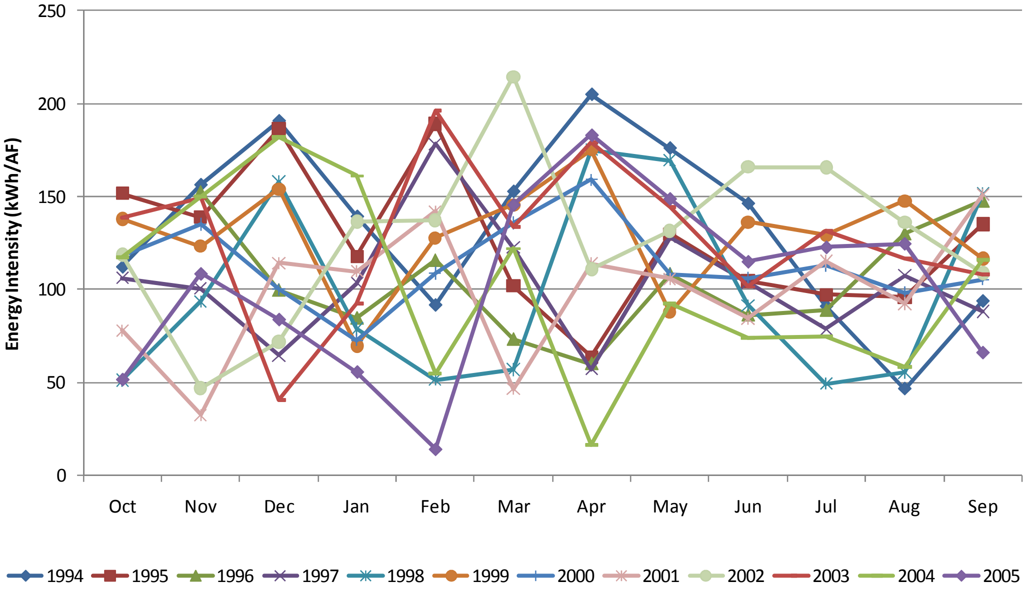


Table 80: Peninsula Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
113.9	+/- 71%	194.8	33.0

C.6.3 City Facilities

Table 81: City Facilities Summary

Facility Name	City Facilities	**Facility ID**	1
Owner	SFPUC	**Facility Type**	Collection of Pump Stations
Hydrologic Region	San Francisco	**DEER Climate Zone**	3
Downstream From	Peninsula Facilities		
Upstream From	San Francisco Retail Customers		
Points of Interconnection	**Other Wholesale Systems**	**Storage**	**Local Water Systems**
	None	None	None

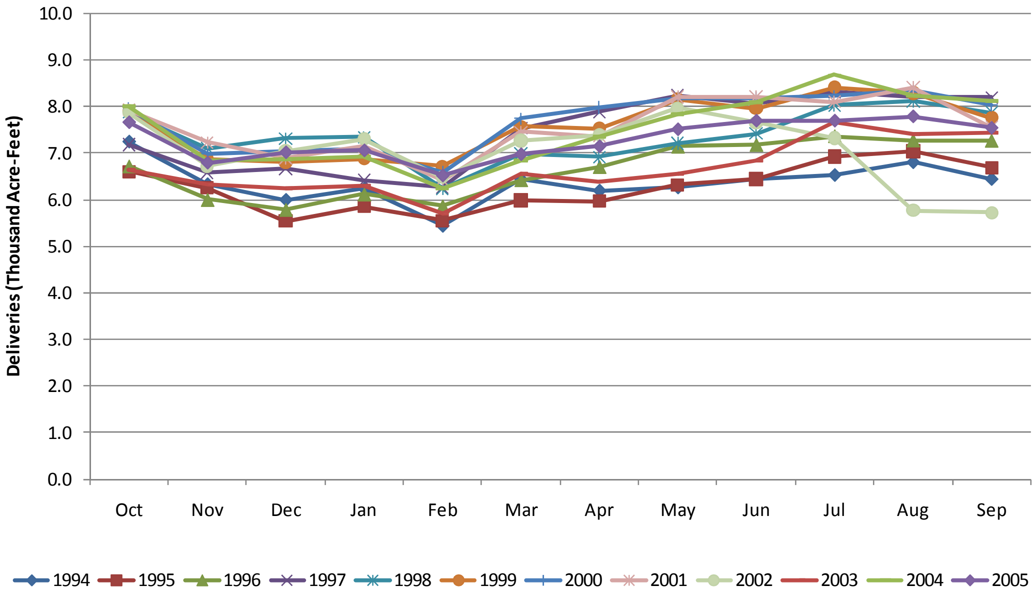
C.6.3.1 Description

The City Facilities include the Lake Merced pump station. Lake Merced Pump station pumps treated water to transport it to San Francisco's water distribution system. Water from Hetch Hetchy and the SVWTP can flow directly to the City bypassing HTWTP.

C.6.3.2 Water Flow

The City Facilities delivered between 75,200 to 92,400 AF/year of water during the data collection period. Deliveries are slightly lower during November through February than other months of the year, see Figure 124. Water deliveries include all water delivered to San Francisco's water distribution network including water produced at HTWTP, water from Hetch Hetchy, and water from SVWTP.

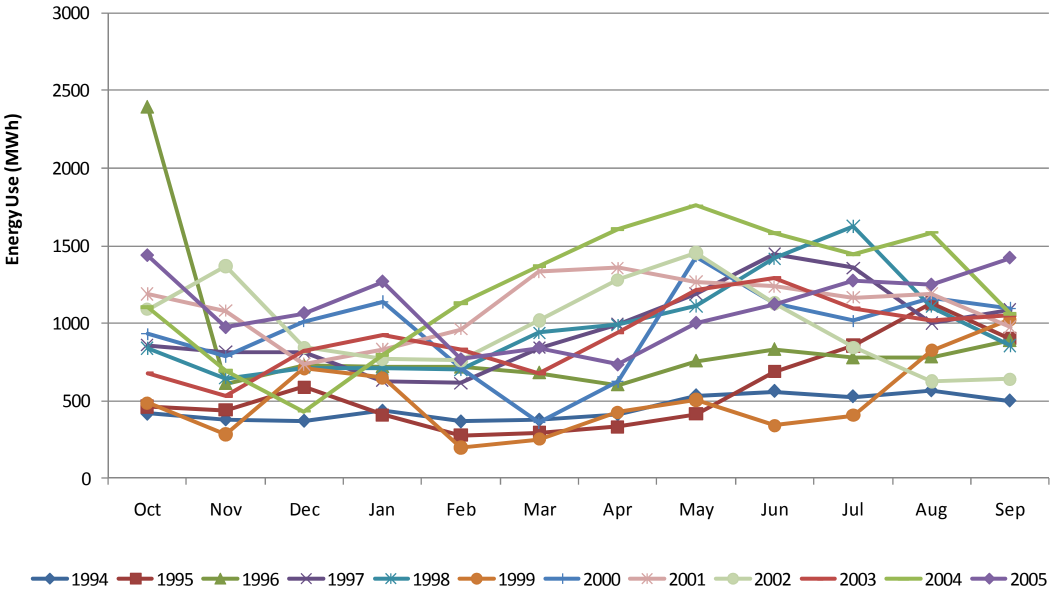
Figure 124: City Facilities Deliveries



C.6.3.3 Energy Use

The City Facilities' annual energy consumption ranged between 5,461 and 14,569 MWh/year during the data collection period. The large variations in monthly and annual energy use are attributed to the intermittent operation of various facilities depending on available supply and the needs of demand, see Figure 125.

