# WATERSHED SANITARY SURVEY UPDATE, 2012
# FOR SOLANO PROJECT BELOW MONTICELLO DAM
# PREPARED FOR
# SOLANO COUNTY WATER AGENCY

**By**

**Archibald Consulting**
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## 1.0 INTRODUCTION

Watershed Sanitary Surveys were prepared on the Solano Project in 1993, 2001, and 2006. These documents provide a comprehensive description of the watershed and water quality conditions along Putah Creek below Monticello Dam and along the Putah South Canal (PSC). The California Department of Public Health (CDPH) agreed that the 2012 Update could be a simplified report that describes the changes in the watershed since the 2006 Update was prepared and provides updates on water quality conditions for key constituents. The Solano County Water Agency's (SCWA's) responses to the recommendations in the 2006 Update are also discussed.

## 2.0 WATER TREATMENT PLANTS

A number of water providers rely on PSC water for all or a portion of their drinking water supply. **Figure 1** is a schematic showing the relative location of the water treatment plants (WTPs) and other facilities on the PSC. The facilities are identified by milepost along the PSC. The Headworks of the canal is at milepost 0.0.

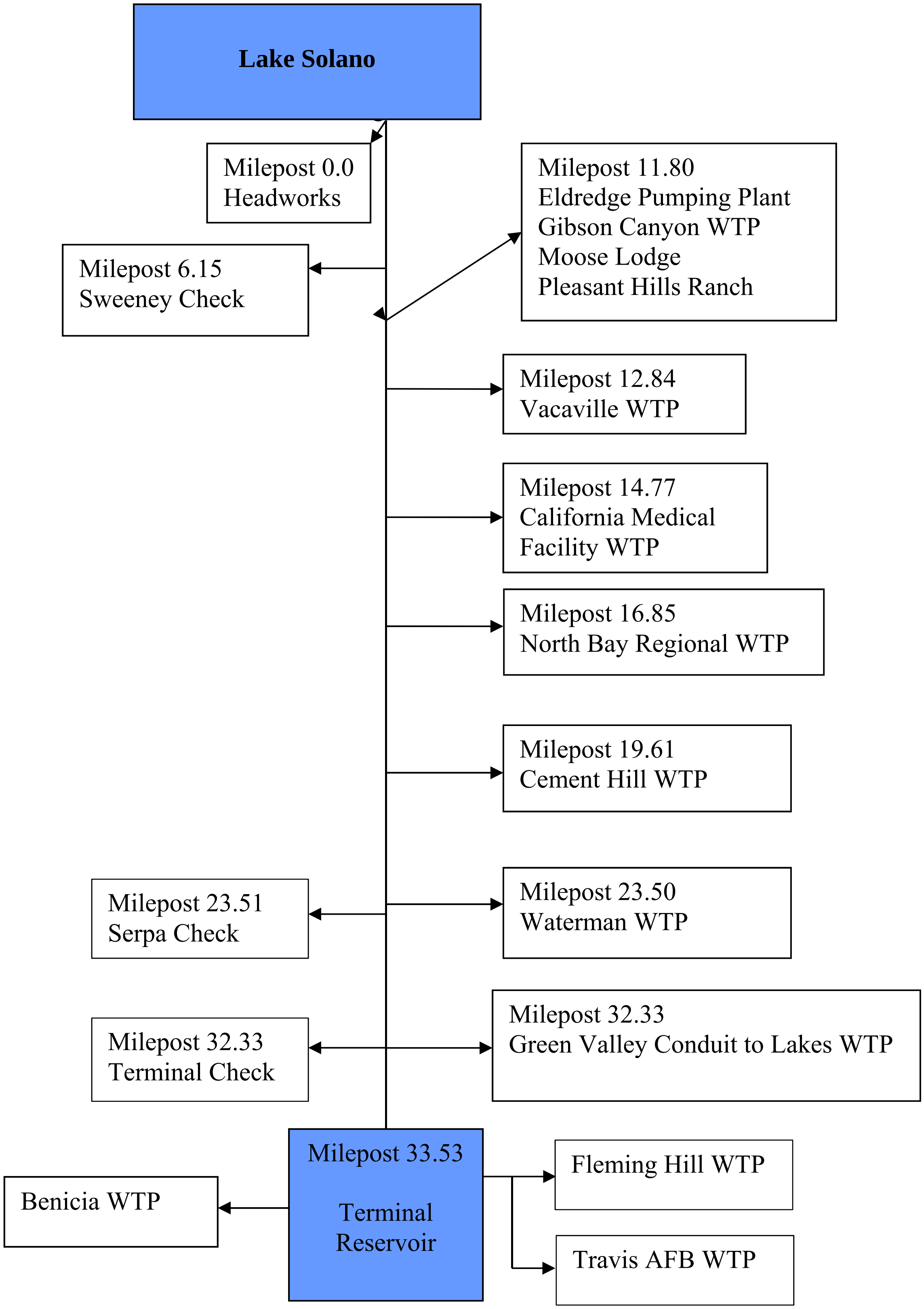
### 2.1 Gibson Canyon Water Treatment Plant

The Gibson Canyon WTP receives water from the PSC at milepost 11.80. Water is pumped from the canal by the Solano Irrigation District (SID) Eldredge Pumping Plant to the 21 acre-feet Bascherini Reservoir. SID owns and operates the 1.3 million gallons per day (mgd) membrane microfiltration plant that serves 157 service connections. The typical production rate is 0.5 to 0.55 mgd.

### 2.2 Moose Lodge

The Moose Lodge receives water from the PSC at milepost 11.80. Water is pumped from the canal by the Eldredge Pumping Plant and delivered to the Moose Lodge by an SID pipeline. The Moose Lodge owns and operates a nanofiltration membrane plant with chlorine disinfection. The Moose Lodge is classified as a transient non-community water system.

**Figure 1. Schematic of Solano Project Facilities and Water Treatment Plants**



## 2.3 Pleasant Hills Ranch Estates

Pleasant Hills Ranch Estates receives water from the PSC at milepost 11.80 and is a public water system. Pleasant Hills Ranch Estates is presumably operating with non-state approved POE water treatment systems. There are currently 22 connections and there will be 39 connections at full build out. Residents are currently on a bottled water program, where each resident is required to purchase 10 gals / resident / month of bottled water. Furthermore, a moratorium is in place such that no new construction, renovation, or new connections are allowed. SID has completed a pilot study on state-approved POEs and found the cost to be the same as a centralized water treatment system. In comparing the two options, SID determined that a centralized water treatment system was the best option. SID has already purchased land for a central treatment system. In addition, SID was able to obtain a $2M Prop. 50 grant for constructing a centralized water treatment plant. However, the awarding grant agency determined that the monthly O&M costs for the treatment plant would be cost prohibitive for residents in the area, and the grant was not awarded. SID is pursuing other options.

## 2.4 City of Vacaville

The Vacaville WTP receives water from the PSC at milepost 12.84. This WTP treats Solano Project water on a seasonal basis (typically April to September). The WTP has a capacity of 11.8 mgd but the typical production rate is 5 mgd. The plant is a diatomaceous earth filter plant with two sides that can produce 6 mgd each. Chlorine is used for disinfection. There is no adjustment of pH for corrosion control in the distribution system. The Vacaville WTP does not treat water during the November to March period, when water quality tends to be challenging during storm events.

## 2.5 California Medical Facility

The California Medical Facility/California State Prison-Solano takes water from the PSC at milepost 14.77. The WTP uses two parallel micro-flocculation package plants rated at 780 gallons per minute with post chlorination. The facility has the capability of blending Solano Project water with water from the City of Vacaville.

## 2.6 North Bay Regional WTP

The North Bay Regional (NBR) WTP is a regional facility jointly owned by the cities of Fairfield and Vacaville. Water from both the PSC and the State Water Project's North Bay Aqueduct (NBA) is treated at this plant. The NBR WTP takes water from the PSC at milepost 16.85. Water from the NBA is delivered, via pipeline, from Barker Slough. Water from both sources can be blended. The NBR WTP has a design capacity of 40 mgd but the typical production rate is 20 mgd, with 10 mgd going to each of the two cities. The plant is a conventional water treatment plant consisting of pre- and post-ozonation, coagulation and flocculation with cationic and non-ionic polymers, sedimentation, and filtration. The filters are dual media, granular activated carbon/sand gravel. Sodium hypochlorite is used for disinfection and for maintaining a residual in the distribution systems. Caustic soda is used for pH adjustment of the finished water to prevent corrosion in the distribution system. Fluoride is applied to reduce the potential for dental caries.

High turbidity and low alkalinity associated with runoff into Putah Creek and the canal during storm events results in the need for additional chemical treatment, reduction in the amount of water taken into the plant, increasing the NBA blend, and occasionally the plant shuts down for short periods of time until water quality improves. Other than during storm events, the Solano Project water is considered by NBR WTP staff to be a high quality source.

### 2.7 Cement Hill WTP

The Cement Hill WTP, owned and operated by the Suisun-Solano Water Authority, provides water to Suisun City. Water is diverted from the PSC at milepost 19.61. Solano Project water is the only source of water for this WTP. The WTP has a design capacity of 10 mgd but the typical production rate is 4.5 mgd. The plant is a conventional water treatment plant consisting of coagulation/flocculation with polyaluminum chloride, sedimentation, and filtration in multi-media pressure filters. Free chorine is used for disinfection.

High turbidity caused by runoff into Putah Creek and the canal during storm events results in the Cement Hill WTP being shut down occasionally to avoid taking the highly turbid water into the plant. The Suisun-Solano Water Authority is currently evaluating options for complying with the requirements of the Stage 2 Disinfectants/Disinfection Byproducts Rule to calculate running quarterly averages of disinfection byproducts at various locations in the distribution system.

### 2.8 Waterman WTP

The Waterman WTP, owned and operated by the City of Fairfield, receives water from the PSC at milepost 23.50. This plant only treats Solano Project water and was designed to reliably deliver 30 mgd peak summer flow and at least 6 mgd in the winter. Waterman is a conventional treatment plant consisting of Actiflo (high rate flocculation/sedimentation), intermediate ozonation, and dual media filtration ( anthracite over sand). Aluminum Sulfate (Alum) and Poly Aluminum Chlorhydrate (PACL) are interchangeable primary coagulants depending on water quality conditions. Anionic and cationic polymers are used to aid in flocculation and filtration respectively. Sodium hypochlorite provides disinfection and maintains a chlorine residual in the distribution system. Caustic soda adjusts pH of the finished water to prevent corrosion in reservoirs and system piping. Fluoride is added to reduce the potential for dental caries.

Turbidity during storm events coupled with low alkalinity creates treatment challenges. When SID alerts the plant operators that turbidity is increasing in the PSC, the treatment plant may shut down until the slug of higher turbidity water has passed the intake. Waterman can usually be taken off-line with short notice up to 24 hours or longer if planned in advance but that is rarely needed. High concentrations of total organic carbon (TOC), usually during annual canal cleaning, also create treatment challenges at this plant.

### 2.9 Green Valley WTP

Solano Project water can be diverted at the end of the open canal (milepost 32.33) to the City of Vallejo's Green Valley WTP. Solano Project water is blended with water from Vallejo's Lakes System at this 1 mgd conventional plant. The treatment plant is a conventional package plant, with the addition of MIEX (magnetic ion exchange) pretreatment, coagulation and flocculation with polymers, sedimentation, filtration in multimedia filters consisting of anthracite and sand, and chlorine disinfection. Lakes Madigan and Frey have an alkalinity below 20 mg/L. Normally Solano Project water is blended with water from the lakes to increase alkalinity and pH. Soda ash may also be added to increase alkalinity and pH. Water in excess of system demands is pumped to a 1.1 million gallon finished water reservoir.

The long detention times in the Lakes System results in difficulties meeting the disinfection byproduct (DBP) standards of 80 micrograms per liter (µg/L) for total trihalomethanes (TTHMs) and 60 µg/L for haloacetic acids (HAA5). As a result, MIEX was added to the plant to increase TOC removal to produce a water that has a TTHM formation potential below 80 µg/L

### 2.10 Fleming Hill WTP

Water is pumped from the Solano Project's Terminal Reservoir to the City of Vallejo's Cordelia Complex. The Cordelia Complex is a small forebay that also receives NBA water. Water from the Cordelia Complex is then pumped to the Fleming Hill WTP and occasionally to the Travis AFB WTP. The Fleming Hill WTP treats water from both the Solano Project and from the NBA. The sources can be treated individually or blended. The WTP has a capacity of 42 mgd but the typical production rates range between 14 and 25 mgd. The plant is a conventional WTP with the addition of pre- and intermediate ozone. Treatment consists of alum/polymer coagulation and flocculation, sedimentation, ozonation and filtration. The filters are dual media; granular activated carbon over sand and gravel. Free chorine is used disinfection and for maintaining a residual in the distribution system. Caustic soda is used for pH adjustment of the finished water to prevent corrosion in the distribution system. Fluoride is applied to reduce the potential for dental caries.

Pre-ozone is used for taste and odor control and enhanced coagulation (increased TOC removal). Intermediate ozone is used for disinfection which delays and reduces chlorine addition to the minimum needed in the distribution system, thus reducing DBP formation. Turbidity, TOC, diatoms, and all other water quality issues affect Fleming Hill just like every other plant on the PSC. Fleming Hill has a very long sedimentation time which helps in times of high turbidity, but the increases are still observed at the WTP.

### 2.11 Travis AFB WTP

The Travis Air Force Base (AFB) WTP is operated by the City of Vallejo and provides municipal water for the Travis AFB. The Travis AFB WTP receives water primarily from the NBA, but the City of Vallejo can deliver Solano Project water to the WTP. At the Solano Project's Terminal Reservoir, a City owned pump station and pipeline conveys water to the City of Vallejo's Cordelia Complex. The Cordelia Complex is a small forebay that receives both NBA and Solano Project water. From the Cordelia Complex water is then pumped to the Fleming Hill WTP and/or to the Travis AFB WTP. It is important to note that at the Cordelia Complex, blending ratios of NBA to PSC water are controlled by the Fleming Hill WTP. If the Travis AFB WTP is using PSC water, the WTP will be receiving the same blend as the Fleming

Hill WTP. The Travis AFB WTP also has continuous access to 100 percent unblended NBA water, which is the primary source of water to the plant.

The Travis AFB WTP is a conventional WTP with a rated capacity of 7.5 mgd and typical production rate of 2.0 to 4.5 mgd. Treatment consists of pre-ozonation, coagulation, flocculation, sedimentation, and filtration. The filters are dual media using granular activated carbon and sand. Sodium hypochlorite is used for primary disinfection and for maintaining a residual in the distribution system.

### 2.12 City of Benicia

The City of Benicia WTP receives water from the Solano Project via a Terminal Reservoir pump and pipeline, as well as from the NBA, and Lake Herman. The Solano Project water is a secondary supply to the City's NBA entitlement. The majority of the time, Solano Project water is blended with NBA water to reduce the influent TOC concentrations in the NBA water. The WTP has a rated hydraulic capacity of 12 mgd but the typical production rates range between 3 and 10 mgd. The plant is a conventional water treatment plant consisting of alum/cationic polymer coagulation-flocculation, dual granular activated carbon/sand gravel media filtration, and free chorine disinfection. With the additional Solano Project water purchased from SID, the Benicia WTP currently begins pumping 100 percent PSC water once the winter rains arrive (December or January) and continues pumping into late April or May. During the transition from the NBA to the PSC source, there is a one to three day blending scheme as the City switches from one source to the other.

**2.13 Non-PWS Service Areas:** In addition to the Pleasant Hills Ranch Estates water system, SID serves untreated surface water to 109 properties within 10 non-PWS service areas. Residents at these properties also participate in the bottled water program and are subject to a moratorium such that no new connections or any expansion of historic uses is allowed.

## 3.0 POTENTIAL CONTAMINANT SOURCES

The 1993, 2001, and 2006 Watershed Sanitary Surveys provide a comprehensive description of the watershed and potential contaminant sources along Putah Creek below Monticello Dam and along the PSC. Agreement was reached with CDPH that the 2012 Update would focus on a few of the more significant contaminant sources and provide updates on any changes from 2006 through 2011.

### 3.1 Rural Runoff into the Putah South Canal and Sediment Sources

Runoff from rural areas adjacent to the PSC routinely enters the canal during storm events at several locations near the canal Headworks and in the Suisun Valley. Runoff occasionally enters the canal during large storm events at a number of locations along the canal. SCWA contracted with Northwest Hydraulic Consultants (NHC) to investigate the sources of sediment entering the canal.

### *Direct Drainage to Putah South Canal*

**Figure 2** shows the locations of drains that discharge drainage from the local watershed into the PSC. Near the canal Headworks, there is a short portion of the right-of-way that drains to the canal via eight drains. Drainage enters the canal at nine locations in Suisun Valley.

