calcium, iron, magnesium, sodium, chloride, sulfate, nitrate, potassium, barium, cadmium, copper, mercury, and zinc. Mercury was measured during the spring only; the remaining 21 parameters were measured during all four seasons. Constituent concentrations measured below the detectable limits for laboratory analyses are provided at the minimum reporting level.

TABLE 3-3
WATER QUALITY PARAMETERS MEASURED DURING BASELINE WATER QUALITY MONITORING IN THE PCWA RAW WATER SERVICE AREA

Water Quality Parameters		
Basic Physical and Chemical Parameters	**Major Ions**	**Trace Elements**
Water Temperature	Calcium	Aluminum
pH	Iron	Barium
Alkalinity	Magnesium	Cadmium
Dissolved Oxygen	Potassium	Copper
Specific Conductivity	Sodium	Mercury
Turbidity	Chloride	Zinc
Total Suspended Solids	Nitrate	
	Sulfate	

Water Temperature and Dissolved Oxygen

Water temperature is an important water quality parameter because it affects water chemistry. Higher temperatures can increase the rate of chemical reactions, which can increase chemical toxicity. Water temperatures reflect seasonal variations in air temperatures, with higher temperatures in spring and summer than in fall and winter. Flow velocity also influences water temperatures because a particle of water in a fast-moving stream is exposed to sunlight for a shorter time than that in a slow-moving stream. Water temperature changes in these streams within the PCWA raw water distribution area are assumed to be affected by changes in canal flows. Water temperatures change as water flows downstream from reservoirs. Inputs from runoff and tributaries can also change downstream water temperatures.

DO is a measure of gaseous oxygen dissolved in a liquid. Waters with higher, relatively stable levels of DO are usually considered healthy ecosystems, supporting many different kinds of aquatic organisms. Extreme DO fluctuations may cause organism stress. DO levels would be expected to be greater in areas with higher flows and colder water temperatures. DO is inversely related to temperature because as water temperature increases, the water has less capacity to hold gases, and DO levels decrease. Therefore, warmer water holds less oxygen than colder water. DO levels typically increase with higher flows due to increased turbulence, which may bring more water into contact with the atmosphere, aerating the moving water. DO levels also naturally fluctuate daily depending on rates of respiration, decomposition, or chemical reactions (decrease), and photosynthesis, or diffusion with surrounding air (increase). Daily maximum DO levels typically occur in the afternoon and daily minimum levels occur in the early morning.

pH, Alkalinity, and Hardness

The parameters pH, hardness, and alkalinity are interrelated. The parameter pH is a measure of dissolved hydrogen ions, or acidity. The pH scale ranges from 0 and 14, with 7.0 defined as neutral; solutions with pH lower than 7.0 are considered acidic, while solutions with pH greater than 7.0 are considered basic. The lower the pH value, the higher the acidity. Seasonal pH trends within canals can be influenced by biological processes. Respiration occurs primarily in reservoirs within the system, and rates are highest during spring and summer, when aquatic organisms are more active. Rates of photosynthesis are also highest during spring or summer, when the most sunlight is available. Seasonal pH trends within canals can also be influenced by flow volumes and rainfall.

Whereas acidity is the capacity to neutralize bases, alkalinity is a measure of the capacity of water to neutralize strong acid (Snoeyink and Jenkins, 1980). Alkalinity is a bicarbonate concentration. In general, alkalinity concentrations in natural waters are primarily composed of carbonate, bicarbonate (HCO_3^-), and hydroxyl ions (Tchobanoglous and Schroeder, 1985). High alkalinity values will reduce the variation in pH.

Water hardness is the measurement of the total dissolved minerals, primarily calcium and magnesium ions, in water. Water hardness is the total quantity of bases present to absorb acid in water. Calcium and magnesium are the most common sources of water hardness; therefore, water hardness is typically represented as the sum of calcium and magnesium concentrations. A low hardness value can indicate that calcium carbonate ($CaCO_3$) concentrations are low, but high hardness does not necessarily reflect a high calcium concentration. There are two types of hardness: carbonate and noncarbonate. Carbonate hardness is associated with HCO_3^- and carbonates, and noncarbonate hardness is associated with other anions, particularly chloride, and sulfate. Since water hardness was not measured in this study, it is calculated as total hardness using the following equation:

$$\left[\left(\frac{(Ca^{2+})\ \text{mg/L}}{\left(\frac{(\text{Molecular Weight } Ca^{2+})\ \text{mg/mmol}}{\text{Number of moles}}\right)}\right) \times \begin{array}{c}\text{Eq. Wt. of}\\ \text{CaCO3}\\ \text{(mg/meq)}\end{array}\right] + \left[\left(\frac{(Mg^{2+})\ \text{mg/L}}{\left(\frac{(\text{Molecular Weight } Mg^{2+})\ \text{mg/mmol}}{\text{Number of moles}}\right)}\right) \times \begin{array}{c}\text{Eq. Wt. of}\\ \text{CaCO3}\\ \text{(mg/meq)}\end{array}\right]$$

Water alkalinity and hardness are often reported as an equivalent of the $CaCO_3$ concentration in milligrams per liter (mg/L).

Total Suspended Solids and Turbidity

TSS is a water quality parameter that provides a measurement of particulates in a water sample. Turbidity is an optical measurement of water's ability to scatter light, resulting from the interaction of incident light with particulate material in a water sample, commonly referred to as the cloudiness or haziness of water. Increased turbidity is caused, in part, by TSS in water, but the correlation is spatially and temporally variable.

Specific Conductivity and Ions

SC is a measure of the capacity to transmit electricity through a water sample at 25 degrees Celsius (°C), and typically displays a linear relationship to total dissolved solids (TDS) and salinity of the water. SC is a function of the quantity of dissolved (ionic) constituents, primarily calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), potassium (K^+), HCO_3^-, sulfate (SO_4^{2-}), and chloride (Cl^-). Freshwater has a low SC compared to that of seawater. Rainwater can increase

SC because it often contains dissolved airborne gases and dust from the air. Agricultural and urban runoff can also increase SC through loading of salts or other dissolved constituents.