Figure 125: City Facilities Energy Use



C.6.3.4 Energy Intensity

The Study Team determined the energy intensity of operations at the City Facilities is 121.2 kWh/AF; scatter in the data reveals a spread of 69% around the average, see Table 82. The value of energy varies over time, see Figure 126. Variation is due to intermittent use of various facilities and supply sources required by operations. If water for the City is primarily supplied by Hetch Hetchy, energy use is relatively low. However, if water is supplied by local reservoirs, energy use increases due to additional conveyance requirements. For the purposes of the model, the energy intensity of this group of facilities will be one constant number equal to the 12-year average of 121.2 kWh/AF.

Figure 126: City Facilities Energy Intensity Plot

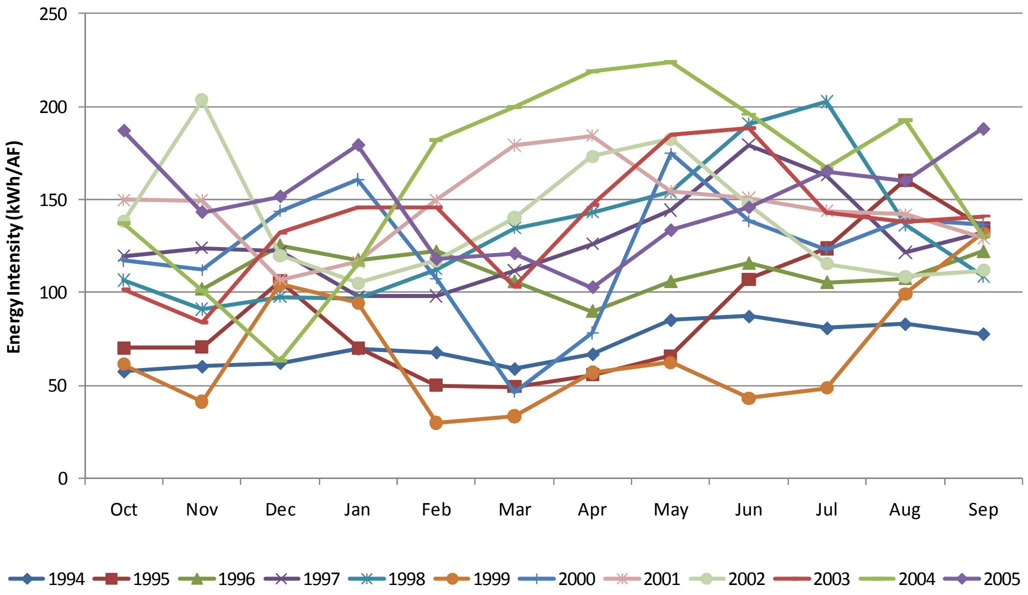


Table 82: City Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
121.2	+/- 69%	205.3	37.2

C.6.4 Sources

San Francisco Public Utilities Commission “Fact Sheet San Joaquin Regional Water Quality Improvement Project” May 2007. <http://sfwater.org/Files/ProjectStatus/sanj_joaq_WQ_FS_0507.pdf>

Bay Area Water Supply & Conservation Agency “Annual Survey FY 2007-08” January, 2009. <http://bawsca.org/docs/BAWSCA_Survey_FY07_08_2.pdf>

Alexis Dufour,. P.E., Water Operations Analyst, SFPUC - Water Enterprise. Personal Communication. February 4th, 2010.

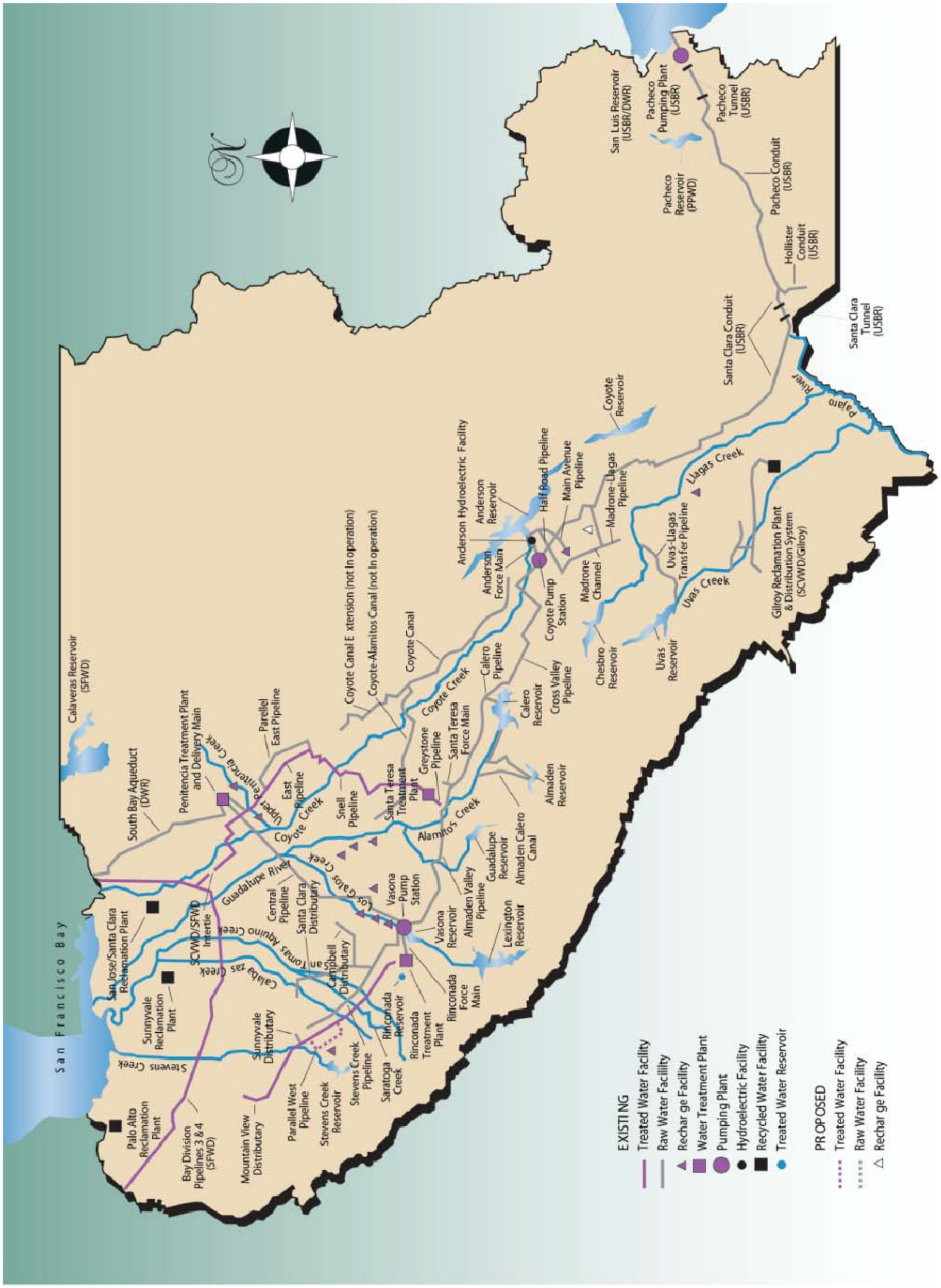
C.7 Santa Clara Valley WD

The Santa Clara Valley Water District is the primary water resources agency for Santa Clara County, California. As the county's water wholesaler, the water district makes sure there is enough clean, safe water for homes and businesses. The Santa Clara Valley Water District manages Santa Clara County's drinking water resources, coordinates flood protection for its 1.7 million residents, and serves as steward of the county's more than 800 miles of streams and 10 district-built reservoirs. The District has a diverse mix of water supplies and a strong commitment to water use efficiency. The District's water supply system is a complex interdependent system comprised of storage, conveyance, treatment, and distribution facilities that include water treatment plants, local reservoirs, the groundwater sub-basins, imported water supply facilities, and raw and treated water conveyance facilities.