**Table 1** presents the land use and acres drained at each location. Drains RD05 and RD06 are located on the floor of Suisun Valley and routinely discharge sediment laden water into the canal. A field investigation conducted for this project showed that these two areas are largely devoted to the cultivation of wine grapes. Drains RD07 to RD13 are located along the elevated portion of the canal on the west side of Suisun Valley. These drains discharge runoff from rural residential land. The field investigation showed that there are four homes on Stonefield Lane which is upslope of the canal.

**Table 1. Areas Draining to PSC**

| Drain No. | Land Use | Acres Drained |
|---|---|---|
| RD05 | Cultivated agriculture | 30 |
| RD06 | Cultivated agriculture | 57 |
| RD07 to RD13 | Open space | 153 |

Source: NHC et al. (2010)

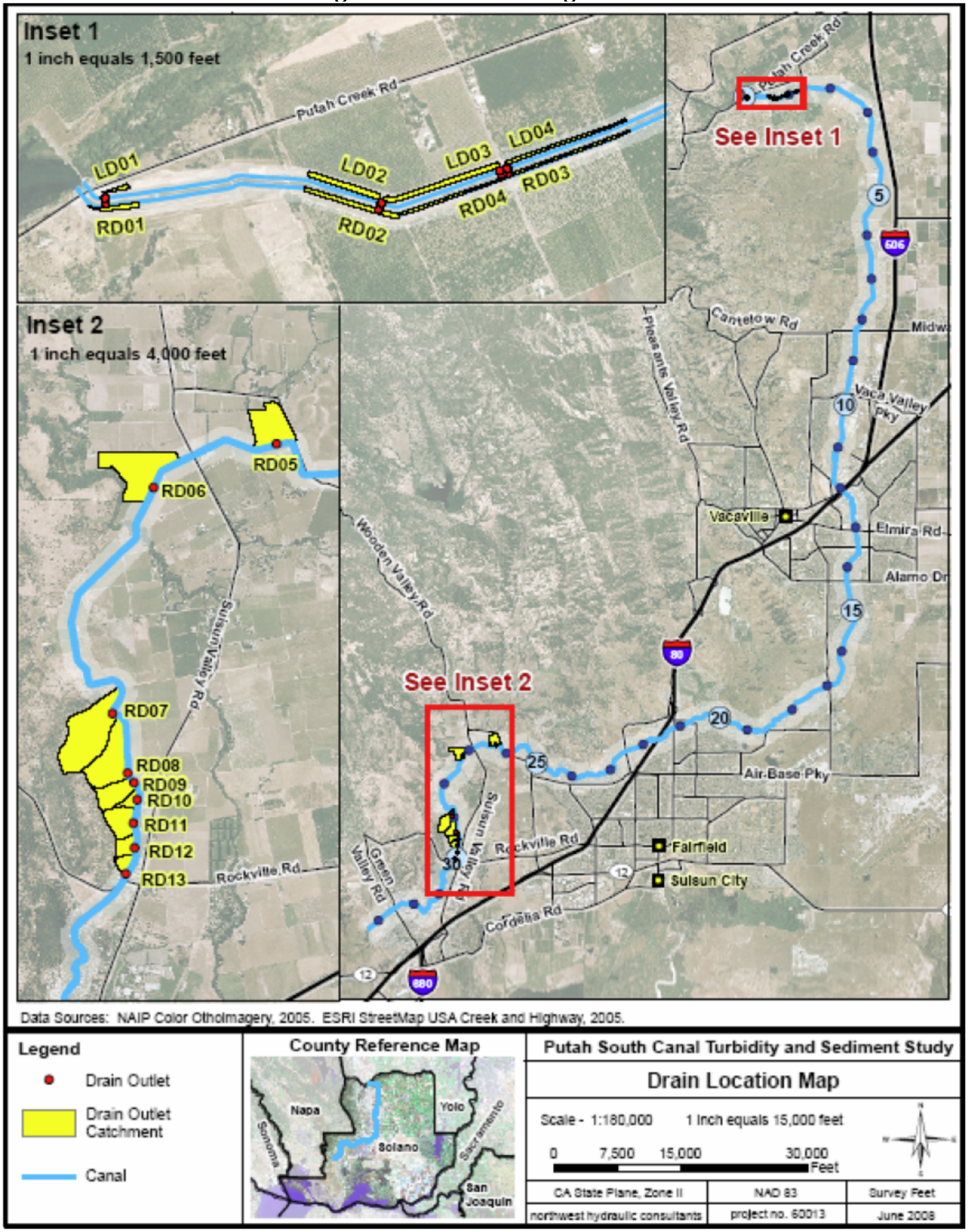
### *Occasional Discharges to Putah South Canal*

During large storm events, runoff enters the canal when flooding occurs alongside the canal and the canal is overtopped or when culverts carrying local streams across the canal are overtopped. Large amounts of sediment enter the canal during these events. Sediment is also discharged to the canal due to bank erosion and canal bank mass failures that occasionally occur during large storm events. These events are episodic and the amount of runoff and sediment entering the canal depends on the severity of storm events or the occurrence of multiple storms in a short period of time.

### *Sources of Sediment*

SCWA contracted with NHC to conduct a study on the sources of sediment, turbidity, and aquatic vegetation in the PSC (NHC et al., 2010). The study investigated the amount of sediment entering the PSC from Lake Solano and from other sources (termed lateral sources in the study). **Table 2** presents the results for the three years that were investigated. The primary sources of sediment to Lake Solano are the Interdam Reach tributaries, which are defined as the tributaries between Monticello Dam and the Putah Diversion Dam. Turbidity and sediment data collected as part of the NHC study showed that Pleasants Creek is the most significant source of sediment to Lake Solano. During the three years that were evaluated, lateral sources contributed far more sediment than Lake Solano contributed.

**Figure 2. Areas Draining to PSC**




Source: NHC et al. (2010)

There were large storm events in early 2006 and in 2008 that resulted in wide-scale flooding and overtopping of the canal. These types of storm events typically occur every 10 to 20 years (NHC et al., 2010). These events transported considerable sediment to the canal. Other contaminants are also likely to be transported to the canal during these events. The water quality data are examined in the following section to determine if any notable changes in water quality occur during and after the winter storm events.

**Table 2. Sources of Sediment to the PSC**

| Water Year | Year Type | Sediment (tons) | | |
|---|---|---|---|---|
| | | Lake Solano | Lateral Sources | Total |
| 2006 | Wet | 900 | 4,400 – 11,900 | 5,300 – 12,800 |
| 2007 | Dry | 540 | 400 – 900 | 940 – 1,440 |
| 2008 | Critical | 900 | 2,000 – 6,000 | 2,900 – 6,900 |

### *Sediment and Aquatic Weeds*

Aquatic vegetation has become more problematic in recent years, primarily due to regulatory caused changes in canal cleaning practices (i.e. the inability to use the canal wasteways). The volume of vegetation is increasing and resulting in operational challenges. NHC et al. (2010) determined that Lake Solano is the primary source of the aquatic vegetation in the canal. Tubers, plant fragments, seeds, rhizomes, and turions enter the canal through the Headworks and propagate in the canal. The canal is also a significant source because some plant fragments, seeds, etc. remain in the canal after cleaning and propagate the next spring when the water temperature increases and there is adequate sunlight. NHC et al. (2010) conducted vegetation monitoring along the entire length of the canal and found that the most common species are Eurasian watermilfoil, Sago pondweed, Horned pondweed, and Elodea.

NHC et al. (2010) found that the deposition of sediment in the canal promotes the growth of aquatic weeds, which in turn promotes more sediment deposition in the canal. This results in the development of thick mats of aquatic weeds and sediment that grow in thickness as more vegetation filters suspended sediment and plant fragments out of the water column, which promotes more plant growth. These mats become anaerobic in the summer and fall and generate hydrogen sulfide and other undesired compounds such as elevated concentrations of organic carbon, iron, manganese, nutrients, and chlorine demand when disturbed during the annual canal cleanout. The combined problem of sediment and aquatic weed growth results in the need to conduct annual cleaning of the canal (discussed later) to remove these black sludge like mats at the bottom of the canal. The decaying aquatic vegetation and fine sediment produces a black sludge-like material that is easily suspended, hard to remove, and can cause substantial water quality issues in the PSC.

### *Management Practices*

NHC conducted an erosion inventory in 2007 and 2008 and developed a Geographical Information System database that identified erosion sources. Each reach of the canal was then assigned an erosion hazard rating. Best management practices were identified and ranked and cost estimates were prepared. The following management practices have been implemented in the last several years:

- Gravel was applied on the non-operational access road downstream of the Pleasant Creek overchute. This effectively eliminated sediment loading from direct drains LD01 to LD04.

- Gravel was applied on the non-operational access road in the watershed of direct drain RD05. This effectively eliminated sediment loading from the access road. A demonstration project with the Solano Resource Conservation District (RCD) was also conducted for this watershed. Native vegetation was planted within the PSC right of way, and the neighboring landowner to the north was contacted to plant native vegetation within the watershed area. Unfortunately the landowner was not cooperative and had no interest in working with the Solano RCD or SID. Additionally, within the PSC right of way, the native vegetation was unable to grow. Soil tests were inconclusive on the soil quality, and no further action has been done.

- Gravel was applied on the non-operational access road in the watersheds of direct drains RD07 to RD13. This effectively eliminated sediment loading from the access road but there may be sources of sediment in the watersheds.

- The use of a broad-spectrum herbicide was eliminated along the canal banks starting in the 2008 to 2009 rainy season. This resulted in the establishment of Wimmera Ryegrass along most of the canal, reducing erosion from the inside canal banks.

- Plot studies were conducted on the effectiveness of various grasses in establishing groundcover along the canal banks.

- Numerous pilot scale Best Management Practices (BMPs) were also conducted throughout the PSC. Successful BMPs included (i) graveling the canal banks where soil conditions were of poor quality and (ii) hydroseeding with Wimmera Ryegrass recently repaired areas of the canal banks. Several other BMPs were deemed unsuccessful because they were either cost prohibitive or were not effective and include (i) the use of floc logs at each of the direct drains to reduce downstream sediment in the PSC and (ii) the use of polyacrylamides to stabilize canal banks.

NHC et al. (2010) recommended a number of other actions for managing sediment in the PSC. SCWA is conducting a feasibility study for improvements at the Headworks, including finer screens, sediment deflection, sediment flushing, and an alternate intake upstream of Pleasants Creek which is the single biggest contributor of turbidity and sediment to Lake Solano.

### 3.2 Canal Cleaning

SID has to clean the canal every year during the fall to remove sediment and aquatic vegetation that accumulates in the canal. Although SID works closely with the WTP operators to schedule the cleaning operation, it has been identified as one of the primary challenges for the WTPs. It takes two months to clean the entire canal and approximately three days to clean one segment of the canal between check structures. This results in WTP shut-downs and poor water quality immediately after the cleaning process. Water quality issues identified by the WTP operators are high chlorine demand and high concentrations of TOC, iron, manganese, and copper. NHC et al. (2010) conducted water quality monitoring during the cleanout operations in the fall of 2007 and 2008. The water contained high concentrations of nutrients, metals, and TOC and, the water had high levels of color, turbidity, and alkalinity. NHC et al. (2010) concluded that without extensive dilution and settling time, the water in the canal during cleanout operations is untreatable.

The WTP operators report that the water quality conditions during canal cleaning operations are becoming more challenging and that prior to 2004, there was no need for high levels of chlorination. NHC et al. (2010) hypothesized that there may be a relationship between the increasing water quality problems and the carryover load of organic detritus that remains in the bottom of the canal after cleanouts. SID used to use wasteways along the canal to wash the organic matter out but that practice has been discontinued due to environmental concerns.

SCWA contracted with NHC to conduct a study on alternative canal cleaning methods (NHC, 2010). Suction dredging is promising in that it can be done during normal operations, will not require WTPs to shut down, and can potentially remove 100 percent of the fine black residual that currently is only partly removed; however, the process is expensive and may not be economically feasible to clean the entire canal. SCWA intends to test this method in the near future.

## 3.3 Agriculture and Pesticide Use

### *Putah Creek and Lake Solano*

A small amount of land is devoted to agriculture in the Lake Solano watershed between Monticello Dam and the PSC diversion dam. Although agricultural practices can result in increased loads of suspended solids, nutrients, and organic carbon in receiving waters, pesticides are the primary concern. Information was obtained from the California Department of Pesticide Regulation on pesticide usage on the sections of land that drain to Putah Creek between Monticello Dam and the PSC diversion dam. **Table 3** provides a summary of the ten pesticides used in the largest quantities between 2006 and 2010 (data are not yet available for 2011). The primary crops that these pesticides were used on are walnut, prune, and citrus trees.

Copper and glyphosate are the only pesticides listed in **Table 3** for which drinking water standards have been established. Copper is used primarily on walnut trees between March and May to prevent fungus and bacterial diseases. Glyphosate is an herbicide used in prune and walnut orchards in all months of the year, with the heaviest use between June and September. A review of all of the pesticides used in the watershed from 2006 through 2010 revealed that simazine is the only other pesticide used for which there is a drinking water standard. During this period, 692 pounds of simazine were applied to walnut orchards in the watershed. Simazine is an herbicide that is used in February and March.

**Table 3. Pesticides Used in the Largest Quantities in the Watershed of Putah Creek**

| Pesticide | Total Pounds Used | | | | | |
|---|---|---|---|---|---|---|
| | 2006 | 2007 | 2008 | 2009 | 2010 | Total |
| Sulfur | 1432 | 1980 | 2809 | 0 | 1818 | 8039 |
| Petroleum Oil | 1309 | 658 | 766 | 3278 | 140 | 6151 |
| Copper | 869 | 924 | 621 | 105 | 2245 | 4764 |
| Glyphosate | 556 | 657 | 913 | 953 | 637 | 3716 |
| Chlorpyrifos | 341 | 811 | 735 | 516 | 174 | 2577 |
| Maneb | 184 | 629 | 680 | 152 | 0 | 1645 |
| Ethephon | 96 | 523 | 229 | 231 | 53 | 1132 |
| Chlorothalonil | 572 | 0 | 105 | 0 | 315 | 992 |
| Mineral Oil | 136 | 0 | 789 | 0 | 0 | 925 |
| Diazinon | 310 | 171 | 146 | 72 | 0 | 698 |

Source: California Department of Pesticide Regulation Pesticide Use Database.

### *Putah South Canal*

As discussed previously, there are two drainages (RD05 and RD06) that drain into the PSC that are vineyards. The specific pesticides used on these individual drainages are not available; however, the most common pesticides used on wine grapes in Solano County are sulfur, glyphosate, petroleum distillates, and simazine (California Department of Pesticide Regulation, 2010).

SID uses several types of weed and pest control pesticides to control algal growth in the canal, weeds on the bank of the canal and in the right-of-way, and rodents. The only chemical applied directly to the water in the canal is copper sulfate for algae control. **Table 4** lists the various chemical compounds applied by SID.

Copper sulfate is applied to the canal from April to October to control algal growth. SID has decreased the frequency of applications because the WTPs have to shut down during the copper sulfate applications until copper levels return to acceptable levels. SID has also started using a new product (Earthtec) that is effective at lower concentrations of copper. The most problematic algae are filamentous green algae, which grow rapidly and clog WTP intake structures.

## 3.4 Grazing

A small amount of land is devoted to grazing in the watershed. Information is available on the number of cattle and sheep that graze in Solano County but not specifically on land that drains to Putah Creek and the PSC. Cows, particularly young calves, are a source of *Cryptosporidium*. The greatest risk of microbial contamination occurs during periods when there is flooding that results in local streams overtopping the canal. The pathogen monitoring data collected by the water providers taking water from the PSC were reviewed and show no indication that cattle in the watershed are a source of *Cryptosporidium*. As discussed in the following Water Quality section, the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) monitoring was conducted at milepost 11.80. *Cryptosporidium* was detected in 2 of the 24 samples collected from the PSC at 0.1 oocysts/L. All water treatment plants treating PSC water were given a Bin 1 designation by CDPH.