Trends in ion concentrations typically follow trends in SC. Major ions include elements that naturally occur in high concentrations and/or nutrients. This study included analyses for several major cations including calcium, iron (Fe^{2+}), magnesium, potassium, and sodium. Calcium is an essential mineral, is common in waters, and contributes to water hardness as $CaCO_3$. Iron is a common element in the regional geology and soils that can leach into water; however, most iron compounds are relatively insoluble in the pH ranges observed in streams. Magnesium occurs widely in rocks and soils, and is a major contributor to water hardness in many water bodies in the form of magnesium carbonates. Potassium is also an essential nutrient and occurs in nature as an ionic salt. Compounds consisting of potassium generally have excellent water solubility. Sodium is a very active ion. Excess sodium in runoff water may affect soils by decreasing rates of infiltration, and result in a build-up of salts on the soil surface.

Major anions evaluated for this study include chloride, nitrate, and sulfate. Chlorides include negatively charged chloride ions and salts containing chloride ions, such as sodium chloride (NaCl) and magnesium chloride ($MgCl_2$). Nitrate is an essential nutrient which, in excessive concentrations, leads to eutrophication of waterways and drinking water toxicity. Eutrophication promotes excessive aquatic plant growth and decay, which decreases DO and the overall water quality of a water body. Major sources of nitrate include fertilizers and sewage. SO_4^{2-} is a major anion in hard water reservoirs, and can be naturally occurring or the result of municipal or industrial discharges. When naturally occurring, SO_4^{2-} is often associated with organic matter decay, rocks or soil containing gypsum and other common minerals, or atmospheric deposition. Point sources include sewage treatment plants and industrial discharges. Fertilizers in runoff also contribute sulfates to water bodies. SO_4^{2-} can interact and precipitate with several parameters, including barium, copper, calcium, and magnesium; these interactions are interdependent with the pH, water temperature, and alkalinity contents in each water sample.

Trace Elements

Elements that typically occur in very low concentrations are referred to as trace elements. At higher concentrations, most trace elements become toxic to plants, animals, or humans. Sources may be natural or urban, agricultural, or municipal. The solubility of most trace elements – whether they adsorb to bottom sediments or remain in the water column – is dependent on oxidation and reduction potential and pH. Water quality monitoring included analyses for the following trace elements: aluminum, barium, cadmium, copper, mercury, and zinc.

Aluminum is one of the most abundant elements in the earth's crust and occurs in many rocks and soils. Many aluminum salts are readily soluble; those that are insoluble will precipitate and settle out of water. Barium is an alkaline earth metal that is primarily insoluble. Barium concentrations in water are often associated with mining activities. Cadmium is a metal commonly associated with wastewater, pesticides, and fertilizers. It is toxic to humans and aquatic species, although toxicity levels vary widely by species.

Copper persists and cycles through ecosystems. It can be dissolved in water, or bound to organic and inorganic materials either in suspension or in sediment. Dissolved copper is known to affect a variety of biological endpoints in fish (e.g., survival, growth, behavior, osmoregulation, sensory function, and others (NMFS 2007, Eisler 1998). Water hardness, alkalinity, pH, and dissolved organic matter tend to alter the bioavailability of dissolved copper to aquatic organisms. Exposure routes other than the water column, such as consumption of contaminated prey items (dietary) or direct contact with contaminated sediments are also important (NMFS 2007). Potential sources of copper in the environment include vehicle emissions and brake pad dust (Drapper et al. 2000), pesticides (EPA 2005a), herbicides, fungicides, algaecides, industrial processes, municipal discharges, mining, and rooftops (Good 1993; Thomas and Greene 1993) (NMFS 2007). Recent studies indicate typical dissolved copper concentrations originating from road runoff from a California study were 3.4 to 64.5 micrograms per liter (µg/L), with a mean of 15.8 µg/L (NMFS 2007).

Mercury is a legacy contaminant present in the source waters of PCWA (Yuba and Bear rivers), associated with hydraulic gold mining activities in the Sierra Nevada and foothill region during the nineteenth century. Methyl mercury, the species of mercury formed during a process known as methylation, is known as the predominant form bioaccumulated in fish, and is toxic to animals and humans. The California Environmental Protection Agency issued a health advisory and report during 2003 on the health effects of eating fish from water bodies in Nevada, Placer, and Yuba counties after high concentrations of mercury were found in samples collected within the Yuba River and Bear River watersheds. NID is currently proposing a pilot project to remove mercury from Lake Combie, a small reservoir on the Bear River.

Zinc is a relatively insoluble metal, and will precipitate from the water column. Zinc is supplied in animal feeds and fertilizers in the form of zinc sulfate, and occurs naturally in the environment. It is also associated with a wide variety of industrial activities, and may be associated with WWTP discharges.

3.1.1.3 Soils and Sediment Quality

Soil and sediment characteristics in the study area were evaluated by reviewing existing reports and studies conducted within the region, and soil survey data for Placer County from the U.S. Department of Agriculture Natural Resource Conservation Service (USDA-NRCS). These survey data comprise soil classifications and soil textures that cover most of Placer County, including the majority of PCWA Zones 1, 3, and 5.

3.1.2 Biological Resources

The following sections describe methodology for characterizing biological resource conditions in the NRMP study area. Biological resources evaluated for the NRMP include terrestrial habitat and species, aquatic habitat and species, as well as special-status species.

3.1.2.1 Terrestrial Habitat and Species

The study area for terrestrial habitat and species includes areas adjacent to canals and reservoirs that may be directly affected by O&M activities. Reservoirs in the analysis are: Clover Valley Reservoir, Mammoth Reservoir, Lake Alta, McCray, Whitney, Caperton, Lake Arthur, and Lake Theodore. In addition, habitats and species along water bodies that serve as conveyances, specifically Auburn Ravine and Canyon Creek, could be affected indirectly by changes in flow, water quality, and sedimentation.

This analysis focuses on habitat types and their associated species. The linear extents of habitat types paralleling all PCWA canals in Zones 1, 3, and 5 and reservoirs that may be affected by O&M activities were evaluated to describe the setting. Habitat types and their associated species are discussed in the following sections.