In 2000, the population in the county was 1,682,585 with a projection of 2,267,100 by the year 2030. Overall, countywide water demand is projected to increase by about 70,000 acre-feet (af) or 18 percent over the next 25 years, even with increases in new water conservation efforts. Demand in 2030 is projected at approximately 450,000 AF. The District manages and operates a complex and integrated water supply infrastructure, including storage, transmission, treatment, and recycled water facilities, to provide a reliable supply of water. These facilities include 10 surface reservoirs, 393 acres of recharge ponds, 76 miles of in-stream recharge, 142 miles of pipelines, 3 pump stations, 3 treatment plants, and 1 recycled water treatment plant and distribution system.

The SCVWD consists of 4 primary arteries that transport raw imported water: the Pacheco Conduit, Santa Clara Conduit, Cross Valley Pipeline, and the Central Pipeline (see Figure 127). The Pacheco Conduit stretches from Pacheco Pumping Plant near San Luis Reservoir to the bifrication into the Santa Clara and Hollister Conduits, it is used to import water from CVP. The Santa Clara Conduit continues to Coyote Pump Station near the base of Anderson Reservoir, continuing to transport CVP water. The Cross Valley Pipeline links Coyote Pump Station to Vasona Pump Station and transports both CVP water and water released from Anderson Reservoir. The Central Pipeline links Vasona Pump Station and the SWP-import location near Penitencia Water Treatment Plant. This pipeline transports SWP, CVP, and local water in either direction depending on supply available and demand requirements. The SCVWD's service territory and conveyance systems cover the majority of Santa Clara County crossing 3 hydrologic regions within one DEER climate zone.

Figure 127: Santa Clara Valley Water District



Source: SCVWD 2005

The SCVWD is used for the following primary purposes:

1. Import water from CVP, SWP, and SFPUC to its contractors
2. Provide flood protection
3. Manage streams, creeks, underground aquifers, and district-built reservoirs.

During WY 2000, a "normal" water year, the SCVWD delivered 235 TAF of water to contractors (from all sources; CVP, SWP, and SFPUC). The majority of energy consumption required by SCVWD's conveyance system is used to transport imported water from CVP. The annual amount of energy needed to convey import and convey CVP water in SCVWD was 28.2 GWh. All energy use associated with the conveyance of water are attributed to Pacheco and Coyote pumping plants. Table 83 summarizes imports and energy use in other water year types.

SCVWD purchases power to operate its CVP import pump stations. It does not use any power generated power though in-conduit hydropower or other means of self generation for CVP imports. The majority of energy used for these pump stations is obtained from CVP via WAPA, however some energy is purchased from PG&E.

Table 83: Water Deliveries and Energy Use by the SCVWD

Water Year	Data Year	CVP Imports to SCVWD (TAF)	SWP Imports to SCVWD (TAF)	SFPUC Imports to SCVWD (TAF)	Energy Used for CVP Imports (GWh)
Wet	1998	66	45	43	27.3
Above Normal	2000	89	84	62	28.2
Below Normal	2004	135	63	61	26.1
Dry	2002	127	60	59	34.7
Critical	2001	141	55	63	21.2

In order to support scenario analyses, the Study Team needed to determine an appropriate method of approximating the amount of energy needed to deliver contract water under a range of hydrologic conditions. For this purpose, the Study Team collected and analyzed historical monthly water deliveries and associated energy requirements for the period 1994-2005. The sources of these data for the SCVWD were: water flow data from SCVWD staff, SCVWD's

Watt's to Water Report, interviews with SCVWD staff, and SCWVD's 2005 Urban Water Management Plan.

The results of our findings and recommendations are documented below.

C.7.1 Pacheco Pumping Plant

Table 84: Pacheco Summary

<table>
<tr><td>Facility Name</td><td colspan="15">Pacheco Pumping Plant</td><td colspan="5">Facility ID</td><td colspan="10">1</td></tr>
<tr><td>Owner</td><td colspan="15">Central Valley Project</td><td colspan="5">Facility Type</td><td colspan="10">Pumping Plant</td></tr>
<tr><td>Hydrologic Region</td><td colspan="15">San Joaquin</td><td colspan="5">DEER Climate Zone</td><td colspan="10">4</td></tr>
<tr><td>Downstream From</td><td colspan="30">San Luis Reservoir</td></tr>
<tr><td>Upstream From</td><td colspan="30">Coyote Pumping Plant</td></tr>
<tr><td rowspan="2">Points of Interconnection</td><td colspan="10">Other Wholesale Systems</td><td colspan="10">Storage</td><td colspan="10">Local Water Systems</td></tr>
<tr><td colspan="10">CVP</td><td colspan="10"></td><td colspan="10">San Benito County Water District</td></tr>
<tr><td rowspan="2">Facility Configuration</td><td colspan="6">Number of Pumps</td><td colspan="6">Power (HP)</td><td colspan="6">Speed (RPM)</td><td colspan="6">Maximum Flow (CFS)</td><td colspan="6">Static Head (ft)</td></tr>
<tr><td colspan="6">12</td><td colspan="6">2000</td><td colspan="6">N/A</td><td colspan="6">55.9[a]</td><td colspan="6">309</td></tr>
<tr><td>Maximum Plant Capacity</td><td colspan="30">670 CFS (limited to 480 CFS)</td></tr>
<tr><td>Date of Last Major Retrofit</td><td colspan="15">2007 - Present</td><td colspan="5">Description of Last Major Retrofit</td><td colspan="10">Refurbishing all pumps (approximately two each year)</td></tr>
</table>

a) Variable speed motors, represents maximum speed and flow.