**Table 4. Pesticides Used in and along the PSC**

| Pesticide (Chemical Name) | Reason for Use | Rates | Application Period |
|---|---|---|---|
| Granular copper sulfate[1] | Algae control in water | 1 to 2 pounds/ cubic feet per second | Apr to early Oct |
| Liquid copper sulfate[1] | Algae control in water | Injected to maintain 0.3 to 1.0 mg/L of copper in water | Apr to early Oct |
| Diuron[2] | Pre-emergent weed control (Use decreased from past) | 12 pounds/ acre | Nov to Feb |
| Glyphosate[2] | Some post-emergent weed control and brush control and some chemical "mowing" | 6 to 96 ounces/acre | All year |
| 2,4-D amine[2, 3] | Broadleaf weed control | 32 to 64 ounces/acre | Oct to Apr |
| Triclopyr[2, 3] | Broadleaf weed control | 32 to 96 ounces/acre | All year |
| Clopyralid[2, 3] | Broadleaf weed control | 4 to 10 ounces/ acre | As needed |
| Amino pyralid[2, 3] | Broadleaf weed control | 7 ounces/acre | Dec to Mar |
| Aluminum phosphide[2, 3] | Ground squirrel control | 3 to 4 tablets/burrow | Nov to Mar |
| Activator 90[2, 3] | Spreader - activator | 48 to 64 ounces/100 gallons of spray | All year |
| LI 700[2, 3] | Water buffer | 20 ounces/100 gallons | All year |

[1]Applied directly to the water in the PSC.
[2]Applied on inside bank of PSC above concrete liner.
[3] Applied in right-of-way adjacent to the PSC.

## 3.5 Recreation

The recreational areas in the watershed were described in detail in the 2006 Update. Information is presented in this section on current usage of these facilities and any changes to the facilities since the 2006 Update was prepared.

### *Stebbins Cold Canyon Reserve*

Stebbins Cold Canyon Reserve is a 638 acre reserve set in a steep, north-facing canyon of the northern Coast Range, managed by the University of California Davis (UC Davis). The reserve is on the south side of Putah Creek, immediately below Monticello Dam. The reserve is open to the public year-round from sunrise to sunset and has up to 30,000 visitors per year. The 2006 Update reported that there were 5,000 visitors per year. Recreational usage has increased steeply in the last couple of years due to an increase in the number of publications that list the reserve as a hiking destination (Personal Communication, Jeffrey Clary, UC Davis). Starting in 2012, UC Davis undergraduate interns involved in the Student Education Outreach Program will organize and lead guided hikes of the area. This may increase recreational usage. As reported in the 2006 Update, there are no restrooms or portable toilets.

### *Canyon Creek Resort*

Canyon Creek Resort Recreational Vehicle (RV) Park is located adjacent to Putah Creek, just below Monticello Dam. This is a membership resort that is open year-round, with peak occupancy between May and September. An updated brochure for the resort indicates that some of the information in the 2006 Update needs to be corrected. There are 127 (rather than 115) camping sites, 2 (rather than 1) swimming pools, and 2 (rather than 1) dump stations. Swimming and wading in Putah Creek is permitted but discouraged by the RV Park owners.

### *Putah Creek Fishing Access Parks*

The five access locations that collectively make up the Putah Creek Fishing Access Parks are located on approximately 87 acres, along a 3.25-mile stretch of creek, on the north side of Putah Creek, starting 7 miles west of the town of Winters. The sites are operated and maintained by the Yolo County Department of Parks and Recreation under an Operating Agreement with the California Wildlife Conservation Board, which owns the sites. The sites are used primarily for fishing and for access to the creek. The Department of Parks and Recreation estimates that there are 1200 visitors each year based on the user fees that are collected; however, there are likely many more visitors that park on Highway 128 to use the facilities but do not pay the fees (Personal Communication, Laura Liddicoet, Yolo County Department of Parks and Recreation). The Parks and Open Space Master Plan described the Putah Creek Fishing Access Parks as under-utilized and recommended developing amenities such as picnic tables, cultural and environmental interpretive signs, and expanding hiking trails (Yolo County, 2006). In July 2009, Yolo County opened primitive campgrounds at Access Site 1 (the most upstream site) and Access Site 3 as a pilot project. It was not considered a success by the Department of Parks and Recreation and was discontinued after one summer (Personal Communication, Laura Liddicoet, Yolo County Department of Parks and Recreation). The portable toilets were replaced with permanent restrooms at these two sites. There is a portable toilet at Access Site 3 but no facilities at Access Sites 2 and 5. As of early 2012, the Department of Parks and Recreation is renovating the fishing access sites. These renovations include constructing new trails at the most popular and highest use areas, installing educational panels, and repaving roads, and parking areas. These improvements may increase the number of people using the facilities.

### *Lake Solano Regional Park*

Lake Solano Regional Park, located on the southern side of Putah Creek, opened in 1973. The park offers camping, picnicking, swimming, boating, and fishing on 45 acres of land and approximately 110 acres of water. Solano County operates the park under a management agreement with the U.S. Bureau of Reclamation. According to the County website, over 200,000 people visit the park each year. The County opened a new Lake Solano Nature Center at the park in April 2009. Another new feature is a 0.5 mile shoreline interpretive trail that runs between the campground area and the Nature Center. The County anticipates significant population growth and increased demand for the recreation opportunities that the park offers in the next 25 years. The County has developed a Master Plan to govern planning to meet the demand (Solano County, 2006). The Master Plan recommends a number of improvements be made in five phases:

- Phase 1 – American Disability Act (ADA) upgrades to the interiors of all existing restrooms and to add a shower facility to the Group camping area. The project also includes ADA signage throughout the park and remodeling the ranger residence area above the day use parking lot entrance.

- Phase 2 – Construct a Visitor's Center at the main entrance to the camping side of the park. The Lake Solano Nature Center was opened in April 2009. It serves as a visitor's center, park headquarters, and nature center.

- Phase 3 – Revise Day Use side of the park – this will include the following key areas:

    - Construct a boardwalk over the wetlands area
    - Enhance access to the water by adding fishing piers and beach areas
    - Provide educational study areas and a location for a mobile display trailer at strategic locations throughout the park
    - Enhance the existing picnic, play, and sports areas

- Phase 4 – Expand camping facilities into the Walnut Orchard at the west end of the park and upgrade and expand the current camping areas at selected locations. This phase includes the construction of a new restroom facility, roads, utilities, and campsites at the west end of the park. This phase also includes providing ADA accessible paths to all facilities and installing new directional signage and location maps throughout the park.

- Phase 5 – Enhance water access and hiking trails throughout the park:

    - Rebuild stairs and paths connecting parking areas to the rest of the park
    - Construct a bridge over Pleasants Creek
    - Build Solano County's portion of the Dam to Dam trail
    - Remove invasive plants and add native plants to stabilize the soil

Recreational usage of Lake Solano Regional Park is expected to increase due to population growth and to the improvements made at the park to accommodate this growth.

### 3.6 Spills/Illegal Dumping

A review of the Response Information Management System (RIMS) indicated that during the 2006 to 2011 period there have been very few reported hazardous materials spills. In April 2007, a citizen reported broken leach lines at the Canyon Creek RV Park and believed sewage was leaking under Highway 128. Later that month, a vehicle went into Putah Creek from Highway

128 just west of Pleasants Valley Road. There have been no spills into the PSC. Caltrans no longer allows public access to its database on vehicle accidents on California highways; however, RIMS has only one record of a vehicle going into Putah Creek.

### 3.7 Urban Runoff

The PSC flows through the cities of Vacaville and Fairfield; however, all urban runoff is conveyed over or under the canal. There is no need to update this section since there have been no changes since the 2006 Update was prepared.

### 3.8 Wildfires

There was one wildfire in the vicinity of Putah Creek and one in the vicinity of the PSC from 2006 through 2011. Information on these fires was obtained from the CAL FIRE website (www.calfire.ca.gov/incidents).

- **Braye Fire –** The Braye Fire started on May 18, 2007 and burned 450 acres over a four day period. The fire burned part of the Putah Creek watershed north of Putah Creek in Yolo County. The fire closed Highway 128 between Winters and Lake Berryessa. The cause of the fire was listed as undetermined.

- **Beacon Fire –** The Beacon Fire was located on the slopes of Cement Hill, just outside the northeast boundary of the City of Fairfield and directly uphill from the PSC. The fire started on August 27, 2011 and was extinguished on August 29, 2011 after burning 715 acres. There is no drainage into the PSC in this area.

Erosion after fires is the primary water quality concern. As discussed in the water quality section, turbidity levels increase during storm events in all years. The levels in the winter of 2008, following the Braye Fire, were lower than in 2009 and higher than in 2007. It is not possible to isolate the effects of the fire from other sources in the watershed.

## 4.0 WATER QUALITY

The PSC provides a high quality source of drinking water most of the time. WTP operators have identified three short-term water quality issues that affect their operations:

- Annual Canal Cleanout Operations – WTP operators report that they experience their most significant water quality issues during the annual cleanout operations. Some plants are able to switch to other sources during this time, while others such as the Waterman and Cement Hill WTPs rely solely on the PSC, and can only bypass PSC water for one to two days.

- Winter Storm Events – Winter storms produce high levels of turbidity in the canal and occasionally, when inflows from area creeks enter the canal, very low levels of alkalinity.

- Copper Treatments – During copper treatments, WTP operators have to bypass PSC water until the copper concentrations return to acceptable levels.

Each of these issues is described in the Contaminant Sources section. In this section, the water quality data are examined to describe the magnitude of these problems. Other water quality data associated with microbial contaminants, disinfection byproduct precursors, and pesticides are also described.

### 4.1 Rainfall

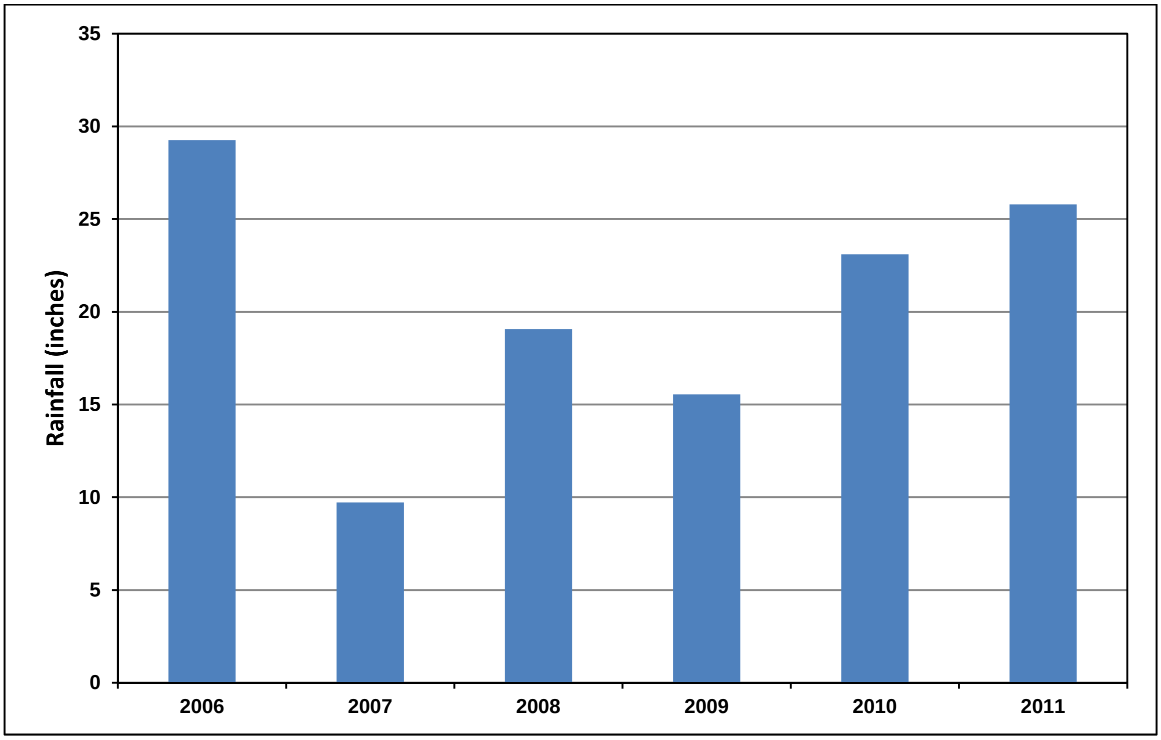
The water year annual rainfall at Winters, which is near the Headworks of the PSC, during the 2006 to 2011 period covered by this watershed sanitary survey is shown in **Figure 3**. Annual rainfall varied from a low of 9.72 inches in 2007 to a high of 29.26 inches in 2006. The average annual rainfall at Winters is 22.8 inches. Two major rainfall events affected water quality during this period (Personal Communication, Alex Rabidoux, SCWA).

- December 31, 2005 – There was wide-scale flooding throughout Solano County from the "New Year's Eve Storm." It rained almost every day between December 16 and December 31, with a total of 8.31 inches falling in Winters by December 30. On December 31, another 2.8 inches of rain fell, leading to wide spread flooding throughout the County. Pleasant, Sweeney, Alamo, Legewood, and Suisun creeks all overtopped the PSC and there was additional runoff that entered the canal near Winters. This filled the canal with highly turbid, low alkalinity water.

- January 4, 2008 – During this first flush event, the Allendale area, which is about 7 miles south of winters, received 9.5 inches of rain and Winters received 5.23 inches in 24 hours. Lake Solano was filled with highly turbid water from Pleasants Creek and other tributaries to Putah Creek downstream of Lake Berryessa. Pleasant Creek and Sweeney Creek overtopped the PSC. Initially, only the first two checks were filled with highly turbid, low alkalinity water but because of water demands, the water moved through the entire canal system. Turbid water also entered the canal from the drains that discharge to the canal in Suisun Valley.

In the following sections, the water quality data are examined for these two extreme events and the implications for water treatment are discussed.

**Figure 3. Water Year Annual Rainfall at Winters**




Source: CIMIS

## 4.2 Turbidity

Many of the agencies treating PSC water that were interviewed for the 2006 Update reported that high turbidity and low alkalinity during storm events create water treatment challenges. Several agencies confirmed for the 2012 Update that this is still a significant treatment challenge. There are dramatic increases in turbidity during winter storm events. When possible, the WTPs close their intakes until the slug of turbid water passes.

**Figures 4 and 5** present the daily average turbidity data for the NBR and Waterman WTPs. These data are consistent with the data presented in the 2006 Update in that turbidity levels are generally less than 10 NTU during most of the year but rise rapidly during the late fall and early winter months. Peaks exceeding 100 NTU occur almost every year.

**Figure 4. Turbidity at the NBR WTP Intake**

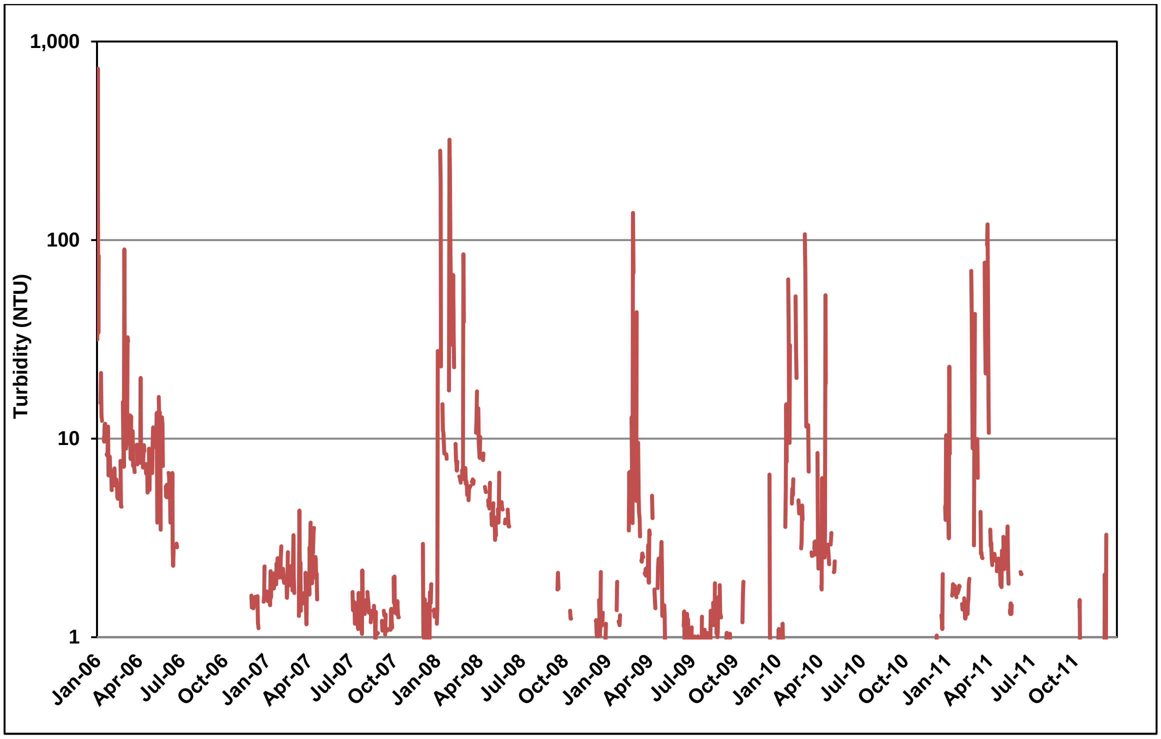
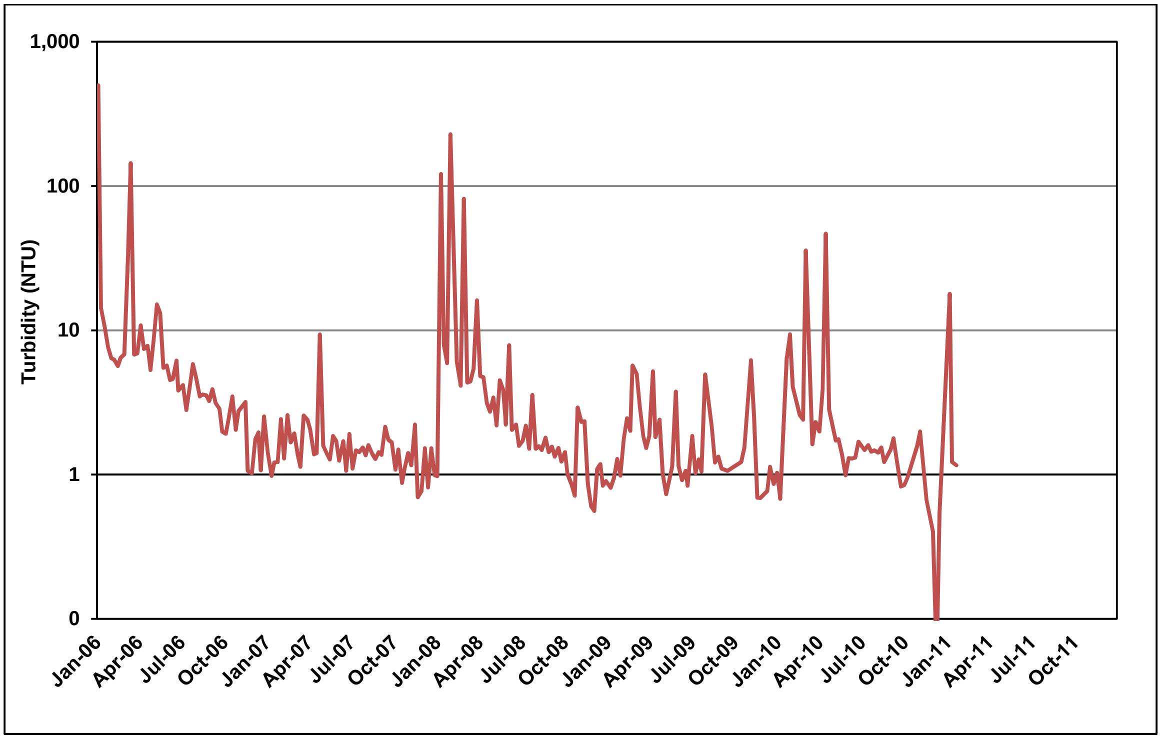