Existing habitat data used in quantitative analysis were obtained from:

- Placer Legacy Phase 1 prepared by Jones and Stokes Associates for Placer County on May 13, 2003 and last updated April 9, 2007

- California Department of Forestry and Fire Protection Fire and Resource Assessment Program (FRAP) Multi-source Land Cover Data (v02_2) published in 2002

Habitat classifications for both of these sources were assigned based on the California Wildlife Habitat Relationship (WHR) system, with some modifications as appropriate for the study area.

Field reconnaissance-level visits were conducted on December 1 and 2, 2005; September 28 and 29, 2006; and September 13 and 14, 2007, to calibrate and verify habitat mapping for portions of the study area.

Terrestrial habitat types in the study area can be grouped into general categories: forested, shrub-dominated, herbaceous-dominated, agricultural, urban, and barren. The general structure, composition, and wildlife value of habitats within the study area are described below.

<u>Forested</u>

A variety of forested habitat types occurs in the study area. These are summarized in the following categories: valley foothill riparian, Sierra Nevada montane forest, and foothill hardwood woodland.

Valley Foothill Riparian Forest

Valley foothill riparian forests are found in floodplains and lower foothills in seasonally or permanently wet areas. The structure of this habitat is multi-layer, consisting of a mix of trees, shrubs, and vines including valley oak (*Quercus lobata*), cottonwood (*Populus fremontii*), sycamore (*Platanus racemosa*), willow (*Salix* spp.), white alder (*Alnus rhombifolia*), Oregon ash (*Fraxinus latifolia*), elderberry (*Sambucus* spp.), California grape (*Vitis californica*), and the nonnative Himalayan blackberry (*Rubus discolor*). Grasses, sedges (*Carex* spp.), rushes (*Juncus* spp.), and forbs, such as mugwort (*Artemesia douglasiana*) and hoary nettle (*Urtica dioica* ssp. *holosericea*), may occur in the understory. This habitat provides cover, forage, and breeding areas for a number of wildlife species, including numerous species of resident and migratory birds, at least 50 amphibian and reptile species, and large and small mammals (Mayer and Laudenslayer 1988).

Sierra Nevada Montane Forests

Sierra Nevada montane forest types in the study area include conifer-dominated habitats (ponderosa pine [*Pinus ponderosa*], Sierran mixed conifer, Douglas-fir [*Pseudotsuga menziesii*], and closed-cone pine-cypress), and hardwood-dominated habitats (montane hardwood and montane hardwood conifer). Conifer-dominated habitats are multi-layer and contain a variety of species, with conifers typically forming a closed canopy. Sierra Nevada montane forest habitat types generally occur at higher elevations than hardwood habits (Brussard 1999). These habitat types intergrade, with ponderosa pine occurring at lower elevations and Sierran mixed conifer occurring at higher elevations (Placer County Planning Department 2005a). Sierran mixed conifer habitats support coniferous and hardwood species including ponderosa pine, knobcone pine (*Pinus attenuate*), sugar pine (*Pinus lambertiana*), Douglas-fir, white fir (*Abies concolor*), California black oak (*Quercus kelloggii*), incense cedar (*Calocedrus decurrens*), white alder, and bigleaf maple (*Acer macrophyllum*). Common shrub species include deerbrush (*Ceanothus integerrimus*), manzanita (*Arctostaphylos* spp.), chinquapin (*Chrysolepis chrysophylla*), mountain whitethorn *(Ceanothus cordulatus*), sagebrush (*Artemesia* spp.), and gooseberry (*Ribes* spp.). Closed-cone pine-cypress habitat is dominated by knobcone pine and generally occurs in areas with rockier, thinner soil.

Montane hardwood and montane hardwood conifer habitats are dominated by black oak and canyon live oak (*Quercus chrysolepis*). Other common tree species include interior live oak (*Quercus wislizeni*), ponderosa pine, bigleaf maple, Douglas-fir, Pacific madrone (*Arbutus menziesii*), Jeffrey pine (*Pinus jeffreyi*), sugar pine, incense cedar, white fir, and quacking aspen (*Populus tremuloides*). Shrub species include poison oak (*Toxicodendron diversilobum*), ceanothus (*Ceanothus* spp.), manzanita, and mountain mahogany (*Cercocarpus betuloides*) (Placer County Planning Department 2005a).

A variety of wildlife and plant species occur in Sierra Nevada montane forest habitats including cavity-nesting birds, raptors, large mammals, rodents, bats, reptiles, and amphibians.

Foothill Hardwood Woodlands

Hardwood habitat types in the study area include several habitat types: blue oak (*Quercus douglasii*) woodland, oak woodland savanna, interior live oak woodland, and oak foothill pine. These habitats contain a variety of species but are dominated by oaks. Blue oak woodlands are found on drier sites with shallower soils than valley foothill riparian forests. This habitat is generally more open than valley foothill riparian habitats in the study area and grades to oak woodland savanna in some places. Dominant species are blue oak and live oak, with a more open, grassy understory. Shrubs and small trees, including California buckeye (*Aesculus californica*), ceanothus, manzanita, and elderberry may occur, but are generally less dense that in valley foothill riparian forests. Numerous wildlife species use blue oak woodland for nesting and foraging, including acorn woodpecker (*Melanerpes formicivorus*), oak titmouse (*Parus inornatus*), yellow-billed magpie (*Pica nuttalli*), western gray squirrel (*Sciurus griseus*), and coyote (*Canis latrans*) (Mayer and Laudenslayer 1988). Oak foothill pine habitats contain many similar species to those found in blue oak woodlands, but foothill pine is more common and the shrub layer is generally denser.