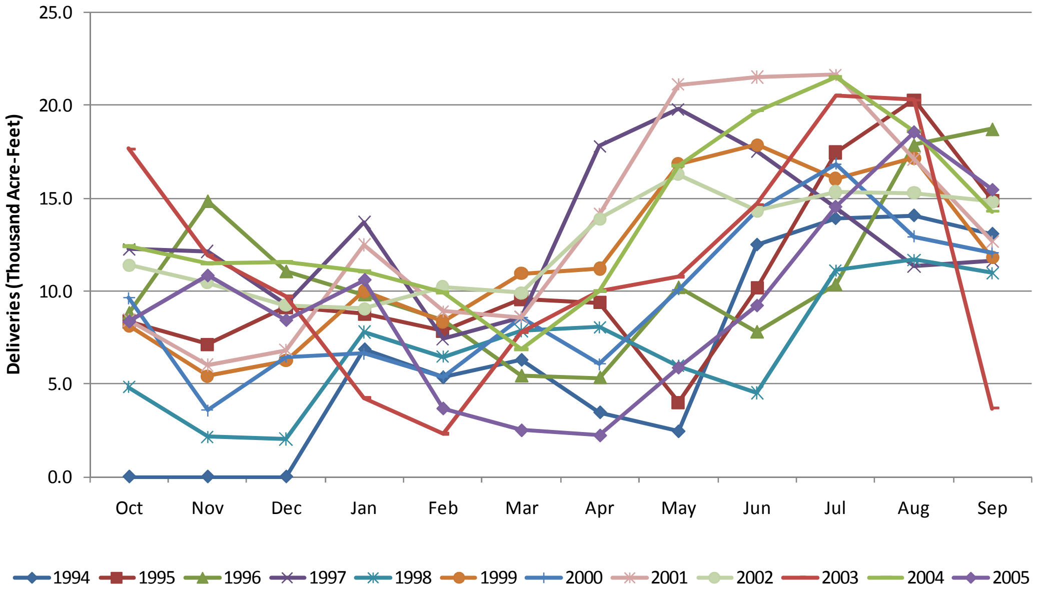
C.7.1.1 Description

Pacheco Pumping Plant lifts water from the lower Pacheco Tunnel to the upper tunnel. The plant contains twelve pumping units, with a combined capacity of 670 CFS though limited to 480 CFS by the Pacheco tunnel. The plant pumps water to a static head 309 feet. The plant is owned by USBR but operated and maintained by SCVWD and shared by both SCVWD and San Benito County Water District (SBCWD). The approximate share of the total water through this facility is: SCVWD (78%), SBCWD (22%). The facility is fully powered by energy obtained from CVP via WAPA. SCVWD is currently refurbishing all pumps in the facility and recently approved a $12 million program to update all motors with a variable frequency drive.

C.7.1.2 Water Flow

Pacheco Pumping Plant pumped between 88,900 and 141,400 AF/year during the data collection period. This represents the water volume pumped for use by SCVWD and does not included SBCWD water. Pumping is low during the months of February and March and high during the months of July and August, see Figure .

Figure 128: Pacheco Deliveries



C.7.1.3 Energy Intensity

Detailed energy data was not available from SCVWD to calculate energy intensity; however SCVWD did provide the study team with their estimate of the energy intensity at this facility. SCVWD estimates the energy intensity of pumping operations at Pacheco is 236.0 kWh/AF. Energy intensity was reported as a single number; the error range for this plant cannot be determined, see Table 4. For the purposes of the model, the energy intensity of this facility will be one constant number.

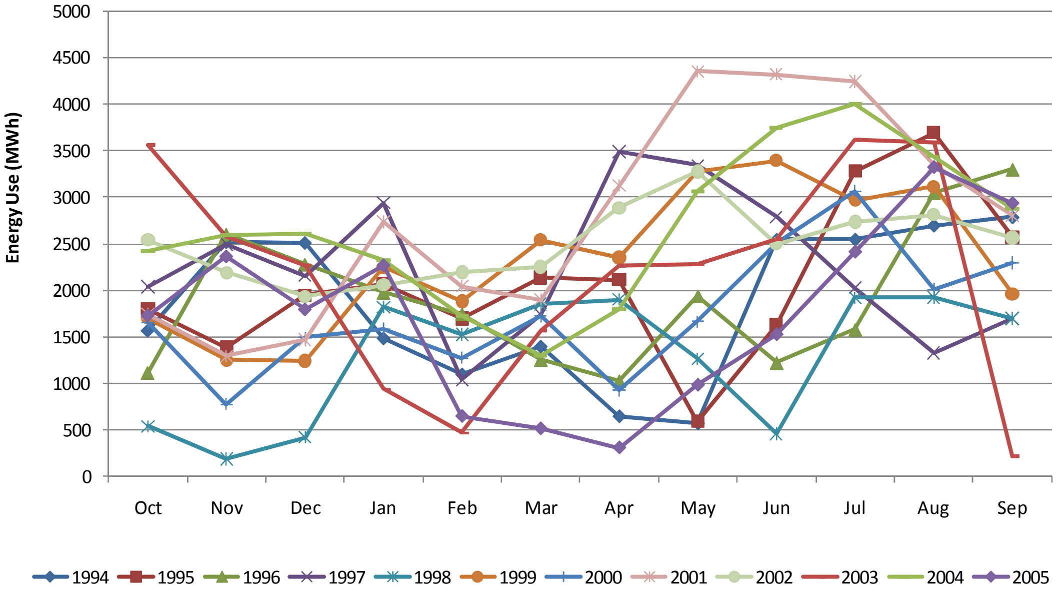
Table 85: Pacheco Energy Intensity

Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
236.0	0%	236.0	236.0

C.7.1.4 Estimated Energy Use

As energy data was not available for this facility, the Study Team estimated energy consumption by multiplying flow by energy intensity. Pacheco Pumping Plant's estimated annual energy consumption ranged between 15,529 and 33,364 MWh/year during the data collection period. This represents the energy consumed to move SCVWD water only. See Figure 129 for more details.

Figure 129: Pacheco Estimated Energy Use



C.7.2 Coyote Pumping Plant

Table 86: Coyote Summary

Facility Name	Coyote Pumping Plant		**Facility ID**	1	
Owner	Central Valley Project		**Facility Type**	Pumping Plant	
Hydrologic Region	San Francisco		**DEER Climate Zone**	4	
Downstream From	Pacheco Pumping Plant, Anderson Reservoir				
Upstream From	Cross Valley Pipeline				
Points of Interconnection	**Other Wholesale Systems**		**Storage**		**Local Water Systems**
			Anderson Reservoir		
Facility Configuration	**Number of Pumps**	**Power (HP)**	**Speed (RPM)**	**Maximum Flow (CFS)**	**Rated Static Head (ft)**
	6	2000	N/A	57	230
Maximum Plant Capacity	342 CFS				
Date of Last Major Retrofit			**Description of Last Major Retrofit**		

C.7.2.1 Description

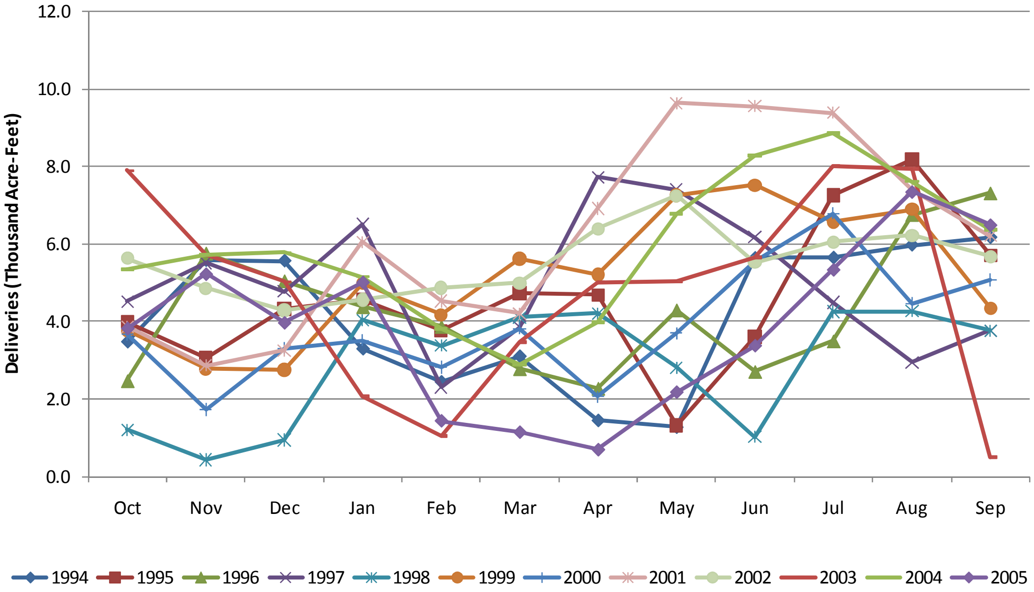
Coyote Pumping Plant operates as a booster pump the majority of the time. It can pumps CVP water from the he Santa Clara Conduit into the Cross Valley Canal, pump CVP water into Anderson Reservoir for storage, or pump water released from Anderson Reservoir into the Cross Valley Canal. The majority of the time Coyote pump station acts to boost pressure of CVP water or Anderson Reservoir releases, it’s not used very often to pump water into Anderson Reservoir.