**Figure 5. Turbidity at the Waterman WTP Intake**



SCWA has installed continuous monitoring equipment at Pleasants Creek, several locations in Lake Solano, and at a number of locations along the PSC. The real-time turbidity data is a valuable tool that allows SCWA to alert the WTP operators to turbidity plumes passing through the canal. **Figure 6** shows the real-time turbidity data for two locations in Lake Solano. The Lake Solano at Pleasants Valley Road (Upstream) data represent turbidity coming from the Interdam Reach tributaries above Lake Solano while the Lake Solano downstream of Pleasants Creek (Downstream) data illustrate the substantial impact Pleasants Creek has on Lake Solano, and on the PSC.

**Figure 6. Real-time Turbidity Data in Lake Solano**

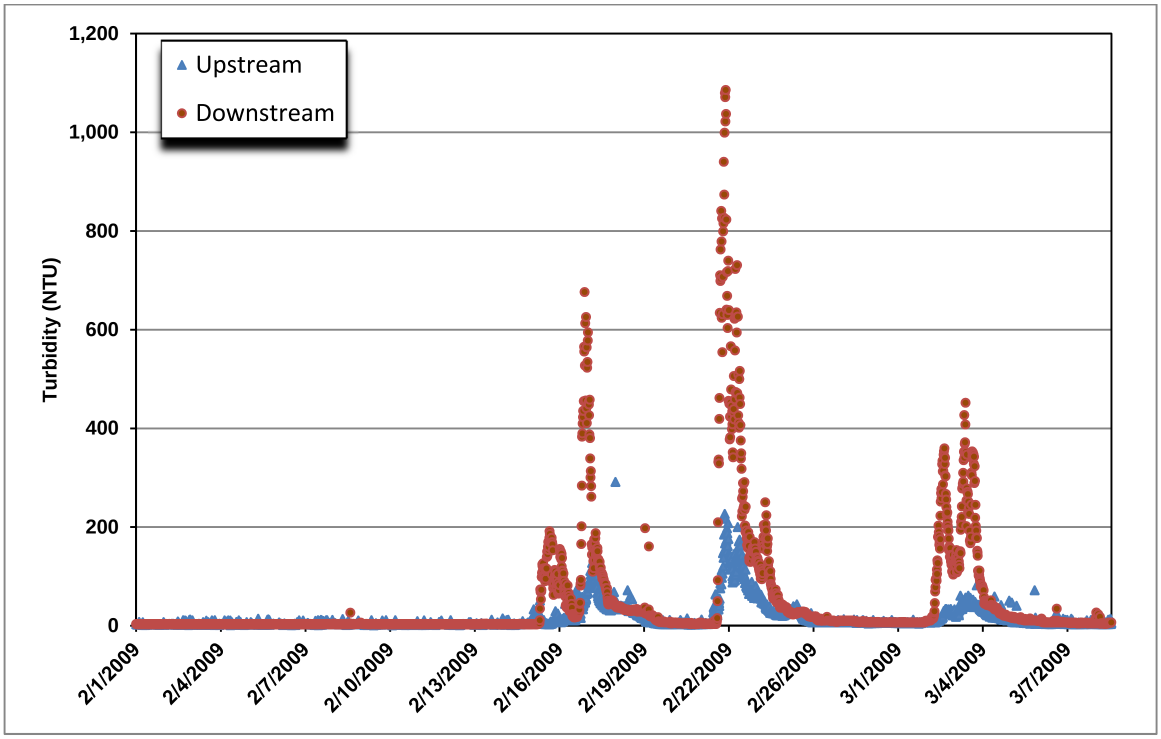



**Figure 7** presents the real-time turbidity data for the PSC for the days following the December 31, 2005 storm and **Figure 8** presents the data for the January 4, 2008 storm. The real-time data quality is moderately good (Personal Communication, Alex Rabidoux) and is available on the SCWA website. NHC et al. (2010) found systematic discrepancies between the real-time data and grab sample data at several locations. Despite these problems, the real-time data does allow SCWA and the WTP operators to track turbidity plumes to determine when they will arrive at individual water treatment plant intakes on the canal. This allows the WTP operators to bypass the water or to prepare for the additional challenge of treating highly turbid water.

**Figure 7. Real-Time Turbidity Data for the December 31, 2005 Storm Event**

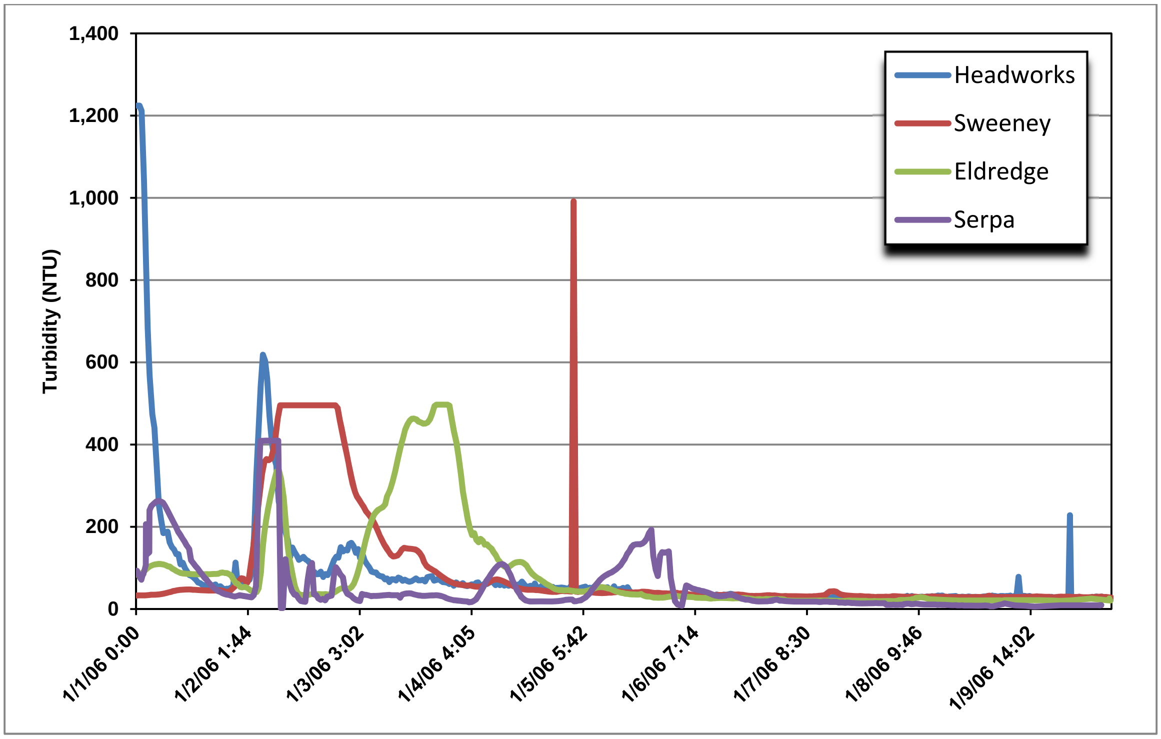
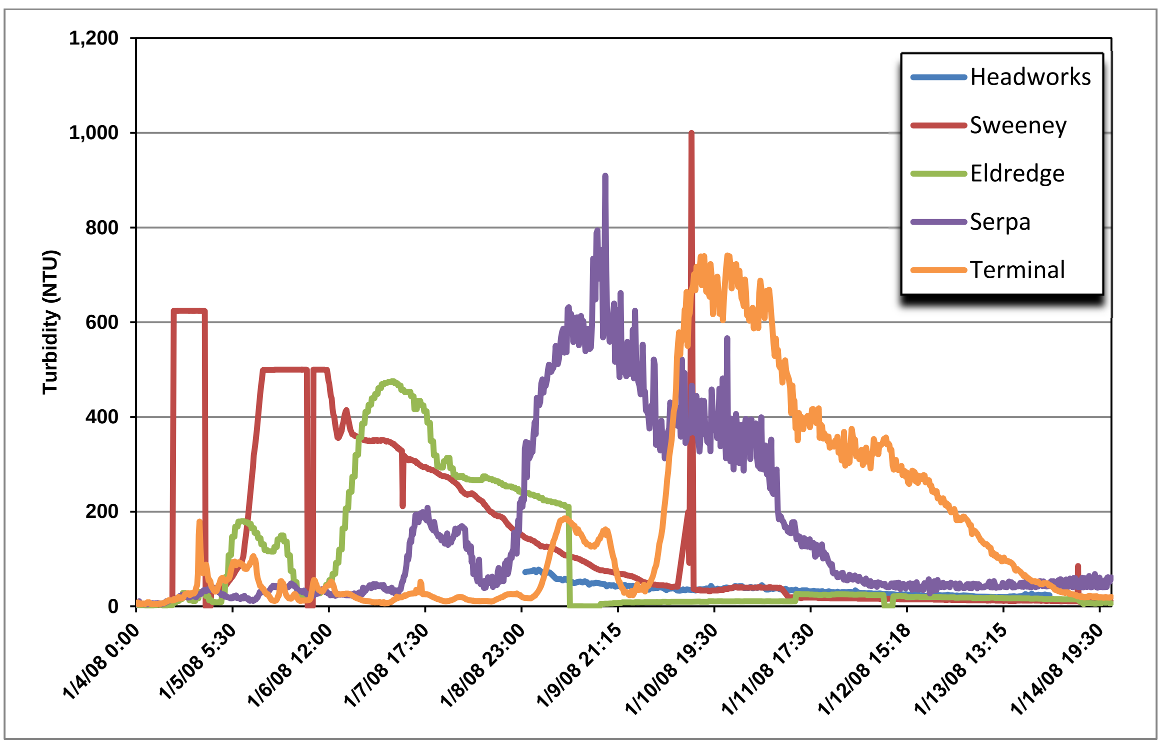



**Figure 8. Real-Time Turbidity Data for the January 4, 2008 Storm Event**



NHC et al. (2010) reported that elevated levels of turbidity occurred during and after fall canal cleaning operations in 2007 and 2008, based on monitoring conducted during the clean out operations. NHC et al. reported that turbidity varied between 5 and 80 NTUs over a 12 hour period but quickly abated once cleanout activities were completed. The elevated levels are not seen in the routine data collected at the Waterman WTP during 2007 and 2008 (**see Figure 5**), perhaps because turbidity samples are generally collected weekly.

Despite the high levels of turbidity that occasionally occur in the PSC, all of the agencies treating the canal water meet the finished water turbidity standards. Although, as discussed previously, the highly turbid water is often bypassed, which at times creates water supply difficulties for the agencies that rely solely on the PSC.

### 4.3 Microbiological Contaminants

Under the Surface Water Treatment Rule (SWTR), the general requirements are to provide treatment to ensure at least 3-log reduction of *Giardia lamblia* cysts and at least 4-log reduction of viruses. The IESWTR requires 2-log reduction of *Cryptosporidium*. Source water monitoring for *Cryptosporidium*, conducted to comply with the LT2ESWTR, will be used to determine if additional inactivation of *Cryptosporidum* is required. Filtered water systems are classified in one of four bins based on their monitoring results, as shown in **Table 5**.

**Table 5. LT2ESWTR Bin Classification and Action Requirements**

| Bin Classification | Maximum Running Annual Average (oocysts/L) | Action Required (log reduction) |
|---|---|---|
| 1 | < 0.075 | none |
| 2 | 0.075 to < 1.0 | 1 |
| 3 | 1.0 to < 3.0 | 2 |
| 4 | ≥ 3.0 | 2.5 |

The California SWTR Staff Guidance Manual provides a description of source waters that require additional treatment above the minimum 3-log *Giardia* and 4-log virus reduction (California Department of Health Services, 1991). The Guidance Manual states "...in a few situations, source waters are subjected to significant sewage and recreational hazards, where it may be necessary to require higher levels of virus and cyst removals...". Due to the expense and uncertainties associated with pathogen monitoring, CDPH staff historically relied on monthly median total coliform levels as a guide for increased treatment. When monthly medians exceeded 1,000 most probable number per 100 milliliters (MPN/100 ml), CDPH staff considered requiring additional log reduction. More recently, CDPH staff has started to rely upon fecal coliform and *Escherichia coli* (*E. coli)* as more specific indicators of mammalian fecal contamination. When the monthly median *E. coli* or fecal coliform density exceeds 200 MPN/100 ml, CDPH staff considers requiring additional log reduction.

The monitoring conducted for the LT2ESWTR is discussed first for all treatment plants treating PSC water. This is followed by a discussion of the coliform data collected at the intakes to each of the water treatment plants. To calculate median coliform densities, data results that were reported as non-detectable were set to zero and those results that were reported as greater than an upper limit were set at the specific upper limit.

### *Long-Term 2 Enhanced Surface Water Treatment Rule Monitoring*

SID collected samples in the PSC at the Eldredge Pumping Plant (milepost 11.80) between October 2006 and September 2008 to comply with the LT2ESWTR. CDPH had previously determined that this monitoring location was representative of the quality of water taken into all water treatment plants that treat 100 percent PSC water. Since several of the water treatment plants also treat water from the NBA, samples were collected on the same dates at the Barker Slough Pumping Plant. For the plants that treated a blend of PSC and NBA water during this time, a flow-weighted average concentration of *Cryptosporidium* was calculated to determine compliance with the LT2ESWTR. *Cryptosporidium* was detected twice at 0.1 oocyts/L in the samples collected from the PSC and it was not detected in any of the NBA samples. This resulted in a Bin 1 classification for all of the plants treating 100 percent PSC water or blends of PSC and NBA water. A second round of source water monitoring for the Putah South Canal and the North Bay Aqueduct is planned to begin by April 1, 2015.