Shrub

Shrub-dominated habitats in the study area are primarily foothill chaparral ecosystems. These are areas that generally do not support forested habitats due to rocky/thin soils or steep slopes. Common shrub species in this habitat include chamise (*Adenostoma fasciculatum*), whiteleaf manzanita (*Arctostaphylos manzanita*), and buckbrush (*Ceanothus cuneatus*). Small interior live oaks also frequently occur. This habitat type occurs on a variety of substrates, including serpentine soils, which may support some special status plant species. A number of wildlife species use chaparral for foraging and nesting including rodents, snakes, mountain lion (*Puma concolor*), black bear (*Ursus americanus*), coyote, ringtail (*Bassariscus astutus*), and a variety of bird species such as western scrub-jay (*Aphelocoma californica*), spotted towhee (*Pipilo maculates*), California towhee (*Pipilo crissalis*), American robin (*Turdus migratorius*), Townsend's solitaire (*Myadestes townsendi*), and wrentit (*Chamaea fasciata*).

Herbaceous

Herbaceous habitats in the study area are generally disturbed areas dominated by nonnative species. These areas provide limited wildlife habitat value. Small mammals and some bird species, including western meadowlark (*Sturnella neglecta*) and horned lark (*Eremophila alpestris*), may breed in less disturbed grassland and pasture areas. These habitats also provide foraging areas for snakes, coyotes, and raptors, such as Northern harrier (*Circus cyaneus*), Red-tailed Hawk (*Buteo jamaicensis*), and White-tailed Kite (*Elanus leucurus*).

Annual Grassland

Annual grasslands in California primarily support nonnative species such as wild oat (*Avena fatua*), bromes (*Bromus* spp.), wild barley (*Hordeum marinum*), and fescue (*Festuca* spp.). Annual grasslands often support vernal pools; however, these were not observed in the study area. Vernal pools are found within the southwestern portion of the watershed near the confluence of Secret and Miners ravines, but these are outside of the study area and do not appear to be influenced by the drainages addressed in this analysis.

Vernal Pool Complexes

Vernal pools are small to large depressions, generally in grassland habitat, that are seasonally wet and support an assemblage of species adapted to these conditions. A number of special status plant and animal species occur in vernal pools including vernal pool fairy shrimp (*Branchinecta lynchi*), vernal pool tadpole shrimp (*Lepidurus packa*rdi), California linderiella (*Linderiella occidentalis*), legenere (*Legenere limosa*), Red Bluff dwarf rush (*Juncus leiospermus* var. *leiospermus*), dwarf downingia (*Downingia pusilla*), Bogg's Lake hedge-hyssop (*Gratiola heterosepala*), and Ahart's dwarf rush (*Juncus leiospermus* var. *ahartii*). Vernal pool complexes are mapped grassland areas that contain individual vernal pools in high, medium, or low densities.

Wetland

Wetlands types in the study area include fresh emergent wetlands and seasonal wetlands. Fresh emergent wetlands support permanently or frequently flooded herbaceous vegetation including cattails (*Typha* spp.), sedges, rushes, and nutsedges (*Cyperus* spp.), and spike-rush (*Eleocharis* spp.). In the study area this habitat may be associated with the margins of artificial ponds, roadside swales, and depressional wetlands. These areas are often isolated, and dominated by nonnative species, such as Johnsongrass (*Sorghum halepense*), dallisgrass (*Paspalum dilatum*), rabbit's foot grass (*Polypogon monspeliensis*), knotweed (*Polygonum* spp.), and dock (*Rumex* spp.). Seasonal wetlands contain some similar species to those found in fresh emergent wetlands, including grasses and sedges. During summer months, seasonal wetlands may support more upland species such as tarweed (*Hemizonia fitchii*), vinegar weed (*Trichostema lanceolatum*), and yellow star-thistle (*Centaurea solstitialis*). Wetlands are used by a number of wildlife species, particularly birds, amphibians, and reptiles. Special status plant species that may occur in wetlands in the study area include hispid bird's-beak (*Cordylanthus mollis* ssp. *hispidus*), dwarf downingia, legenere, Bogg's Lake hedge-hyssop, Ahart's dwarf rush, red-anthered rush (*Juncus marginatus* var. *marginatus*), and Red Bluff dwarf rush.

Agricultural

Agricultural habitat types in the study area include pasture, row crops, rice fields, and unidentified crops. Pasture vegetation is composed primarily of nonnative perennial grasses and legumes such as ryegrass (*Lolium* spp.), fescue, and clover (*Trifolium* spp.). Habitat value may be similar to annual grassland, but is dependent on management. Row crops include wheat, corn, rye, barley, strawberries, and other grains and vegetable crops. Rice fields are seasonally flooded areas that may provide important habitat elements for birds, including shorebirds, water fowl, and raptors. Other species, such as the giant garter snake (*Thamnophis gigas*), may also use rice fields.

Urban

Urban habitats can support trees, shrubs, herbaceous species, or more commonly, a mosaic of these vegetation types interspersed with barren areas (see below). In the study area, urban habitat consists of urban parks, rural residential forested, rural residential, urban/suburban, and urban woodland. Vegetation includes native and nonnative species, including some native forested habitat remnant patches. Urban areas can provide wildlife habitat, the value of which may be determined by vegetative structure and management activities such a pesticide/herbicide applications and mowing and clearing activities. Species using urban habitat types may include western scrub-jay, northern mockingbird (*Mimus polyglottos*), house finch (*Carpodacus mexicanus*), bushtit (*Psaltriparus minimus*), oak titmouse, chestnut-backed chickadee (*Parus rufescens*), California quail (*Callipepla californica*), black-tailed deer (*Odocoileus hemionus*), black-tailed jackrabbit (*Lepus californicus*), raccoon (*Procyon lotor*), opossum (*Didelphis virginiana*), California slender salamander (*Batrachoseps attenuatus*), gopher snake (*Pituophis catenifer*), and fence lizard (*Scleporus undulatus*). Special status species, including White-tailed Kite, tricolored blackbird (*Agelaius tricolor*), Swainson's hawk (*Buteo swainsoni*), western pond turtle (*Actinemys marmorata*), and purple martin (*Progne subis*), may also use urban habitats.