The plant contains 6 pumping units with a combined maximum capacity of 342 CFS. The plant is rated to pump water to a static head of 230 feet.

C.7.2.2 Estimated Water Flow

Detailed water flow data was not available from SCVWD; instead the Study Team estimated the total flow. This estimate was obtained by using the monthly flow through Pacheco Pumping Plant (upstream) and an estimate of the percent of this water that is taken out of the Santa Clara Conduit before arriving at Coyote Pump Station. SCVWD's UWMP reveals in 2004, 48% of water pumped by Pacheco Pumping Plant is delivered prior to reaching Coyote Pumping Plant. The remaining 52% pass through Coyote Pumping plant. Using this value, the Study Team estimates Coyote Pumping Plant pumped between 34,400 and 73,800 AF/year during the data collection period. Pumping is low during the months of February and March and high during the months of July and August, see Figure 130.

Figure 130: Coyote Estimated Deliveries



C.7.2.3 Energy Intensity

Detailed energy data was not available from SCVWD to calculate energy intensity; however SCVWD did provide the study team with their estimate of the energy intensity at this facility. SCVWD estimates the energy intensity of pumping operations at Coyote is 4.0 kWh/AF. Energy intensity was reported as a single number; the error range for this plant cannot be determined, see Table 87. For the purposes of the model, the energy intensity of this facility will be one constant number.

Table 87: Coyote Energy Intensity

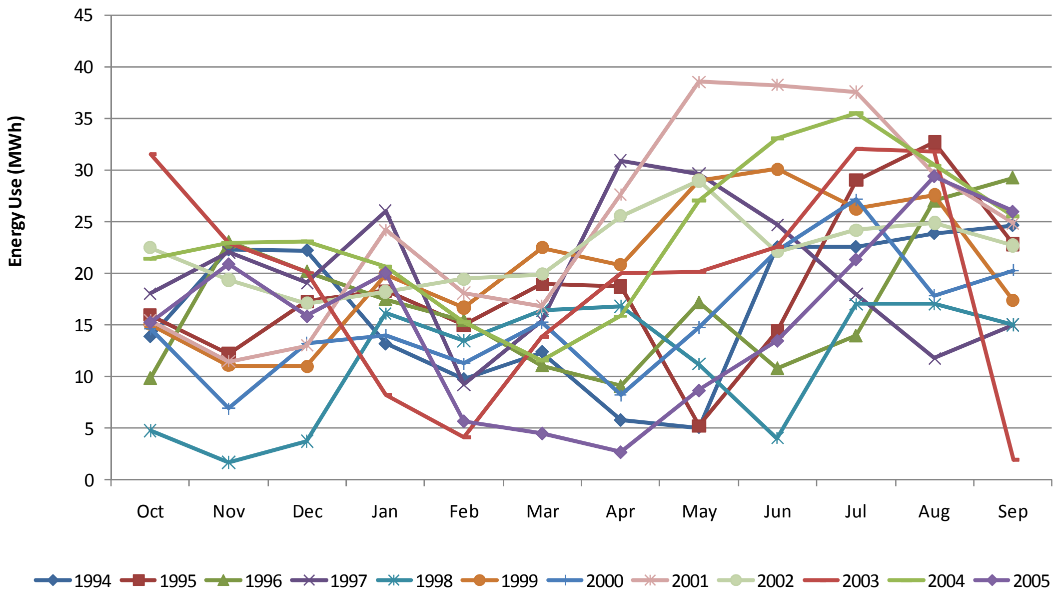
Average EI (kWh/AF)	Range	Upper Bound (kWh/AF)	Lower Bound (kWh/AF)
4.0	0%	4.0	4.0

C.7.2.4 Estimated Energy Use

As energy data was not available for this facility, the Study Team estimated energy consumption by multiplying flow by energy intensity. Coyote Pumping Plant's estimated annual energy consumption ranged between 137 and 295 MWh/year during the data collection period. See Figure 5 for details.

When moving CVP water, Coyote's pumps are powered by energy obtained from CVP via WAPA. This energy is provided to SCVWD when it purchases CVP water and its cost is bundled with the cost of water. When moving water that originates from Anderson Reservoir, Coyote's pumps are powered by energy purchased from PG&E. Staff indicates the majority of water moved by Coyote originates from CVP and that PG&E purchased electricity typically accounts for less than 15% of Coyote's annual energy consumption.

Figure 131: Coyote Estimated Energy Use



C.7.3 Sources

SCVWD. 2005 Urban Water Management Plan. 2005

SCVWD. *From Watts to Water Climate Change Response through Saving Water, Saving Energy, and Reducing Air Pollution*. June 2007

SCVWD Staff. Jeannine Larabee, Water Use Efficiency Unit; Arvind D. Tailor, P.E., Utility Electrical & Control Systems Engineering. Personal communication. January 2010.

SCVWD Water and Energy Data received via communication with SCVWD

C.8 Los Angeles Department of Water and Power

The Los Angeles Department of Water and Power (LADWP), a department of the City of Los Angeles, is responsible for potable water service to the second largest city in the nation with an area of 464 square miles and a population of four million. The City relies on four primary sources of water: imported water from the Los Angeles Aqueduct (LAA), the State Water Project (SWP), the Colorado River Aqueduct (CRA), and local groundwater. Recycled water has played a relatively small role in the overall water supply, meeting only 1% of its total water demand today. The original LAA was constructed between 1908 and 1913 to provide the City of Los Angeles with a larger and more reliable supply of water, it had a capacity of 485 CFS. The second LAA was completed in 1970 to expand the aqueduct to its current capacity of 775 CFS.

The Los Angeles Department of Water and Power (LADWP) procures, treats, and delivers potable water to end-users in the City. The City's primary sources of potable water are the Metropolitan Water District of Southern California (MWD, primarily delivering imported water from the State Water Project and Colorado River Aqueduct), the Los Angeles Aqueduct (water deliveries from the eastern Sierra Nevada Mountains), and groundwater. LADWP's first preference is the high quality, gravity-conveyed water from the L.A. Aqueduct. Local groundwater, while relatively inexpensive, is LADWP's second preference, due to contamination and clean-up issues. Costlier imported water purchased from MWD fills the remainder of LADWP's demand. Recycled water use is increasing in the City, offsetting imported potable water needs (much of which is often used for non-potable purposes). The relative importance of each of LADWP's supplies varies on an annual basis. For example, in years of heavy snow pack, water deliveries from the Los Angeles Aqueduct are higher (ranging up to 400,000 AF), resulting in less imported water from the MWD. Conversely, in dry years, deliveries from the L.A. Aqueduct may be as little as 75,000 AF, and imports from the MWD and groundwater pumping increase to make up for supply shortfalls. On average, from 1995 to 2004, the L.A. Aqueduct supplied approximately half of the City's water needs, with the MWD and groundwater supplies providing the remainder at 35% and 15%, respectively.