### *Gibson Canyon WTP*

Total coliform and *E. coli* data were collected weekly from 2006 through 2011. Total coliform densities range from <2 to 2,419 MPN/100 ml with an overall median of 80 MPN/100 ml. Several samples were not diluted sufficiently during analysis, so results were reported as >1,600 MPN/100 ml, so the actual peak levels cannot be confirmed. *E. coli* densities ranged from <1 to 900 MPN/100 ml with an overall median of 7 MPN/100 ml. The monthly median total coliform densities are shown in **Figure 9** and the monthly median *E. coli* densities are shown in **Figure 10**. Only one monthly median of 1,050 MPN/100 ml in June 2006 exceeded the 1,000 MPN/100 ml threshold for total coliforms. The *E. coli* monthly medians were well below the 200 MPN/100 ml threshold. These data indicate that 2-log *Cryptosporidium*, 3-log *Giardia*, and 4-log virus removal and inactivation is the appropriate level of treatment.

### *Vacaville WTP*

Total coliform and fecal coliform data were collected weekly from 2006 through 2011 during the months that the plant was operating. Total coliform densities range from 86 to 6,867 MPN/100 ml with an overall median of 1,046 MPN/100 ml. Fecal coliform densities ranged from <1 to 240 MPN/100 ml with an overall median of 13 MPN/100 ml. The monthly median total coliform densities are shown in **Figure 11** and the monthly median fecal coliform densities are shown in **Figure 12**. The monthly medians in June of two years and July of four years exceeded the 1,000 MPN/100 ml threshold for total coliforms. The fecal coliform monthly medians were well below the 200 MPN/100 ml threshold. These data indicate that 2-log *Cryptosporidium*, 3-log *Giardia*, and 4-log virus removal and inactivation is the appropriate level of treatment.

**Figure 9. Monthly Median Total Coliforms at the Gibson Canyon WTP**

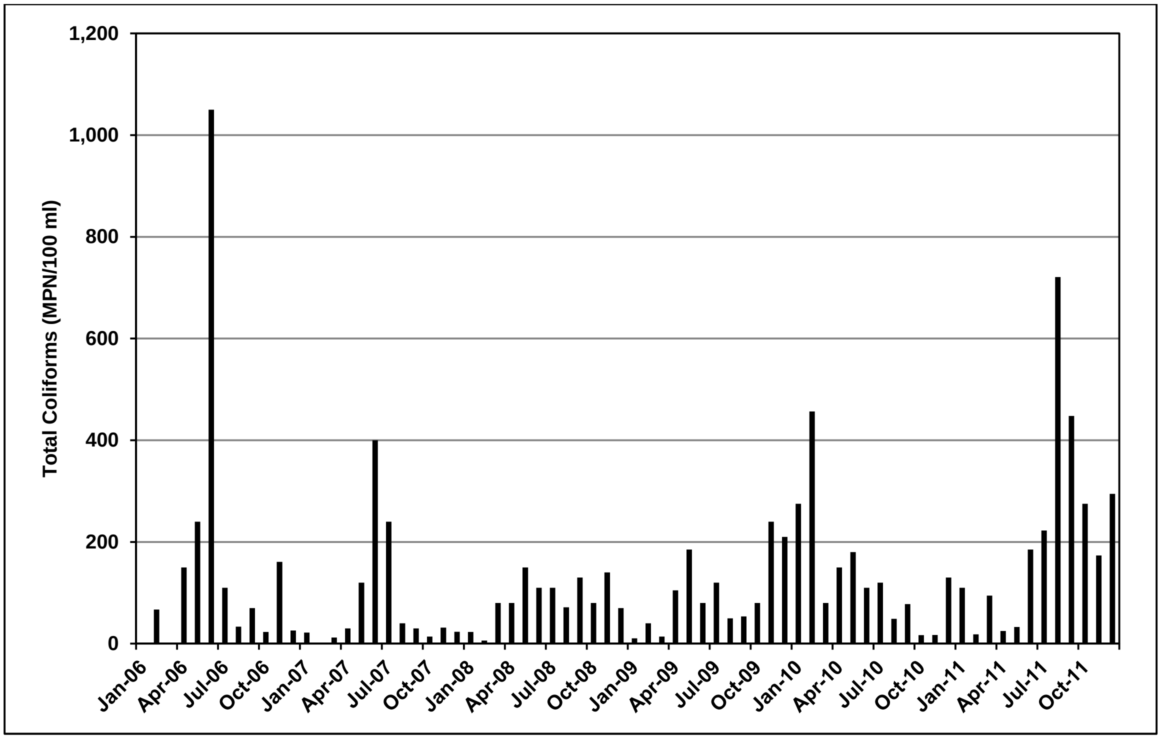



**Figure 10. Monthly Median *E. coli* at the Gibson Canyon WTP**

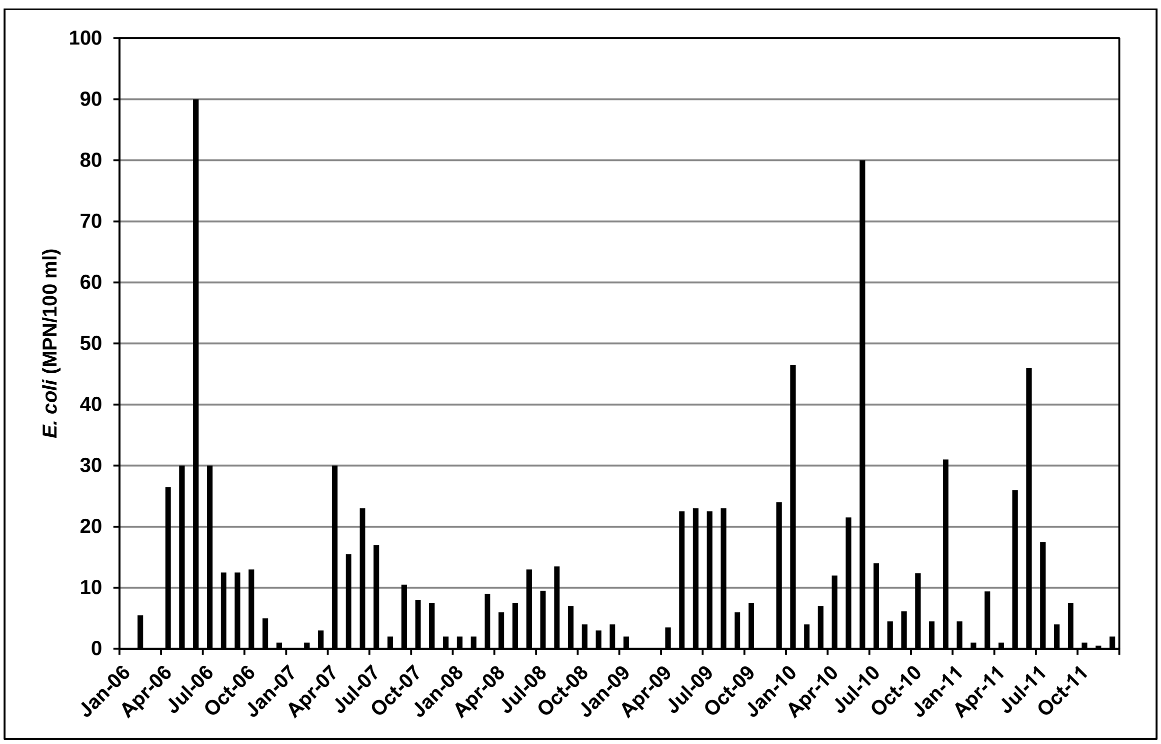


**Figure 11. Monthly Median Total Coliforms at the Vacaville WTP**

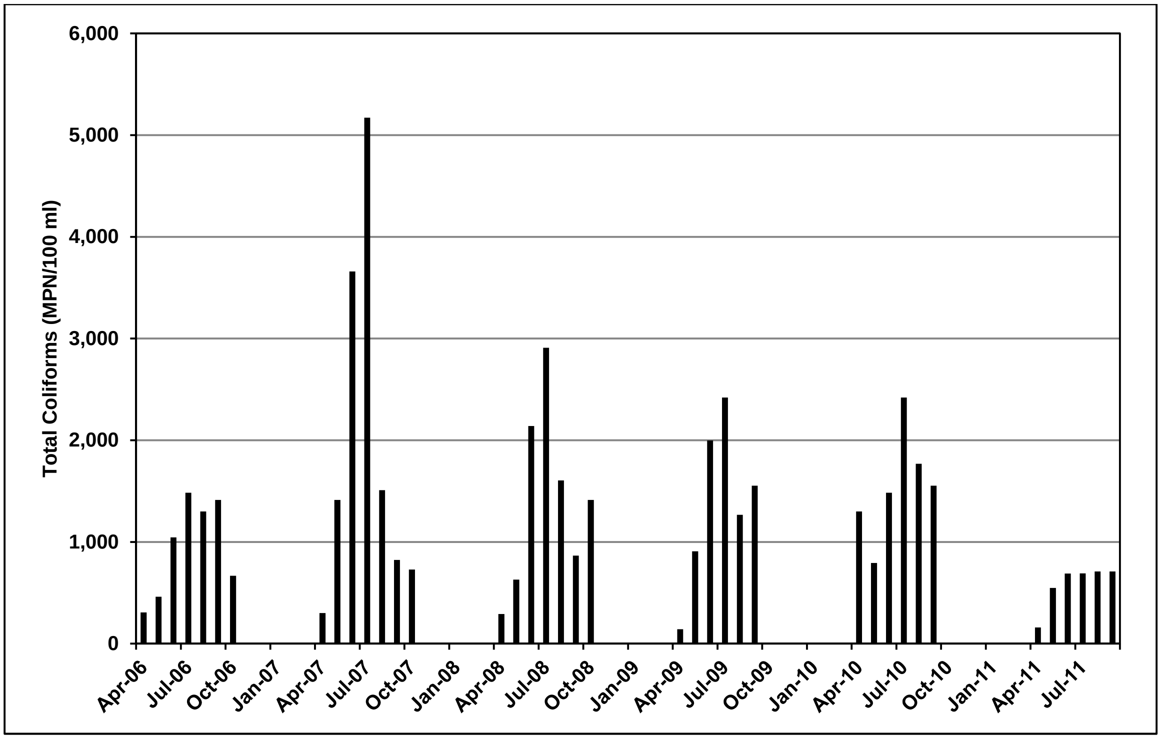
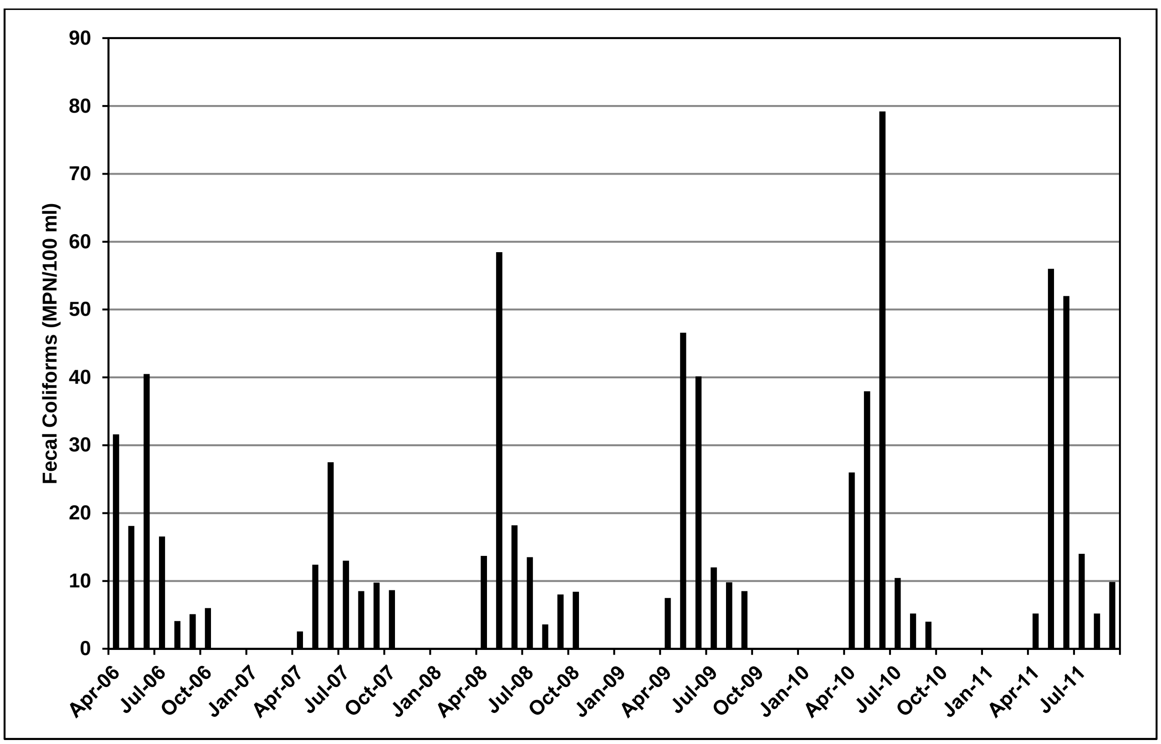



**Figure 12. Monthly Median Fecal Coliforms at the Vacaville WTP**



### *North Bay Regional WTP*

Fecal coliform data were collected between September 2008 and June 2011. The sampling frequency varied from one sample per month to almost daily sampling. Fecal coliform densities ranged from <2 to >1,600 MPN/100 ml with an overall median of 23 MPN/100 ml. Several samples were not diluted sufficiently during analysis so results were reported as >1,600 MPN/100 ml, so the actual peak levels cannot be confirmed. *E. coli* data were collected once a month between October 2006 and September 2009 when the LT2ESWTR monitoring was conducted. E. coli monitoring resumed in October 2011 with several samples collected each month. *E. coli* densities ranged from <1 to 326 MPN/100 ml with an overall median of 6 MPN/100 ml. **Figure 13** presents the monthly median fecal coliform data and **Figure 14** presents the monthly median *E. coli* data. The fecal coliform monthly medians were well below the threshold of 200 MPN/100 ml. The *E. coli* data show that three months exceed the 200 MPN/100 ml threshold; however, only single samples were collected during these months. These data indicate that 2-log *Cryptosporidium*, 3-log *Giardia*, and 4-log virus removal and inactivation is the appropriate level of treatment at the NBR WTP.

### *Cement Hill WTP*

Total coliform and *E. coli* data were collected weekly from 2006 through 2011. Total coliform densities range from <2 to >2,419 MPN/100 ml with an overall median of 110 MPN/100 ml. Several samples were not diluted sufficiently during analysis so results were reported as >1,600 or >2419 MPN/100 ml, so the actual peak levels cannot be confirmed. *E. coli* densities ranged from <1.8 to 1,600 MPN/100 ml with an overall median of 8 MPN/100 ml. The monthly median total coliform densities are shown in **Figure 15** and the monthly median *E. coli* densities are shown in **Figure 16**. Only one monthly median of 1,050 MPN/100 ml in June 2006 exceeded the 1,000 MPN/100 ml threshold for total coliforms. The *E. coli* monthly medians were well below the 200 MPN/100 ml threshold.