Barren

Barren areas include unvegetated disturbed lands (roads, parking lots, gravel pads, and other open areas) and rock outcrop and cliffs. Disturbed lands are dispersed in small areas throughout the study area and provide limited wildlife habitat value. Rock outcrops and cliffs may provide nesting and roosting habitat for some bats, raptors, and other bird species. Some special status plant species, such as Red Hills soaproot (*Chlorogalum grandiflorum*), may occur in rocky outcrops.

3.1.2.2 Aquatic Habitat and Species

This section describes the methodology used to characterize the existing conditions of aquatic resources in streams that may be affected by PCWA O&M activities conducted within the raw water distribution system. These include drainages and streams used for conveyance of water to PCWA customers, and streams that may receive flow contributions from the canal system through regulated or unregulated releases from canal outlets. Streams in the study area include Canyon Creek, Auburn Ravine, Clover Valley Creek, Antelope Creek, Secret Ravine, and Miners Ravine.

Descriptions of aquatic biological resources are based on a literature review of studies conducted within the study area and reconnaissance-level site visits along the streams. Documents consulted in the literature review include the following:

- Dry Creek Watershed Coordinated Resource Management Plan (Dry Creek Watershed Council 2003).
- Streams of Western Placer County: Aquatic Habitat and Biological Resources Literature Review (Sierra Business Council 2003).
- Miners Ravine Habitat Assessment (California Department of Water Resources 2002).
- Secret Ravine Adaptive Management Plan (Dry Creek Conservancy 2001).
- Perennial Rearing Habitat for Juvenile Steelhead in the Dry Creek Drainage (Placer County) (California Department of Fish and Game 2001).
- Survey Habitat in Secret Ravine, Tributary to Dry Creek: Anadromous Fish Restoration Program. Document Control No. 11332-8-J113 (U.S. Fish and Wildlife Service 1998).
- Dry Creek, Secret Ravine and Miners Ravine, Placer County. Memorandum to Nick Villa, California Department of Fish and Game, Region 2, Rancho Cordova, California (John Nelson 1997).
- Auburn Ravine/Coon Creek Ecosystem Restoration Plan (Placer County/CALFED 2002).

- Draft Roseville Creek and Riparian Management and Restoration Plan (City of Roseville 2005).
- Clover Valley Large and Small Lot Tentative Subdivision Maps, Draft Environmental Impact Report (City of Rocklin 2006).
- Aquatic Habitat Survey and Fisheries Assessment for Clover Valley (Placer County 2006).
- A Benthic Macroinvertebrate Survey of Secret Ravine: The Effects of Urbanization on Species Diversity and Abundance (De Barruel and West 2003).
- Assessment of Habitat Conditions for Chinook Salmon and Steelhead in Western Placer County, California (Placer County Planning Department 2005b).

Aquatic habitat conditions and species descriptions are focused on fish communities in the study area. Central Valley steelhead and fall-run Chinook salmon are emphasized due to their statuses under the State and Federal Endangered Species Acts (ESA), and the presence of designated Critical Habitat for Central Valley steelhead in the study area. Central Valley steelhead are listed as threatened under the Federal ESA but have no special status under the State ESA. Fall/Late-fall-run Chinook salmon are a Federal Species of Concern and California Species of Special Concern.

California Department of Fish and Game (DFG) is currently working on a program to inventory and perform a landscape-level assessment of fish communities within and across stream systems throughout California, including Auburn Ravine, Secret Ravine, and Miners Ravine, based on an index of biotic integrity (IBI). An IBI assigns scores to predetermined fish community characteristics that are summed and normalized to create an index of the gross ecological health of the stream (Titus et al. 2005). Reference fish assemblages applied to the IBI include Central Valley pikeminnow, hardhead, sucker, deep-bodied fish assemblages (California roach, speckled dace, rainbow trout, riffle sculpin, tule perch) (State Water Resources Control Board [SWRCB] 2005, Moyle 2002), and anadromous species (lamprey, Chinook salmon, steelhead) (SWRCB 2005). Aquatic habitat conditions and species are presented by the presence of fish communities in the study area and 2004-2005 IBI rating results for Auburn, Secret, and Miners ravines.

Benthic macroinvertebrate (BMI) samples were collected during fall 2007 by DCC using the targeted riffle method described in Standard Operating Procedures for Collecting Benthic Macroinvertebrate Samples and Associated Physical and Chemical Data for Ambient Bioassessments in California (DFG 2007) at three sites: Auburn Ravine below Auburn Ravine Tunnel outlet, Secret Ravine at Loomis Basin Park, and Miners Ravine below Sierra College Boulevard. BMI analyses are used as indicators of stream health. These organisms live in, on, or near streambed material where hydrophobic chemicals tend to concentrate, and have limited mobility. Therefore, the organisms show cumulative impacts of pollution and habitat degradation over a relatively small spatial area not detected by traditional water quality analyses. A benthic index of biotic integrity (B-IBI), recently developed by the DFG's Aquatic Bioassessment Laboratory, was applied to BMI analysis results obtained from Auburn, Secret, and Miners ravines. The index is based on BMI samples collected from 275 sites in central and Southern California by the U.S. Forest Service, U.S. EPA, and RWQCBs. The B-IBI provides a method for measuring ecological conditions in streams characterized by seven metrics for comparison with reference streams with an index of BMI assemblages when human disturbance is absent or minimal, and allows categorization of site conditions as "Good," "Fair," or "Poor" (Ode et al. 2005). The seven metrics for the B-IBI assessment include:

- Coleoptera Richness – the total number of Coleoptera taxa present in the subsamples.
- EPT Richness – the total number of taxa from the *Ephemeroptera*, *Plecoptera*, and *Trichoptera* insect orders.
- Predator Richness – total number of taxa categorized as predators.
- Collectors (%) – the percent of individuals present in the subsample categorized as collectors.
- Intolerant Organisms (%) (0-3) – the percent of individuals present in the subsample categorized as having a tolerance value of 0 to 3.
- Non-insect Taxa (%) – The percent of the subsample taxa that are non-insect.
- Tolerant Taxa (%) – The percent of taxa from the subsample that are considered tolerant of stream degradation.