The Study Team is focusing on LADWP's Los Angeles Aqueduct for this Study. The Los Angeles Aqueduct stretches from Lake Mono in Mono County to the Los Angeles Reservoir northwest of the City of Los Angeles, see Figure 132. The aqueduct consists of approximately 223 miles of canals and pipelines (including 53 miles of tunnels) crossing two hydrologic regions and two DEER climate zones.

Figure 132: Los Angeles Aqueduct Diagram

Source: Los Angeles Aqueduct Daily Report

During WY 2000, a “normal” water year, the LADWP delivered 306 TAF of water to contractors. No energy is required to make these deliveries as the entire aqueduct is gravity fed.

LADWP operates several hydroelectric generation facilities powered by water flow from the aqueduct. For the purposes of this study, these power plants are not considered in-conduit generation facilities and are excluded from analysis. Water deliveries in other year types can be seen in Table 88.

Table 88: Water Deliveries and via the Los Angeles Aqueduct

Water Year	Data Year	Water Delivered via LADWP (TAF)
Wet	1998	401
Above Normal	2000	272
Below Normal	2004	212
Dry	2002	195
Critical	2001	258

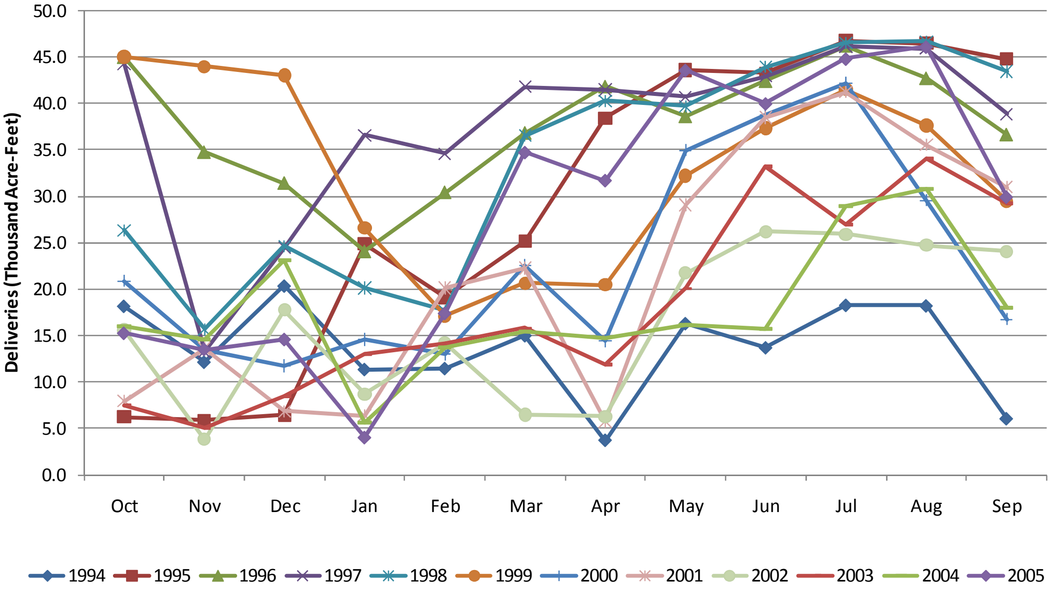
For this study only the imports via the Los Angeles Aqueduct will be analyzed. For this purpose, the Study Team collected and analyzed historical monthly water deliveries for the period 1994-2005. As the aqueducts is entirely gravity fed no energy data was collected. The sources of these data for the LADWP were: Richard Harasick, Assistant Director of Water Operations, LADWP.

The results of our findings and recommendations are documented below.

C.8.1.1 Water Flow

LADWP delivered between 164,600 and 451,100 AF/year during the data collection period. Deliveries are generally lower during the months of November through February and high during the months of July through August, see Figure 133. Deliveries are subject to supply availability.

Figure 133: LADWP Deliveries



C.8.2 Sources

Los Angeles Department of Water and Power "Los Angeles Aqueduct Daily Report". February 1, 2010 <http://wsoweb.ladwp.com/Aqueduct/operations/index.htm>

Richard Harasick, Assistant Director of Water Operations – LADWP. Personal communication. September 15, 2009

SDCWA Water and Energy Data received via communication with Richard Harasick. October 16, 2009

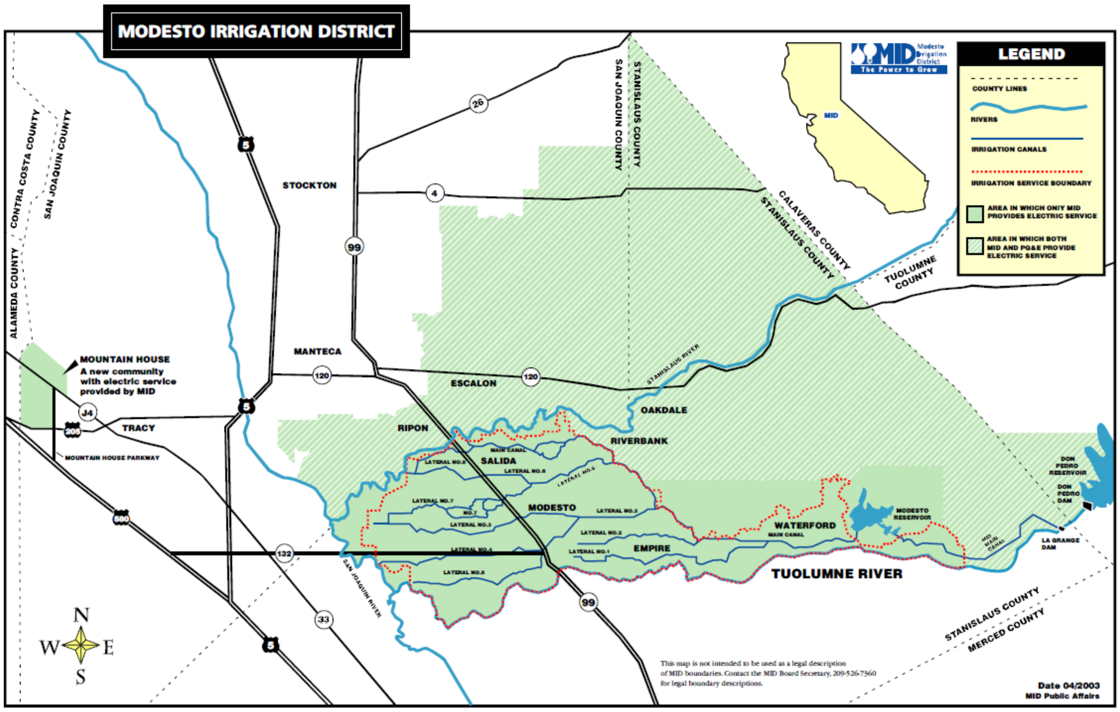
C.9 Modesto Irrigation District

Modesto Irrigation District (MID) was formed in 1887, shortly after the Wright Act of 1887, which allowed for the creation of irrigation districts in California. MID was formed for the purpose of expanding the agricultural base of the area. Today MID provides irrigation water to 60,000 acres of farmland in Stanislaus County. MID's supplies include surface water and local groundwater. MID operates the Modesto Regional Water Treatment Plant and sells treated water to the City of Modesto.