**Figure 13. Monthly Median Fecal Coliforms at the NBR WTP**

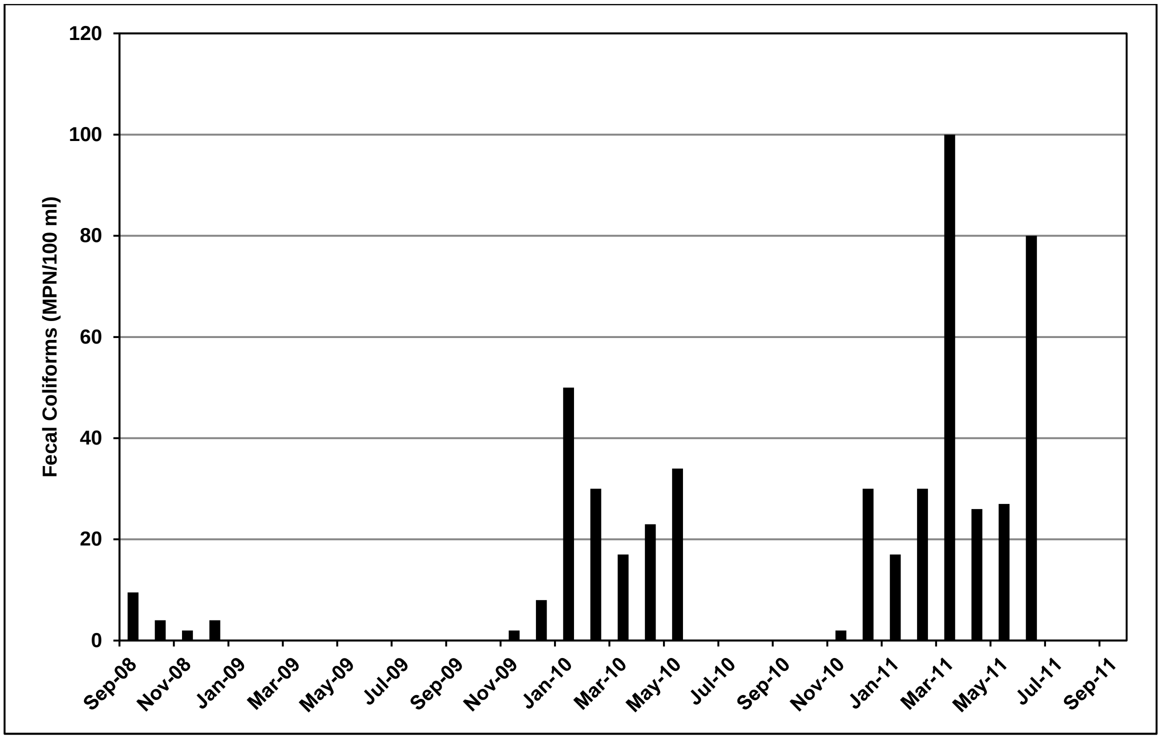



**Figure 14. Monthly Median *E. coli* at the NBR WTP**

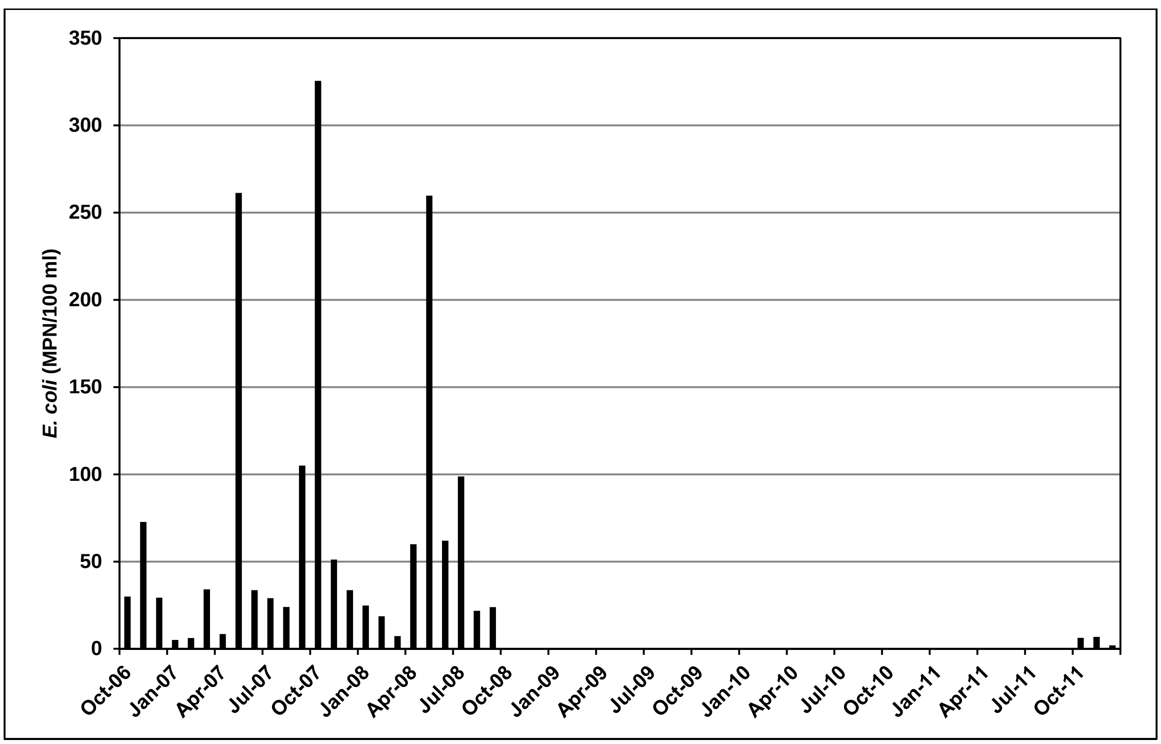


**Figure 15. Monthly Median Total Coliforms at the Cement Hill WTP**

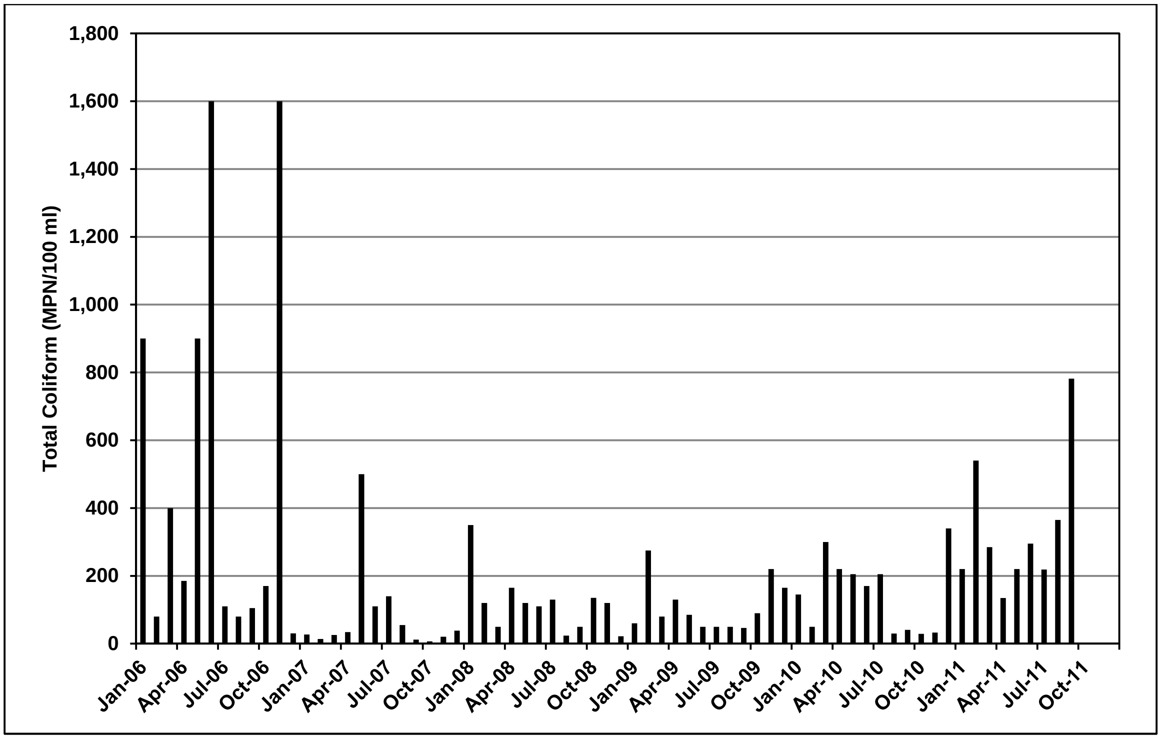
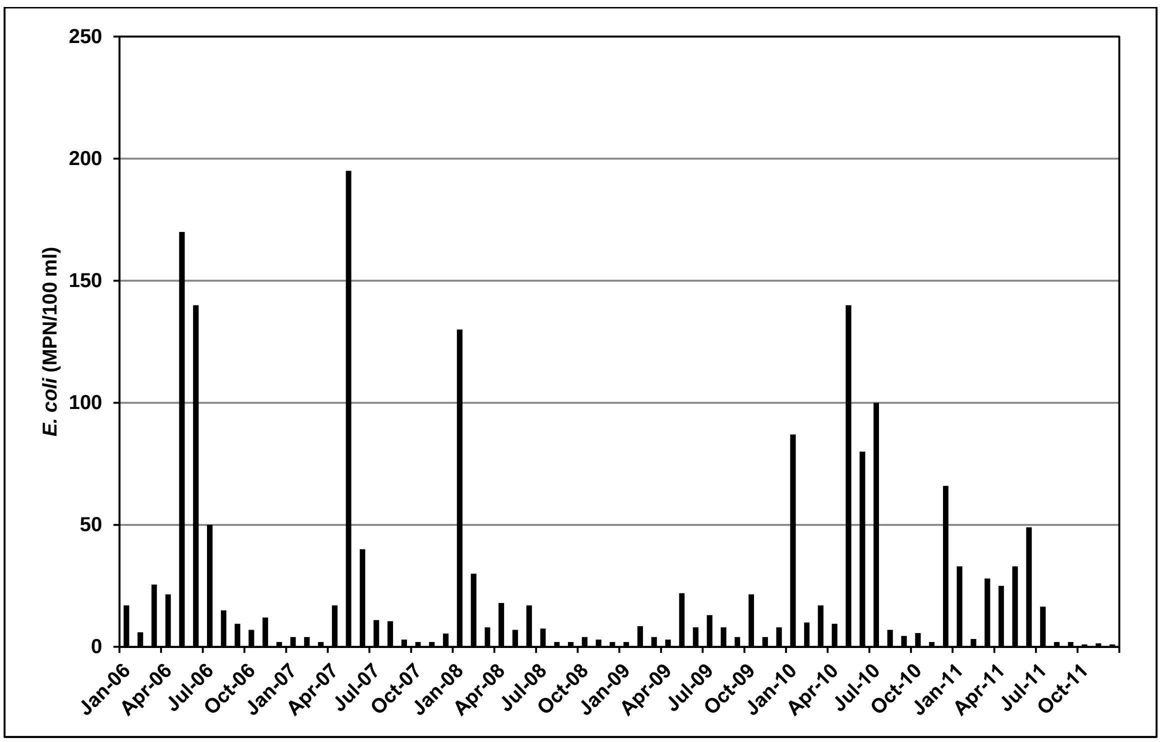



**Figure 16. Monthly Median *E. coli* at the Cement Hill WTP**



### *Waterman WTP*

Fecal coliform data were collected weekly between January 2006 and August 2011. Fecal coliform densities ranged from <2 to 1,600 MPN/100 ml with an overall median of 8 MPN/100 ml. *E. coli* data were collected once a month between October 2006 and September 2008 when the LT2ESWTR monitoring was conducted. Weekly *E. coli* monitoring resumed in September 2011. *E. coli* densities ranged from <1 to 68 MPN/100 ml with an overall median of 6 MPN/100 ml. **Figure 17** presents the monthly median fecal coliform data and **Figure 18** presents the monthly median *E. coli* data. The fecal coliform and *E. coli* monthly medians were well below the threshold of 200 MPN/100 ml.

### *Benicia WTP*

Benicia provided total coliform, fecal coliform, and *E. coli* data for the months that PSC water was being treated between January 2006 and December 2010. Total coliform densities ranged from 13 to 300 MPN/100 ml with an overall median of 36 MPN/100 ml. Fecal coliform densities ranged from <2 to 45 MPN/100 ml with an overall median of 5 MPN/100 ml. *E. coli* was not detected in any of the samples. **Figure 19** presents the total coliform data and **Figure 20** presents the fecal coliform data. Although these graphs show single samples collected each month, both the total and fecal coliform levels are well below the respective thresholds of 1,000 and 200 MPN/100 ml. These data indicate that 2-log *Cryptosporidium*, 3-log *Giardia*, and 4-log virus removal and inactivation is the appropriate level of treatment.

**Figure 17. Monthly Median Fecal Coliforms at the Waterman WTP**

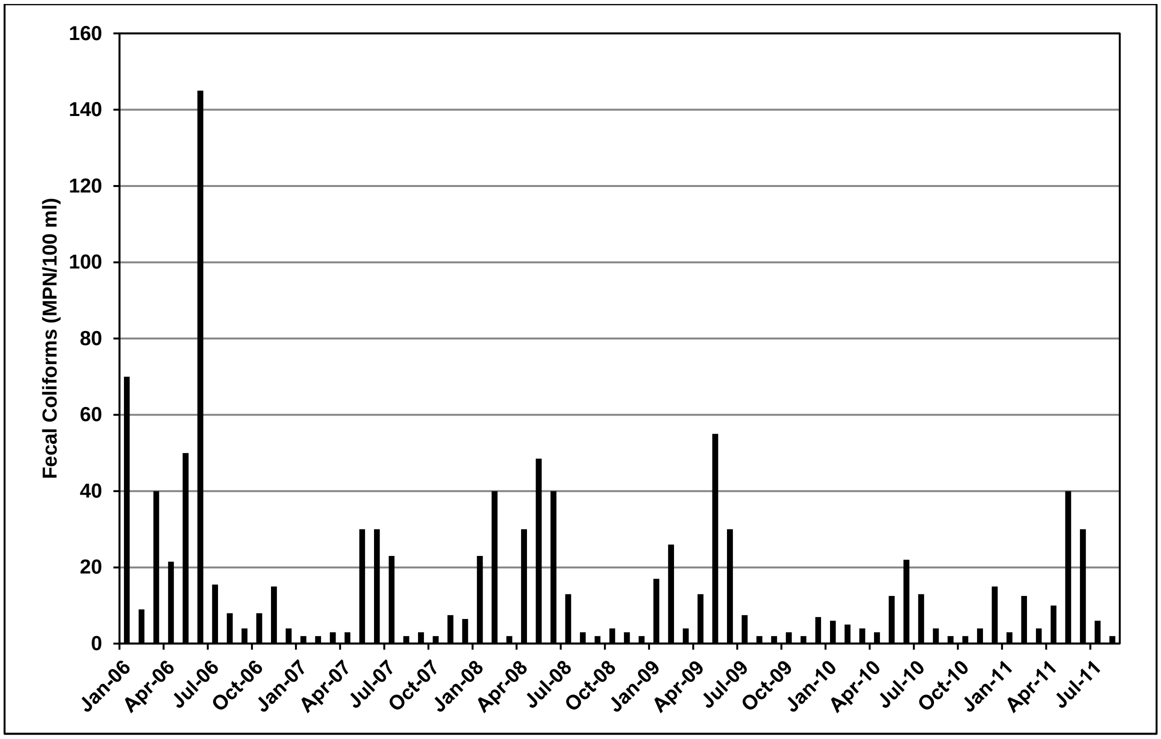
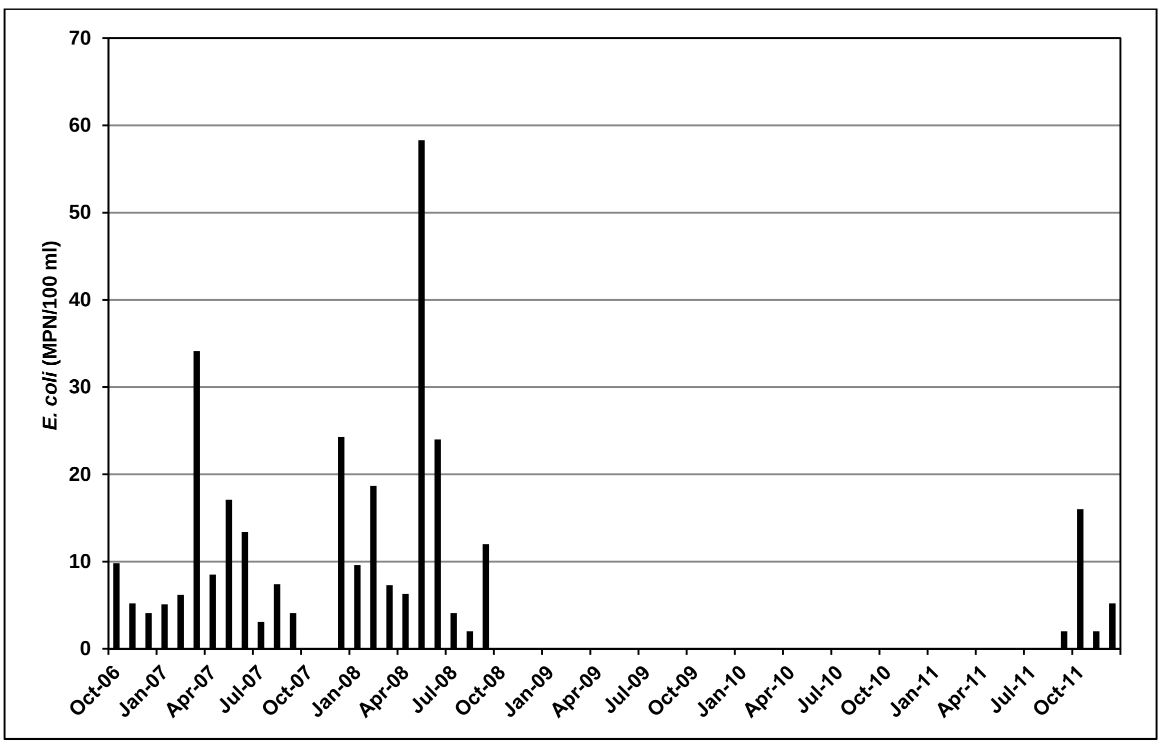
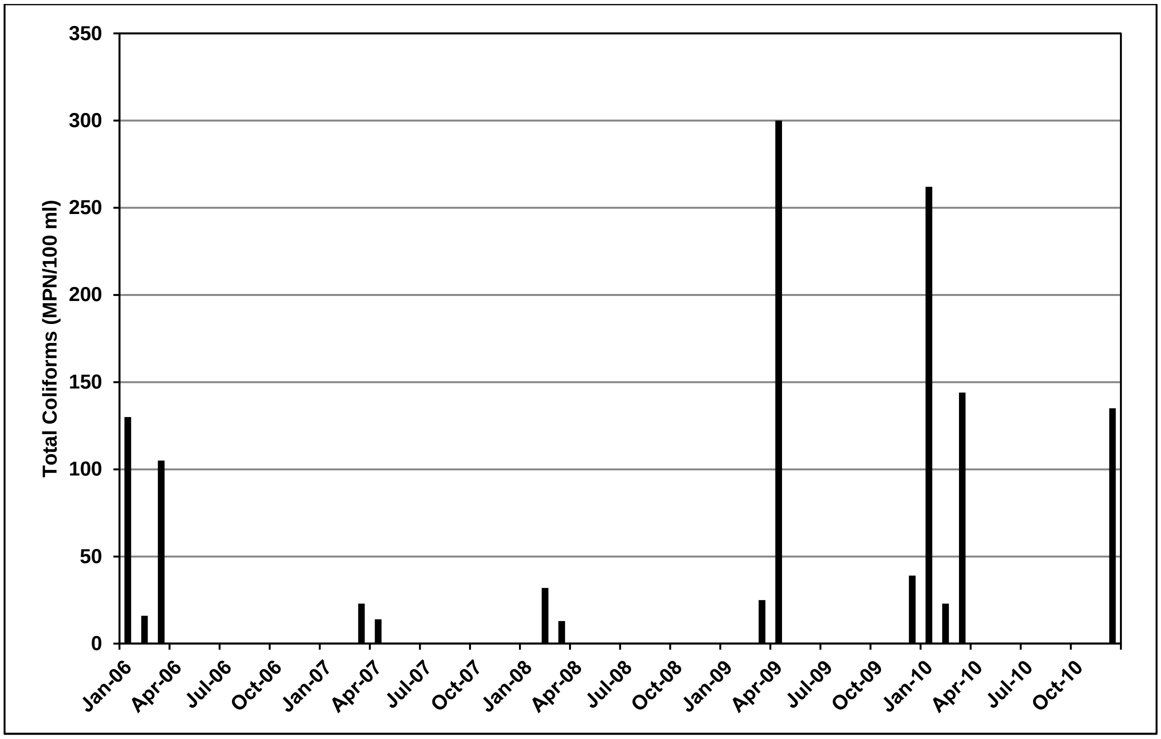