In addition to the BMI analyses conducted for the sites described above, BMI data collected by DCC from sites across the PCWA service area were reviewed for comparison. Data collected by DCC before 2005 using protocols described in the California Stream Bioassessment Procedure were standardized with data collected during fall 2007 for consistency.

3.1.2.3 Special Status Species

This document was prepared with information obtained from species database searches and literature review. Databases and documents consulted include:

- California Natural Diversity Database (CNDDB) Geographic Information System (GIS) layer (CDFG 2008)
- U.S. Fish and Wildlife Service (USFWS) on-line service for information regarding Threatened and Endangered Species final Critical Habitat designation across the U.S. Accessed for Placer County on October 6, 2008. (USFWS 2008)
- On-line Inventory of Rare and Endangered Plants. Accessed for USGS project quadrangles on August 21, 2008. (California Native Plant Society (CNPS) 2008)

- Federal Endangered and Threatened Species that Occur In or May Be Affected by Projects in the Counties and/or USGS 7 1/2 Minute Quadrangles. On-line data accessed for project quadrangles on August 21, 2008 (USFWS 2008)

Project USGS quadrangles are those that contain features (canals and reservoirs) that would be directly affected by operations and maintenance activities, specifically:

- Auburn (Zones 1 and 3)
- Chicago Park (Zone 3)
- Colfax (Zone 3)
- Dutch Flat (Zone 3)
- Gold Hill (Zone 1)
- Greenwood (Zone 3)
- Pilot Hill (Zone 1)
- Pleasant Grove (Zone 5)
- Rocklin (Zone 1)
- Roseville (Zone 5)
- Sheridan (Zone 5)

For purposes of this evaluation, special status species are those that are federally listed (threatened or endangered), species of concern (for aquatic species only), or candidate species; California listed (endangered or threatened) species or species of special concern; and/or species listed on the CNPS inventory of rare and endangered plants. To identify known special status species occurrences in the study area, a GIS layer of PCWA Zones 1, 3, and 5 was overlain on the most recently distributed DFG CNDDB data (this conservatively includes all of Zones 1, 3, and 5, even though most of this area would not be affected). To identify other species that could potentially occur in the study area, databases were queried for known or potential occurrences of special status species in the project USGS quadrangles. Other special status species may have the potential to occur in the study area. Resource agencies should be consulted for information on a site-specific basis.

3.2 PHYSICAL RESOURCES SETTING

The sections below describe physical resources within Zones 3, 1, and 5 of the PCWA raw water distribution area during routine canal operations. Categories of physical resources described are hydrology, water quality, and soil and sediment quality, each of which is organized by watersheds within each PCWA zone.

3.2.1 Hydrology

Hydrology in PCWA's raw water distribution system is affected by release directly from canal outlets and discharge locations, and by return flows from customers. The interrelationship between canals owned by PG&E and PCWA delivers water originating from the Yuba and Bear river systems in varying proportions throughout the raw water distribution system, depending on the season and buy point(s) used. The following sections describe the characteristics that determine the sources and destinations of raw water within Zones 3, 1, and 5 of the PCWA raw water distribution system. These zones are described in the general direction of flow, with Zone 3 representing the upstream zone, and Zone 5 the furthest downstream extent of the system.

3.2.1.1 Zone 3

Hydrology in Zone 3 canals is largely regulated by releases from Lake Alta, a small reservoir near the town of Alta, with a surface area of approximately 20 acres and storage capacity of about 270 acre-feet. Water is conveyed to Lake Alta from PG&E's Alta Powerhouse through the Alta Tailrace, or from PCWA's Pulp Mill Canal, which conveys water from Canyon Creek.

PCWA holds water rights of 40 cfs on Canyon Creek, a tributary to the North Fork American River. PG&E uses Canyon Creek to convey water from PG&E's Drum Forebay to PG&E's Towle Canal, which flows to Alta Forebay. PG&E is required to maintain an instream flow of 1 cfs that is released to Canyon Creek below Pulp Mill Diversion Dam. Canyon Creek flows parallel to Interstate 80 for much of its 10.5-mile length, before turning south to its confluence with the North Fork American River near the town of Dutch Flat (Durham 1998).

The Canyon Creek watershed is small and confined in a steep canyon. Streamflows in Canyon Creek are monitored by USGS at two gaging stations upstream from Pulp Mill Diversion Dam, located upstream and downstream from PG&E's Towle Canal Diversion. USGS Station No. 11426195 (Canyon Creek near Blue Canyon, California) is located upstream of PG&E's Towle Canal Diversion, and reflects streamflow generated within a 0.5-square-mile watershed. USGS Station No. 11426196 (Canyon Creek below Towle Diversion Dam, near Blue Canyon, California) is downstream from PG&E's Towle Diversion, and reflects streamflow for a 1.3-square-mile watershed. Streamflows at these stations are not recorded above 1.2 cfs. Flows at these stations often exceed 1.2 cfs during the winter, but frequently drop below 1 cfs during the summer (USGS, 2007a, 2007b). The hydrology of Canyon Creek is likely representative of other streams in the area, with high flow during winter and spring, and low flow during summer and fall, due, in part, to the small watershed and lack of baseflow contributions from groundwater. Much of the land in Zone 3 is rural with some agriculture and pasture lands. Urbanization increases at the southern portion of Zone 3 near Zone 1.

PCWA releases water from Lake Alta to Cedar Creek Canal, which conveys water to the Monte Vista WTP and Boardman Canal. Boardman Canal is the main conveyance feature in Zone 3. The canal parallels Interstate 80 through much of the zone, generally following the topographical divide of the North Fork American River watershed to the east and the Bear River watershed to the west.

3.2.1.2 Zone 1

Zone 1 hydrology is primarily affected by the topographical transition from the steep slopes and narrow canyons of Zone 3 to the broad, relatively flat topography of Zone 5. Zone 1 is characterized by gradually decreasing gradients from the upper to lower portions, and by numerous branches of gravity-fed canals that deliver water to customers over a large area. Several Zone 1 streams receive flow contributions from the canal system through regulated or unregulated releases from canal outlets, or are used as conveyance features within the PCWA raw water distribution system. These include Auburn Ravine, Clover Valley Creek, Antelope Creek, Miners Ravine, and Secret Ravine.