Don Pedro Reservoir serves as MID's primary water storage facility and supply. In 1893, MID and Turlock Irrigation District built La Grange Dam along the Tuolumne River to serve as the original water supply for both districts. Canals were completed in 1903 and the first official MID irrigation season opened in 1904. MID continues to divert water to the north of the dam and TID to the south. Modesto and Turlock irrigation districts constructed the original Don Pedro Reservoir in 1923 to enhance supply. It was replaced by the completion of New Don Pedro Reservoir and Dam in 1971. MID currently owns 31.5% of the Don Pedro Project, while TID owns the remainder. New Don Pedro is the sixth largest freshwater multi-use reservoir in California.

The MID consists of 208 miles of canals within one hydrologic region and DEER climate zone. Figure 134 illustrates the canals and facilities owned and operated by MID.

Figure 134: Modesto Irrigation District Facility Diagram



Source: "Modesto Irrigation District"

During WY 2000, a “normal” water year, the MID delivered 327 TAF of surface water to clients and contractors. See Table 89 for water deliveries in other water year types. No energy was used for MID’s surface water deliveries from New Don Pedro Reservoir, the system is entirely gravity fed. MID does operate a hyrdo-electric generation facility to generate power at the reservoir; however, the Study Team does not consider this to be in-conduit generation and will exclude it from this study.

Table 89: Surface Water Deliveries by MID

Water Year	Data Year	Water Delivered via MID (TAF)
Wet	1998	248
Above Normal	2000	327
Below Normal	2004	313
Dry	2002	330
Critical	2001	318

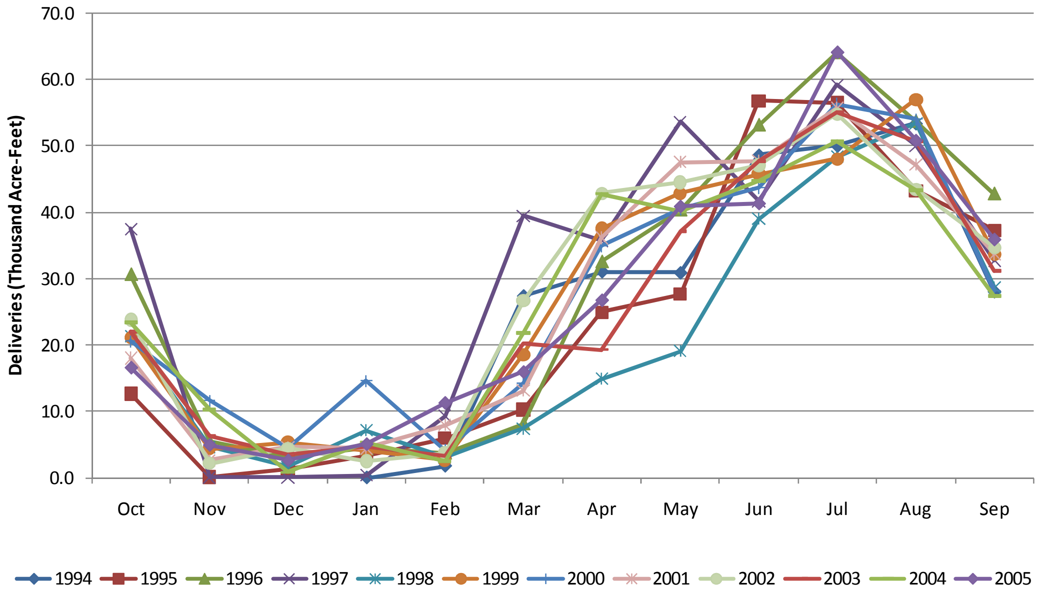
For this study only the deliveries from MID surface water will be analyzed, groundwater will not be included. The Study Team collected and analyzed historical monthly water deliveries for the period 1994-2005. The sources of these data for the MID were: Dave Bakker, Civil Engineer – MID.

The results of our findings and recommendations are documented below.

C.9.1.1 Water Flow

MID delivered between 248,700 and 359,600 AF/year of surface water during the data collection period. Deliveries are low during the months of November through February and high during the months of June through August, see Figure 135

Figure 135: MID Deliveries



C.9.2 Sources

Modesto Irrigation District Water and Power “Modesto Irrigation District”. February 1, 2010, <http://www.mid.org/mid-map.pdf>

Barnes, Dwight H. The Greening of Paradise Valley. February 1, 2010, < http://www.mid.org/about/100-years/default.htm>

Dave Bakker, Civil Engineer – MID. Personal communication. June 9, 2009

MID Water Data received via communication with Dave Bakker. June 12, 2009

C.10 San Diego County Water Authority

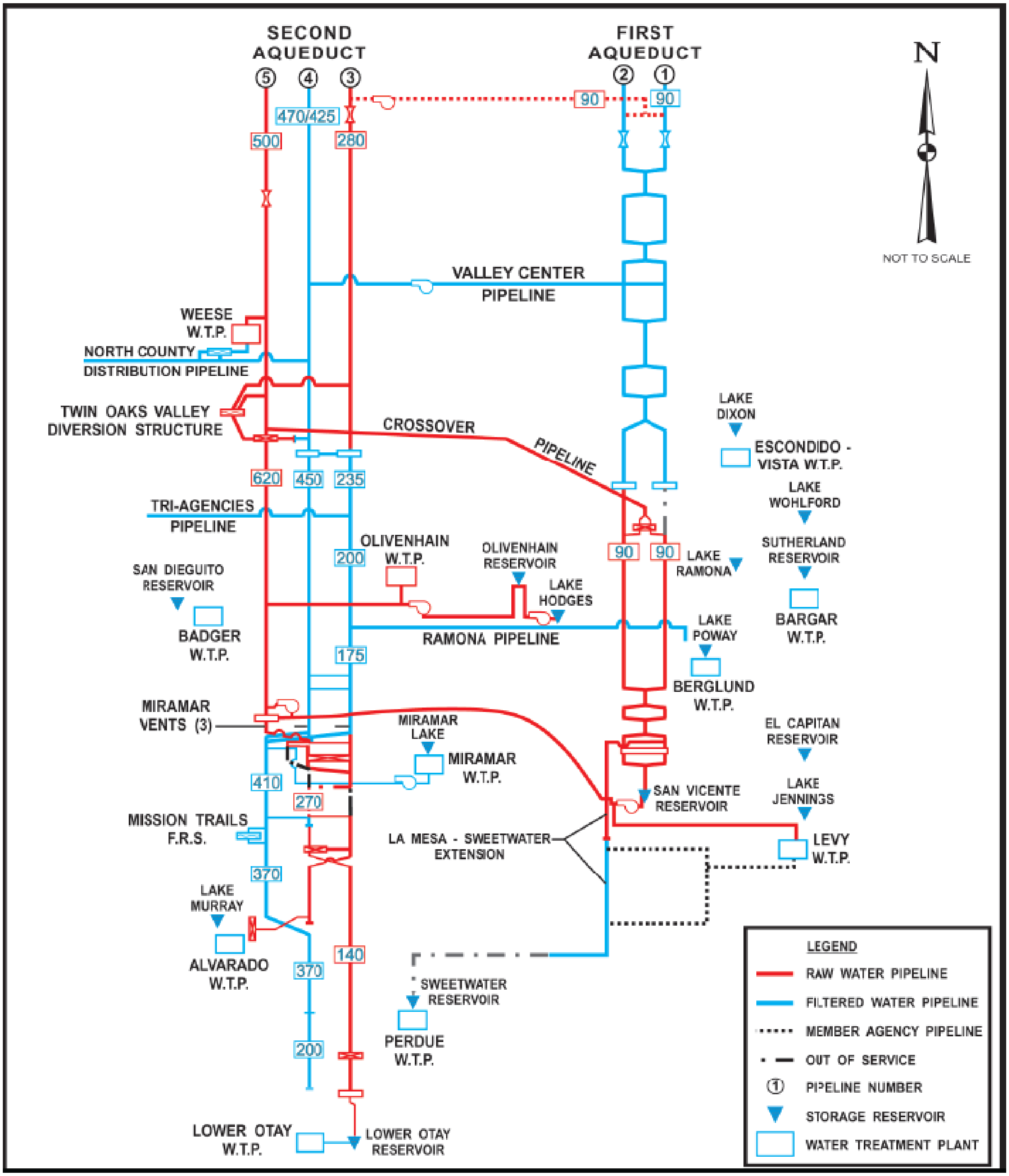
The San Diego County Water Authority (SDCWA), created in 1944, to administer the region's Colorado River water rights, import water, and take over the operation of an aqueduct that connects with MWD. SDCWA provides water supply to the people who live and work in the San Diego region with a population of 3 million and $171 billion economy. All but 11 percent of SDCWA’s imported water is currently obtained from MWD. MWD imports consist of a mix of water that originates from the SWP and the Colorado River Aqueduct; on average 40% of imported MWD water is from SWP while the other 60% is from the CRA. SDCWA imports both treated and raw water from MWD. Currently 43% of the total water imported from MWD is treated; the remaining 57% is raw. Supplies were recently augmented by a transfer agreement with the Imperial Irrigation District (IID). SDCWA funded the lining of the All American Canal which will conserve 67,700 AF, the majority of which will be transferred to SDCWA. SDCWA provides water to 24 member agencies importing water through pipelines with a maximum capacity of 900 million gallons a day.