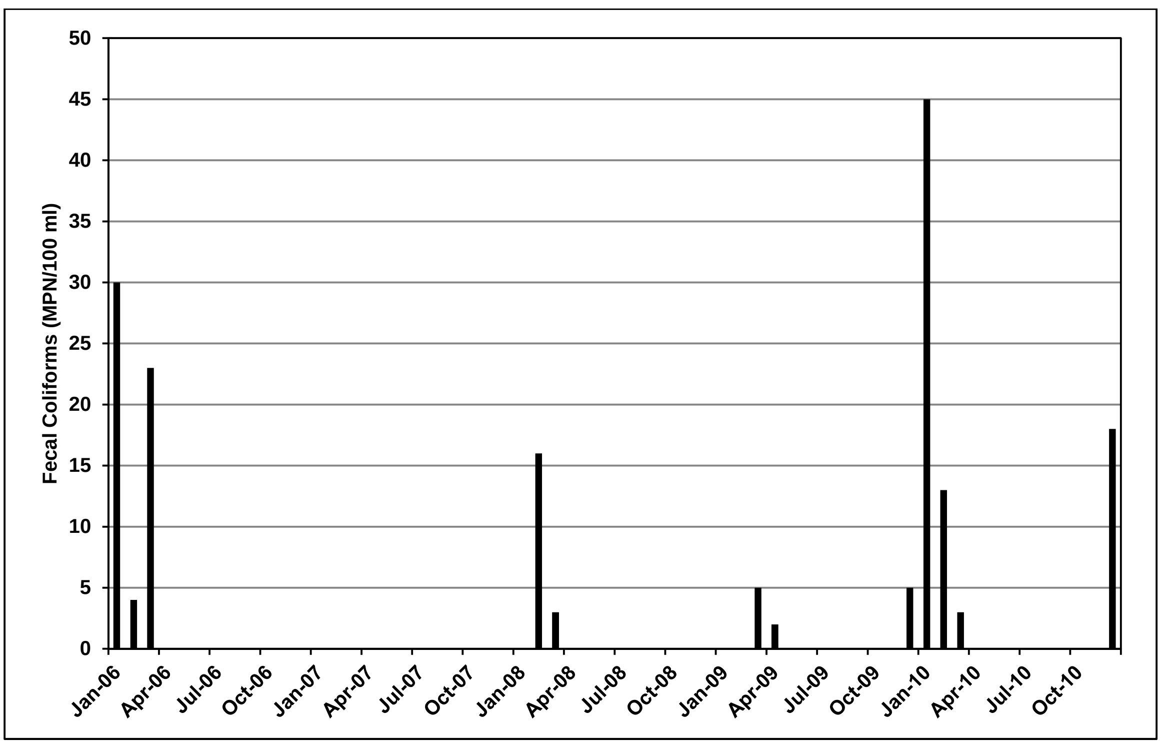

**Figure 18. Monthly Median *E. coli* at the Waterman WTP**



## Figure 19. Total Coliforms at the Benicia WTP Intake




## Figure 20. Fecal Coliforms at the Benicia WTP Intake

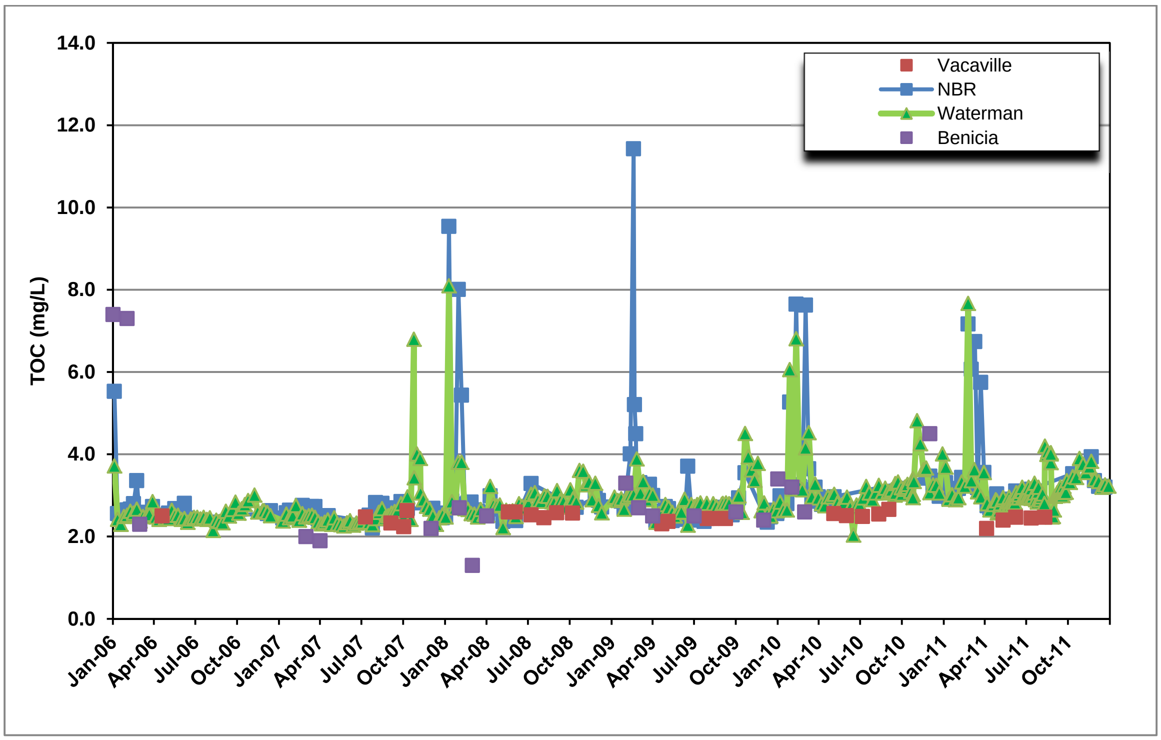


## 4.4 Disinfection Byproduct Precursors

### *Total Organic Carbon*

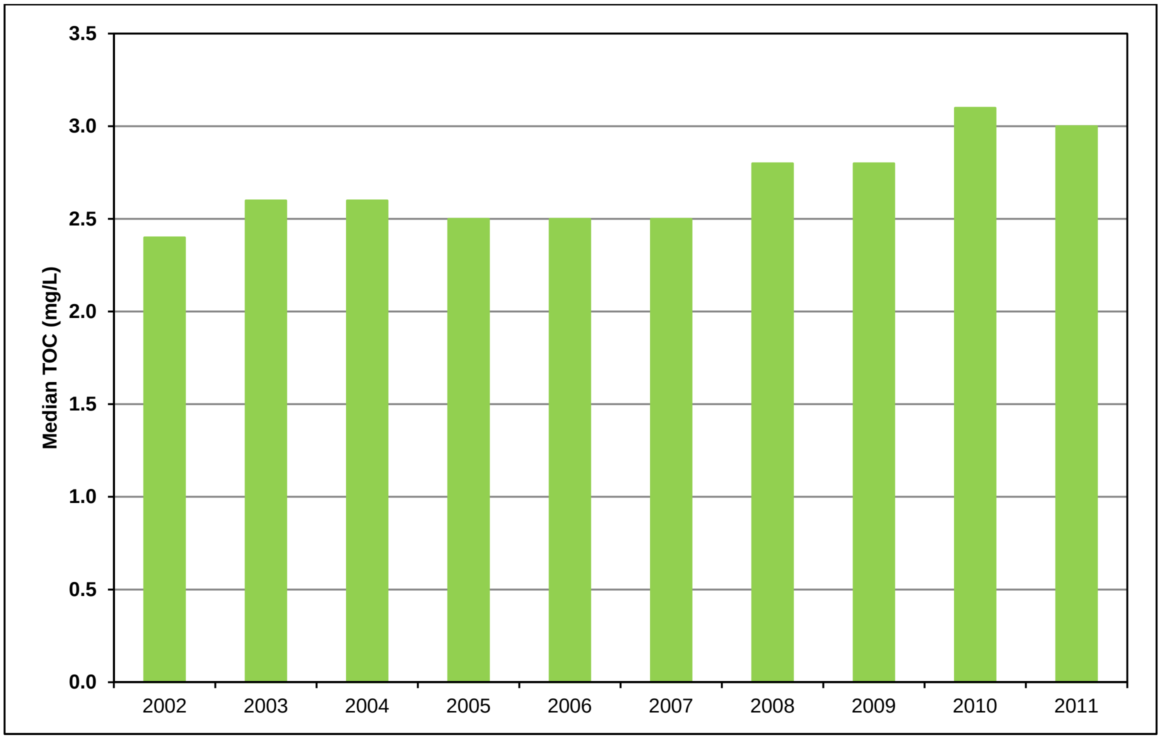
TOC data were available at the intakes of the Vacaville, NBR, Waterman, and Benicia WTPs. **Figure 21** shows the data at these locations. TOC concentrations are generally between 2.0 and 3.0 mg/L and there are no apparent trends along the canal. TOC increases during the wet season with most peaks occurring in January and February. The peak TOC concentration following the December 31, 2005 storm was 7.4 mg/L measured at the Benicia WTP intake. The peak concentration following the January 4, 2008 storm was 9.5 mg/L measured at the NBR WTP intake on January 9. The highest TOC concentration during the 2006 to 2011 period was 11.4 mg/L at the NBR WTP intake on February 18, 2009. Over 3 inches of rain fell between February 15 and 17, 2009. Although flooding did not occur during this period, a large amount of organic matter was washed into the canal via the Putah Creek watershed.

**Figure 21. TOC in the PSC**




The Waterman WTP data show peaks in TOC concentrations of 4.5 to 6.8 mg/L during the fall months. These peaks may be due to canal cleaning operations. NHC et al. (2010) reported a TOC concentration of 106 mg/L during canal cleaning operations. These high levels are not seen in the routine monitoring conducted at the WTPs along the canal. **Figure 21** shows an increasing trend in TOC concentrations in recent years for the Waterman WTP. The Waterman WTP TOC data from the 2006 Update were combined with the recent data and annual median concentrations were plotted. **Figure 22** presents the annual medians from 2002 to 2011. This plot shows that annual median concentrations were between 2.4 and 2.6 mg/L during the 2002 to 2005 period covered by the 2006 Update. During the 2006 to 2011 period, the annual medians range from 2.5 to 3.1 mg/L. The higher TOC concentrations may be due to the organic matter that is left in the canal after canal cleaning.

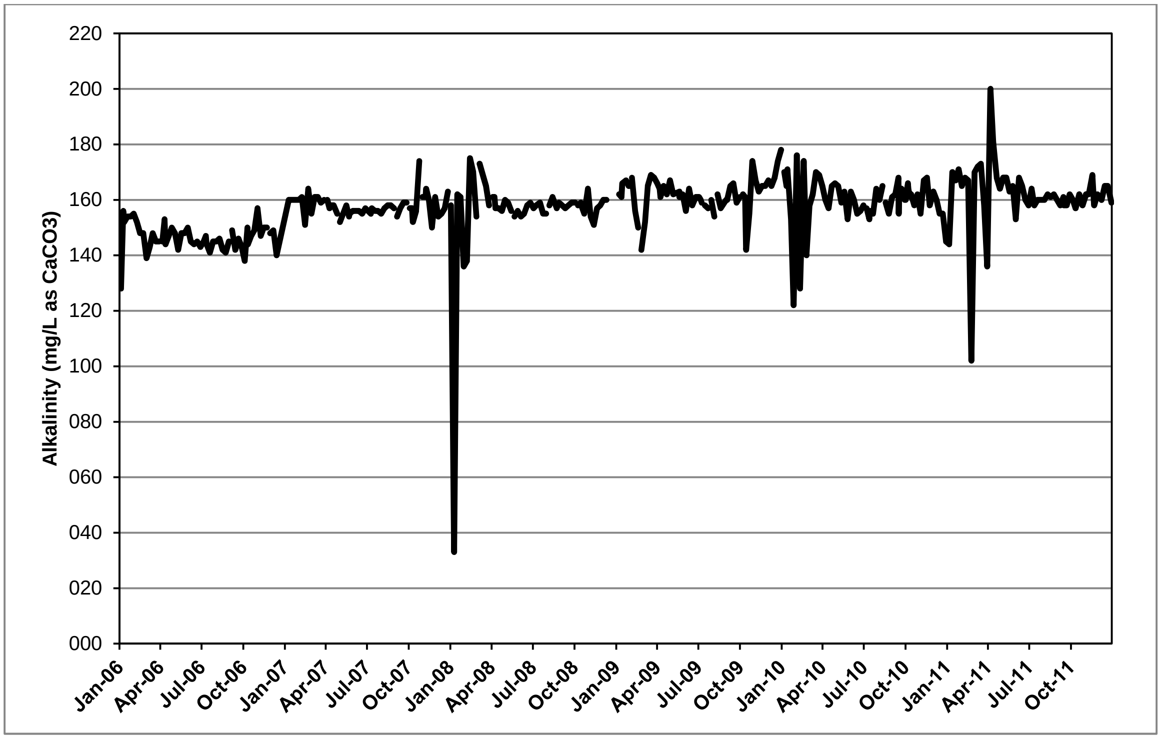
**Figure 22. Annual Median TOC Concentrations at the Waterman WTP**




### *Alkalinity*

Enhanced coagulation is required for the plants that treat Solano Project water because the source water TOC is routinely above 2 mg/L and they implement conventional filtration processes. The amount of TOC reduction is based on both the source water TOC and alkalinity levels. As shown in **Figure 23**, alkalinity is generally between 140 and 170 mg/L as $CaCO_3$ at the Waterman WTP. When alkalinity is greater than 120 mg/L as $CaCO_3$ and TOC is between 2 and 4 mg/L, 15 percent reduction of TOC is required. When alkalinity drops or TOC increases, greater removal of TOC is required. **Figure 23** indicates that alkalinity occasionally drops below 120 mg/L. The decreased alkalinity occurs during storm events when TOC concentrations are often elevated. Alkalinity dropped to 33 mg/L as $CaCO_3$ during the January 4, 2008 storm event. This was accompanied by a TOC concentration of 8.1 mg/L. The alkalinity data collected at the NBR WTP intake and the Benicia WTP intake are consistent with the data from the Waterman WTP.