Auburn Ravine originates on the north side of the City of Auburn, and has a watershed area of approximately 79 square miles. Upstream from the City of Auburn, the stream is confined within a natural channel, is unimpaired, and receives mostly local watershed contributions to streamflow, with some PCWA contributions that are diverted further downstream. Immediately west of the City of Auburn, the character of the stream changes and Auburn Ravine is used as a conveyance feature for PG&E, NID, and the PCWA canal system.

Auburn Ravine's natural streamflow is supplemented through four primary sources: (1) PG&E Drum-Spaulding Project source water; (2) PCWA deliveries from the North Fork American River through the Auburn Ravine Tunnel; (3) City of Auburn effluent discharges from its WWTP; and (4) Auburn Ravine watershed stormwater runoff. In addition to hydrologic influences of PG&E, NID, and PCWA flow contributions and diversions on Auburn Ravine, NID and PCWA customers indirectly affect Auburn Ravine hydrology through customer return flows (remaining portions of customer water deliveries that return to drainages). Middle Fiddler Green Canal, Lower Banvard Canal, Dutch Ravine Canal, and Caperton Canal are the main PCWA canals that supply customers raw water in the Auburn Ravine watershed.

Instantaneous peak flows in Auburn Ravine are highest in the winter months, ranging from less than 3 cfs to an estimated 100-year flow event exceeding 14,000 cfs near the City of Lincoln. Estimated monthly average streamflow for Auburn Ravine under existing management conditions and historic natural streamflow are provided in **Table 3-4** (Reclamation and PCWA 2002). Flows in Auburn Ravine are lowest during the fall, when NID and PCWA customer demands are low. Auburn Ravine flows can vary substantially on a daily and monthly basis. The supplemental flows described above significantly augment the estimated natural late summer and early fall streamflows. Without the influence of existing water management conditions in the watershed, Auburn Ravine would remain an intermittent stream carrying only flow originating at its headwaters and runoff from the watershed (Reclamation and PCWA 2002).

TABLE 3-4
ESTIMATED MEAN MONTHLY FLOW FOR AUBURN RAVINE NEAR HIGHWAY 65 BRIDGE

	October	November	December	January	February	March	April	May	June	July	August	September
	Mean Monthly Flow (cubic feet per second)											
Estimated Under Existing Management Conditions[1]	30	39	84	117	120	132	66	88	82	114	99	43
Estimated Natural Streamflow[2]	4.1	11.7	38.2	70.6	50.9	32.3	20.1	2.4	0.2	0.1	0.0	0.0

[1] Source: Eco:Logic Engineering Water Balances; Nevada Irrigation District (NID) Gauge in Auburn Ravine below Highway 65 in City of Lincoln 1999.
[2] Source: City of Auburn 1997 in City of Lincoln 1999.

Clover Valley Creek, a tributary to Antelope Creek (described below), is 7.1 miles in length, and has a watershed area of about 10.2 square miles (Placer and Sacramento Counties 2003). Clover Valley Creek watershed is a tributary of Dry Creek, and comprises approximately 3.6 percent of the Dry Creek watershed (Placer and Sacramento Counties 2003). Clover Valley Creek receives direct flow contributions from the PCWA raw water distribution system in the form of regulated releases at Clover Valley Reservoir and unregulated releases from the end of the Antelope Canal outlet, as well as indirect flow contributions through customer return flows. Additionally, flows to Clover Valley Creek may be augmented by PCWA during storms through overflow releases from Whitney Reservoir. Clover Valley Creek serves as a natural drainage system for the primarily undeveloped Clover Valley area. The level of development within the Clover Valley Creek watershed increases from upstream to downstream, with significant portions of the land adjacent to the upper reaches undeveloped. Estimated peak flows for 10- and 100-year flood events at the Clover Valley Creek confluence with Antelope Creek are approximately 1,650 cfs and 3,050 cfs, respectively (City of Rocklin 2006).

Antelope Creek Watershed

Antelope Creek flows roughly parallel to Interstate 80 for approximately 9.5 miles in the southern portion of Zone 1. Antelope Creek is a tributary to Dry Creek, which in turn is a tributary to the Sacramento River via Steelhead Creek (formerly the Natomas East Main Drain Canal), and has a watershed area of approximately 21.4 square miles. Antelope Creek comprises approximately 11 percent of the Dry Creek watershed (Placer and Sacramento Counties 2003). Its watershed is urbanized with some light agriculture in the uppermost portions (Placer and Sacramento Counties 2003). Antelope Creek receives direct flow contributions from the PCWA raw water distribution system in the form of unregulated releases from the end of the Antelope Stub Canal outlet, indirect flow contributions through customer return flows, and treated effluent from a sewage disposal pond located a few miles upstream from its confluence with Dry Creek. Antelope Creek also receives treated effluent from a sewage disposal pond located a few miles upstream from its confluence with Dry Creek, north of Highway 65 (Placer County Planning Department 2005b). Flows in Antelope Creek during summer and early fall months are often less than 1 cfs, while potential peak flows for 10- and 100-year flood events at Rocklin Road were calculated by the Placer County Flood Control and Water Conservation District (PCFCWCD) are of approximately 1,430 cfs and 3,490 cfs, respectively (PCFCWCD and Sacramento County Water Agency (SCWA) 1992).

Secret Ravine Watershed

Secret Ravine is a tributary to Miners Ravine, described below. It is 7.8 miles long, flows in a narrow valley underlain by Recent alluvial deposits, and has a watershed area of about 22.3 square miles (Placer and Sacramento Counties 2003). The Secret Ravine watershed comprises approximately 22 percent of the Dry Creek watershed (Placer and Sacramento Counties 2003). Shallow, impermeable soils, granitic bedrock, and a narrow riparian zone characterize the upper watershed of Secret Ravine. The bedrock of the lower watershed is volcanic cap rock. These conditions, coupled with rapid urban and residential development in the watershed, which increases the impervious fraction of land cover, result in rapid surface and subsurface runoff generation, and an increase in peak flows in Secret Ravine.