Two aqueducts (the First and Second Aqueduct) convey raw and treated water from the Metropolitan Water District of Southern California. The aqueducts originate at Lake Skinner in Riverside County and extend south to the City of San Diego. See Figure 136 and Figure 137 for additional details. The pipelines provide the majority of water used by SDCWA member agencies and are the focus of this Study. The pipelines and SDCWA’s service area are within one hydrologic region and span two DEER climate zone.

Figure 136: San Diego County Water Authority Aqueducts

Source: SDCWA 2002

Figure 137: San Diego County Water Authority Water System Schematic



Source: SDCWA 2002

During WY 2000, a “normal” water year, the SDCWA delivered 518 TAF of water to contractors. Table 90 summarized water deliveries in other year types. No energy is used to make these deliveries as the system is mostly gravity fed. Several pumps are located throughout SDCWA’s conveyance system, however these are mostly used to move local surface water and provide integrated connection between pipelines for supply reliability. Water can be pumped from San Diego’s local reservoirs to its entire service area should MWD’s supplies be interrupted. Additionally pumps are capable of reversing the flow in the First and Second Aqueduct delivering SDCWA water to Skinner Lake should MWD need it in an emergency.

Table 90: MWD Water Imports by SDCWA

Water Year	Data Year	MWD Water Imports to SDCWA (TAF)
Wet	1998	284
Above Normal	2000	518
Below Normal	2004	623
Dry	2002	584
Critical	2001	508

For this study only the imports via the First and Second Aqueducts will be analyzed. For this purpose, the Study Team collected and analyzed historical monthly water deliveries for the period 1994-2005.

As the two aqueducts are entirely gravity fed no energy data was collected. The sources of these data for the SDCWA were: data provided by SDCWA staff and interviews with Jeff Stephenson, Senior Water Resources Specialist, SDCWA. For a detailed list of sources, see the end of this section.

The results of our findings and recommendations are documented below.

C.10.1SDCWA First and Second Aqueducts

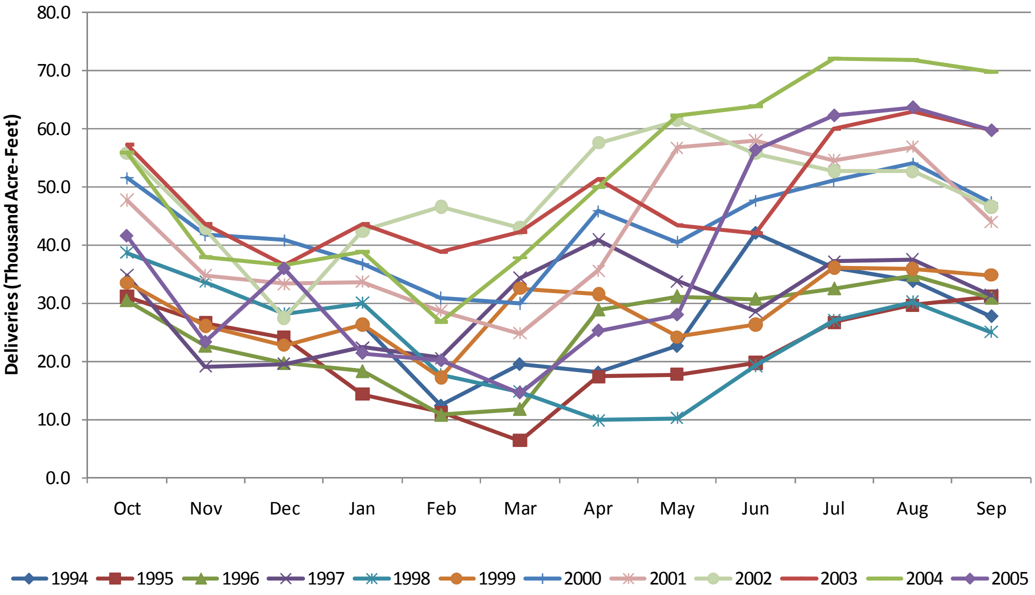
C.10.1.1 Description

Both aqueducts originate at Skinner Lake in Riverside County. The first aqueduct contains two pipelines which carry up to 90 CFS of treated water from MWD’s Skinner water treatment plant. South of a crossover with the second aqueduct, the pipelines carry untreated water and have a capacity of 95 CFS. The second aqueduct contains 2 pipelines carrying untreated water and 1 carrying treated water. The combined capacity of the untreated pipelines is 780 CFS and the design capacity of the treated pipeline is 425, but can be operated at up to 475 CFS for limited periods. South of the crossover pipeline, the second aqueduct changes capacity several times. The pipelines have a combined capacity of 1430 CFS. Raw water pipelines terminate at the San Vicente and Lower Otay Resevoirs SDCWA's service territory.

C.10.1.2 Water Flow

SDCWA delivered imported between 255,800 and 622,900 AF/year of water during the data collection period. This flow represents the total imports of treated and raw water from MWD. Flow is generally low during the months of January through March and high during the months of July through October, see Figure 138.

Figure 138: SDCWA Deliveries



C.10.2 Sources

SDCWA. *DRAFT Regional Water Facilities Master Plan*. December 2002

Jeff Stephenson, Senior Water Resources Specialist – SDCWA. Personal communication. December 17th 2009.

SDCWA Water and Energy Data received via communication with Jeff Stephenson