**Figure 23. Alkalinity at the Waterman WTP**



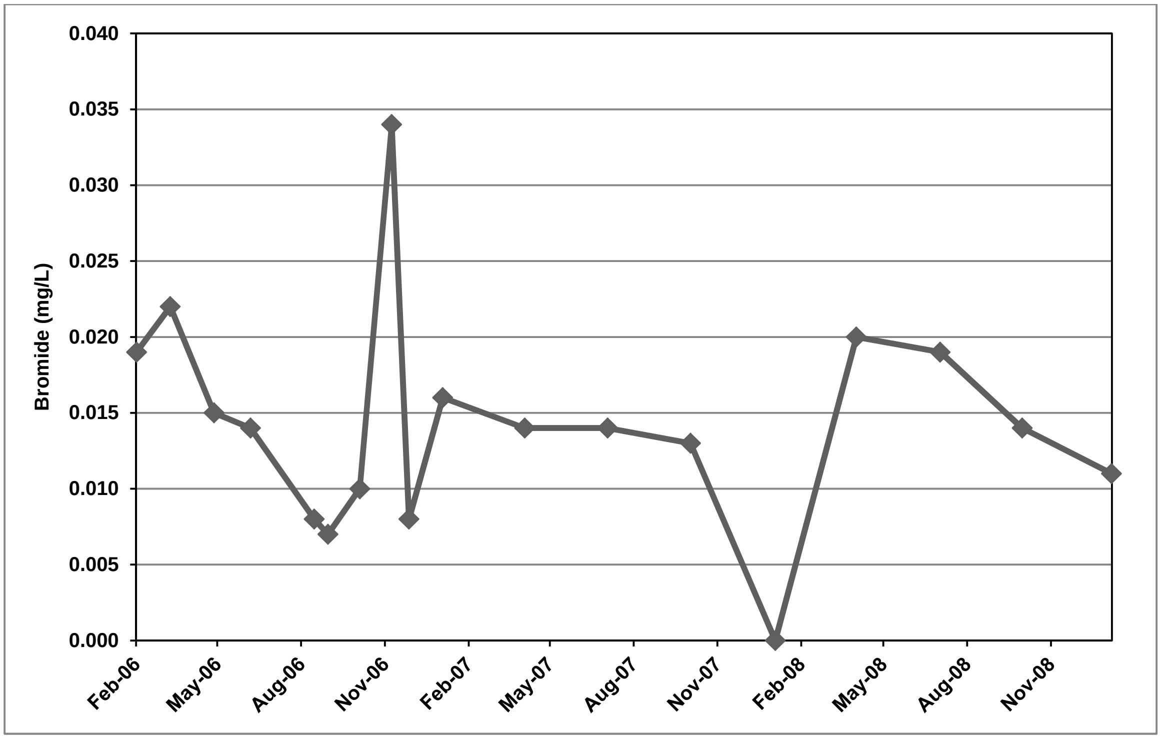

### *Bromide*

Bromide in the source water reacts with chlorine to produce brominated trihalomethanes and haloacetic acids and it reacts with ozone to produce bromate in the finished water. The bromide concentrations at the Waterman WTP intake are shown on **Figure 24**. Bromide is usually less than 0.02 mg/L and never exceeds 0.04 mg/L. In comparison, for the Sacramento-San Joaquin Delta, CALFED established a bromide goal of 0.05 mg/L, which the PSC is substantially below. A recent study conducted for California Urban Water Agencies, showed that plants treating Sacramento-San Joaquin Delta water could easily meet existing disinfection byproduct MCLs with bromide concentrations of 0.20 mg/L and TOC concentrations ranging from 2.0 to 7.0 mg/L (Malcolm Pirnie, 2010). These low levels of bromide in the PSC do not create water treatment challenges.

### *Trihalomethanes and Haloacetic Acids*

The Annual Water Quality Reports prepared by each water provider treating PSC water were reviewed to determine compliance with the treated water standards of 80 µg/L for TTHMs and 60 ug/L for HAA5. The water providers are currently meeting the standards and most are meeting the standards with a large margin of safety. The City of Vallejo indicated that the TTHM standard was violated in the first few months of 2006 for their Lakes System that is served by the Green Valley WTP. That system is now meeting the standard due to the installation of MIEX pretreatment at the WTP.

**Figure 24. Bromide Concentrations at the Waterman WTP**




## 4.5 Pesticides

As discussed previously, the pesticides used along the PSC are copper, diuron, glyphosate, 2,4-D amine, triclopyr, clopyralid, amino pyralid, and aluminum phosphide. Of these chemicals, only copper, glyphosate, and 2,4-D have drinking water standards. The pesticides used in the watershed of Putah Creek were presented previously in **Table 4**. There are no drinking water standards for most of these pesticides, with the exception of copper and glyphosate.

Copper is the pesticide used in the greatest quantity along the PSC. Although copper is a drinking water contaminant, the primary source of copper in treated supplies is plumbing. The major concern for copper in source water is that it is concentrated in the WTP sludge and can result in the sludge being classified as a hazardous waste.

Copper data are collected at varying frequencies at the NBR and Waterman WTP intakes. Between January 2006 and December 2011, 40 samples were collected at the NBR intake and 77 samples were collected at the Waterman intake. Copper was detected on four dates, as shown in **Table 6**. All of the other samples were reported as <50 µg/L. Although this detection level is sufficiently low to determine compliance with the secondary MCL of 1.0 mg/L, it is not low enough to examine any trends in copper because most of the samples were reported as <50 µg/L. The copper concentration exceeded 50 µg/L on January 9, 2008 at both the NBR and Waterman intakes. This was about the time that the turbidity plume from the January 4, 2008 storm was passing by the intakes. The highest levels of copper were found in duplicate samples collected at the NBR intake on April 4, 2008. This is likely due to the application of copper sulfate to control algae in the canal since there had not been any significant rain in the area for several weeks. Similarly, the July 2008 and June 2011 copper concentrations were likely due to copper sulfate applications. SID notifies the WTP operators when a copper sulfate application is planned. The water providers avoid taking water into the treatment plants during these periods.

**Table 6. Copper Detections at the NBR and Waterman WTP Intakes**

| Date | Copper (µg/L) | Location |
|---|---|---|
| 1/9/08 | 61 | Waterman |
| 1/9/08 | 51 | NBR |
| 4/4/08 | 148 | NBR |
| 4/4/08 | 136 | NBR |
| 7/8/08 | 69 | Waterman |
| 6/29/11 | 92 | Waterman |

The Title 22 pesticides are monitored twice a year at the NBR and Waterman WTP intakes. Samples are collected in January to characterize wet season conditions and in October to characterize dry season conditions. Other pesticides are occasionally monitored. SID provided data for the Vacaville intake and the Terminal Reservoir for samples collected in April and July, 2012. **Table 7** provides a summary of the data collected for pesticides that are used in the watershed. Diuron was the only pesticide used in the watershed that was detected in the monitoring. It was measured at 2.6 µg/L at the Waterman WTP intake on January 9, 2008. This was about the time that the turbidity plume from the January 4, 2008 storm was passing by the intake. Diuron was not detected in a sample collected at the NBR intake on January 22, 2008. There is no drinking water MCL for diuron. None of the other Title 22 pesticides were detected at the four monitoring locations.

**Table 7. Pesticide Concentrations in the PSC**

| Pesticide | Vacaville | | NBR | | Waterman | | Terminal Reservoir | |
|---|---|---|---|---|---|---|---|---|
| | No. of Samples | Range | No. of Samples | Range | No. of Samples | Range | No. of Samples | Range |
| 2,4-D | 2 | <0.1 | 8 | <0.1 | 9 | <0.1 | 2 | <0.1 |
| Chlorpyrifos | 2 | <0.05 | 2 | <0.05 | 2 | <0.05 | 2 | <0.05 |
| Diazinon | 2 | <0.1 | 2 | <0.1 | 2 | <0.1 | 2 | <0.1 |
| Diuron | 2 | NA | 4 | <1.0 | 6 | <1.0 - 2.6 | 2 | NA |
| Glyphosate | 2 | <6 - <25 | 8 | <6 | 9 | <6 | 2 | <6 - <25 |

## 5.0 WATERSHED MANAGEMENT PRACTICES

The 2006 Update recommended several actions that SCWA, SID, and water providers treating PSC water should take to protect source water quality in the PSC. These recommendations and the agencies' responses are discussed in this section.

### 5.1 Turbidity

#### *Recommendation*

SID, SCWA, and the individual water providers are doing all that they reasonably can to lessen the impact of the highly turbid water on the drinking water supplies. The real-time monitoring network along the PSC should be maintained and the results should be monitored during storm events so that decisions on diverting water into the canal and at individual water intakes can be made, to the extent feasible, based on the turbidity levels. The real-time data are a valuable tool to monitor the progression of turbidity slugs along the canal. The WTP operators should continue their current practice of optimizing treatment during periods of elevated turbidity. The feasibility and cost effectiveness of implementing source control measures should be determined after the PSC Turbidity and Sediment Management Study is completed.

#### *Response*

As discussed in the Contaminant Sources section, SCWA has expanded the real-time monitoring program and uses the data to advise SID and the water providers on operations during storm events. The sediment management study was completed and SCWA and SID have begun implementing the recommended management measures.

### 5.2 Microbiological Contaminants

#### *Recommendation*

The monthly monitoring for *Cryptosporidium* and *E. coli* required by the LT2ESWTR will provide additional data to determine if the current 2-log *Cryptosporidium*, 3-log *Giardia*, and 4-log virus reduction requirements are adequate for the WTPs that treat Solano Project water. Until that monitoring is completed, existing data suggest that the current 2/3/4-log reduction required by CDPH is adequate. The treatment plants should continue their current practice of optimizing treatment during storm events and avoiding the highly turbid slugs of water. Although not required by the LT2ESWTR, water providers may consider collecting total coliform and fecal coliform data along with the protozoa data to determine if there is a correlation between the coliform data and the pathogen data. The monitoring results for each of the intakes along the canal should be reviewed collectively to determine if there are any inconsistencies or trends in the data. The need to address control of pathogens in the watershed should be reevaluated based on the monitoring results.

***Response***

As discussed in the Water Quality section, the LT2ESWTR monitoring has been completed and the water treatment plants have all been given a Bin 1 designation by CDPH. These data indicate that 2-log *Cryptosporidium*, 3-log *Giardia*, and 4-log virus reduction requirements are adequate for the WTPs that treat Solano Project water. The management measures that are being implemented to control sediment will also provide benefits in controlling microbial contaminants since microbial contaminants are often transported along with the sediment particles.

### 5.3 Disinfection Byproduct Precursors

***Recommendation***

The water providers should conduct their Initial Distribution System Evaluations (IDSE) required by the Disinfectants/Disinfection Byproducts (D/DBP) Rule. An IDSE must be performed to identify locations with representative high TTHM and HAA5 concentrations throughout a system's retail distribution system. The IDSE results will be used in conjunction with the Stage 1 D/DBP Rule compliance monitoring to identify and select Stage 2 D/DBP Rule routine compliance monitoring locations.

***Response***

The water providers treating PSC water have completed their IDSE reports.

### 5.4 Algal Blooms

***Recommendation***

A nutrient monitoring program may provide further insight into the sources and trends of nutrients in the PSC. Unless a specific, controllable source is identified, there is little more SID can do beyond treating the canal with copper sulfate.

***Response***

SCWA contracted with NHC to conduct an investigation of the sources of algae and aquatic weeds in the PSC. NHC has recommended a number of actions that SID and SCWA can take to better manage algae and aquatic weeds.

### 5.5 Pesticides

***Recommendation***

Although pesticides are not likely to be a drinking water quality concern, an effort should be made to conduct organophosphate pesticide monitoring at the drinking water intakes during the dormant spray season, typically December through February.

***Response***

The City of Fairfield conducts Title 22 pesticide monitoring in January, to characterize wet season conditions, and in October, to characterize dry season conditions. The January samples are collected during the dormant spray season. No organophosphate pesticides were detected during the 2006 to 2011 period.

### 5.6 Spills and Illegal Dumping

***Recommendation***

The existing coordination between emergency response agencies, SID, and the WTP operators is effectively protecting drinking water quality and should be continued.

***Response***

The agencies continue to coordinate on emergency response.

### 5.7 Urban Runoff

***Recommendation***

SCWA should maintain its current policy of not allowing urban runoff to be discharged to the PSC except under extreme storm conditions. As rural land is converted to urban uses, developers should be required to route the urban runoff over or under the canal. SCWA should monitor growth in the Winters area and, if growth proceeds to the west along Lake Solano and upper Putah Creek, SCWA should insist that Winters develop a storm water management plan that addresses protection of drinking water quality. SID should maintain its current practice of requiring developers to route all urban runoff under or over the PSC.

***Response***

The policy of routing urban runoff under or over the canal is still in effect. Winters has not expanded to the west and remains out of the watershed of the PSC.

### 5.8 Watershed Programs

***Recommendation***

SCWA and SID should continue to support the public education programs of the Putah Creek Discovery Center and the Lower Putah Creek Coordinating Committee (LPCCC).

***Response***

Both SCWA and SID serve on the LPCCC. In addition, SCWA serves as the fiscal agent for LPCCC restoration projects and has administered over $10 million of grant funds since 2000

(Personal Communication, Rich Marovich). SCWA also provides the $300,000 budget that funds the Putah Creek Streamkeeper, fish and wildlife monitoring, and vegetation management. SCWA also provides engineering and administrative support at no cost to LPCCC. The City of Davis recently awarded the Davis Environmental Award to SCWA for their support of LPCCC.

SCWA also provides $40,000 per year to help fund WaterWays. WaterWays is an outdoor education program for elementary students that is designed to build understanding of Putah Creek

# 6.0 FINDINGS AND RECOMMENDATIONS

There has been minimal change in the watershed of Putah Creek below Monticello Dam and in the watershed of the PSC in the last five years.

## 6.1 Interdam Reach

### *Finding*

The primary contaminant sources in the Interdam Reach are erosion, agricultural discharges, and recreation. There is no evidence that agricultural discharges and recreation are impacting water quality in the PSC at this time. Recreational use of Stebbins Cold Canyon Reserve has increased in the last five years and will likely continue to increase. There are currently no restroom facilities at the reserve. While the water quality data do not indicate that the reserve is a source of microbial contaminants to the PSC, the feasibility of installing portable restroom facilities should be evaluated.

### *Recommendation*

SCWA should work with UC Davis to determine the cost and feasibility of installing and maintaining portable restroom facilities at Stebbins Cold Canyon Reserve.

## 6.2 PSC Contaminant Sources

### *Finding*

The water suppliers have identified canal cleaning operations, copper sulfate treatments, and turbidity during winter storms as the primary water quality concerns. SCWA has thoroughly investigated the sources of turbidity and aquatic weed growth and has implemented some management practices to alleviate erosion along the canal. SCWA is currently conducting a feasibility study for improvements at the Headworks, including finer screens, sediment deflection, and sediment flushing. SCWA is also investigating methods of controlling the aquatic weed growth in the canal. In addition, SCWA is conducting a feasibility study for a winter-time alternate intake upstream of Pleasants Creek, which delivers the largest turbidity sediment load of all the Interdam Reach tributaries. SCWA is also conducting studies on alternative methods of cleaning the canal to lessen the water quality impacts. SID has decreased the frequency of copper sulfate applications and started using a new product that is effective at lower concentrations of copper.

***Recommendation***

SCWA should complete all of the studies that are currently underway to evaluate methods of alleviating the water quality concerns associated with canal cleaning operations, copper sulfate treatments, and turbidity during winter storms.

## 6.3 Urban Runoff

***Finding***

There is currently no urban development in the Putah Creek watershed and no discharge of urban runoff directly to the Putah South Canal. Immediately to the east of the watershed, near Winters, there is on-going residential development.

***Recommendation***

SCWA should maintain its current policy of not allowing urban runoff to be discharged to the PSC except under extreme storm conditions. As rural land is converted to urban uses, developers should be required to route the urban runoff over or under the canal. SCWA should monitor growth in the Winters area and, if growth proceeds to the west along Lake Solano and upper Putah Creek, SCWA should insist that Winters develop a storm water management plan that addresses protection of drinking water quality.

## 6.4 Microbiological Contaminants

***Finding***

The water agencies conducted LT2ESWTR monitoring during the period covered by this Sanitary Survey Update. All of the WTPs have been placed in Bin 1, indicating that no further action is required to remove or inactivate *Cryptosporidium*.

***Recommendation***

None

## 6.5 Organic Carbon

***Finding***

There appears to be an increasing trend in TOC concentrations at the Waterman WTP intake. This may be related to the organic matter that remains in the canal after cleaning operations.

***Recommendation***

The studies that are currently being conducted by SCWA on alternative methods of cleaning the canal should be accompanied by TOC monitoring to determine if the alternative cleaning methods reverse the trend in TOC concentrations.

## 7.0 REFERENCES

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