Secret Ravine flows vary greatly during the year. Flows in Secret Ravine are as low as 0.5 cfs during summer and early fall months, while potential peak flows for 10- and 100-year flood events at Rocklin Road calculated by the PCFCWCD were approximately 1,750 cfs and 3,820 cfs, respectively (Placer County and SCWA 1992). Current summer streamflows are greater than the historic unimpaired flow on Secret Ravine (Placer and Sacramento Counties 2003). Summer flows are most likely attributed to direct flow contributions from the PCWA raw water distribution system in the form of unregulated releases from several PCWA canal outlets, indirect flow contributions through customer return flows, and treated effluent from two sewage disposal ponds located near Interstate 80 and Gilardi Road. Summer flows are two or three times the historic unimpaired flow (Placer County Planning Department 2005b).

Numerous PCWA canals augment flows in tributaries to Secret Ravine through unregulated releases from the ends of canal outlets, including Westside, Lyall, and Eastside canals to the west, and Sugarloaf, Barton, Turner, Yankee Hill, and Boardman canals to the east. Customer return flows also augment streamflow in Secret Ravine. PCWA canal system contributions dominate dry season flows in Secret Ravine (USACE and PCWA 2008). Flows in Secret Ravine at Rocklin Road in Roseville between December 2004 and December 2006 are logarithmically displayed in **Figure 3-5**.

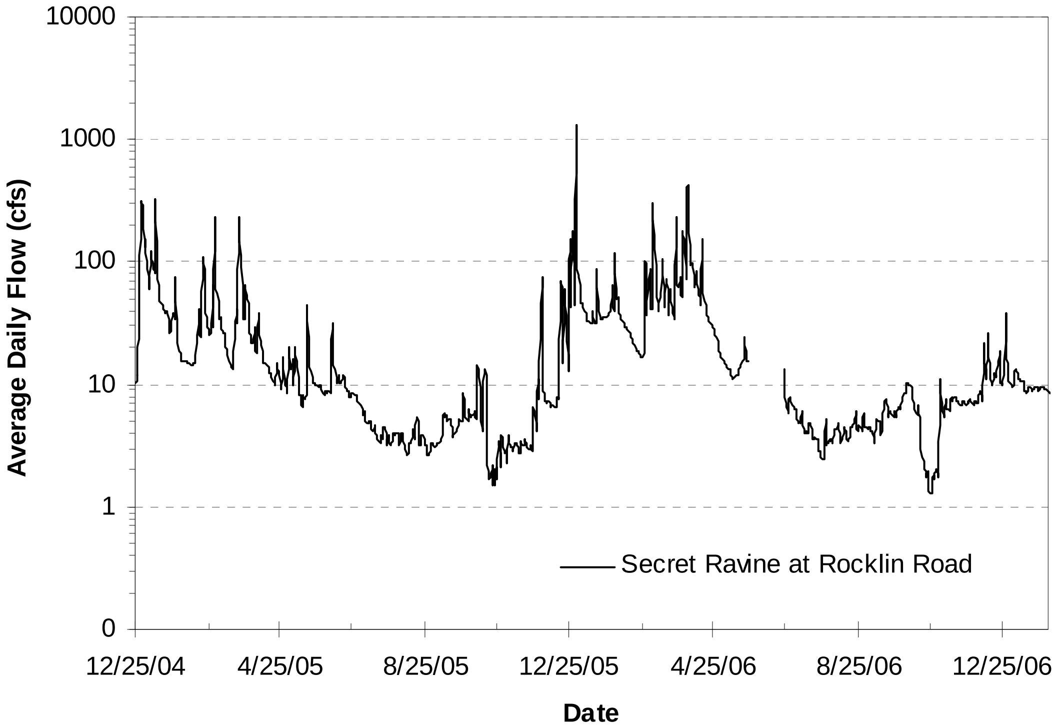

FIGURE 3-5
AVERAGE DAILY FLOWS IN SECRET RAVINE AT ROCKLIN ROAD

Miners Ravine Watershed

Miners Ravine is a tributary to Dry Creek, and is approximately 15.2 miles long, with a watershed area of 20.1 square miles. Miners Ravine watershed represents approximately 20 percent of the Dry Creek watershed. The headwaters for Miners Ravine are in the western foothills of the Sierra Nevada where livestock grazing is common, whereas the downstream portion flows through more developed areas. Similar to Secret Ravine, impermeable soils and shallow depth to bedrock in the Miners Ravine watershed contribute to rapid surface and subsurface runoff generation. Apart from the main channel, the watershed drainage consists of small, intermittent tributaries that only carry low flows and can be expected to flood, on average, every 5 years (Placer and Sacramento Counties 2003).

Summer flows in Miners Ravine are often less than 1 cfs, while peak flows for 10- and 100-year events at Sunrise Avenue were calculated by the Placer County Flood Control and Water Conservation District to be approximately 2,497 cfs and 6,642 cfs, respectively (Placer County and SCWA 1992). Localized flooding often occurs in the Miners Ravine watershed. Fences and other structures within or immediately adjacent to the watercourse and inadequately sized culverts at bridge crossings create flow obstructions, and contribute to issues of flooding in the watershed.

Similar to Secret Ravine, canal system contributions comprise most of the dry weather flows in Miners Ravine (USACE and PCWA 2008). These contributions include customer return flows and unregulated releases from the Lower Greely, Ferguson, and Baughman canals. Additional inputs include the Placer County SMD No. 3 (National Pollutant Discharge Elimination System ((NPDES)) CA0079367) WWTP. The design flow rate of Placer County SMD No. 3 is 0.75 million gallons per day (mgd) (1.16 cfs), but the facility is currently operating at less than 20 percent design capacity. Under current operations, effluent contributes 2 to 3 percent of total flow during high-flow conditions and less than 10 percent of total flow during low-flow conditions (Placer and Sacramento Counties 2003). Flows in Miners Ravine near North Sunrise Avenue in Roseville between December 2004 and December 2006 are logarithmically displayed in **Figure 3-6**.

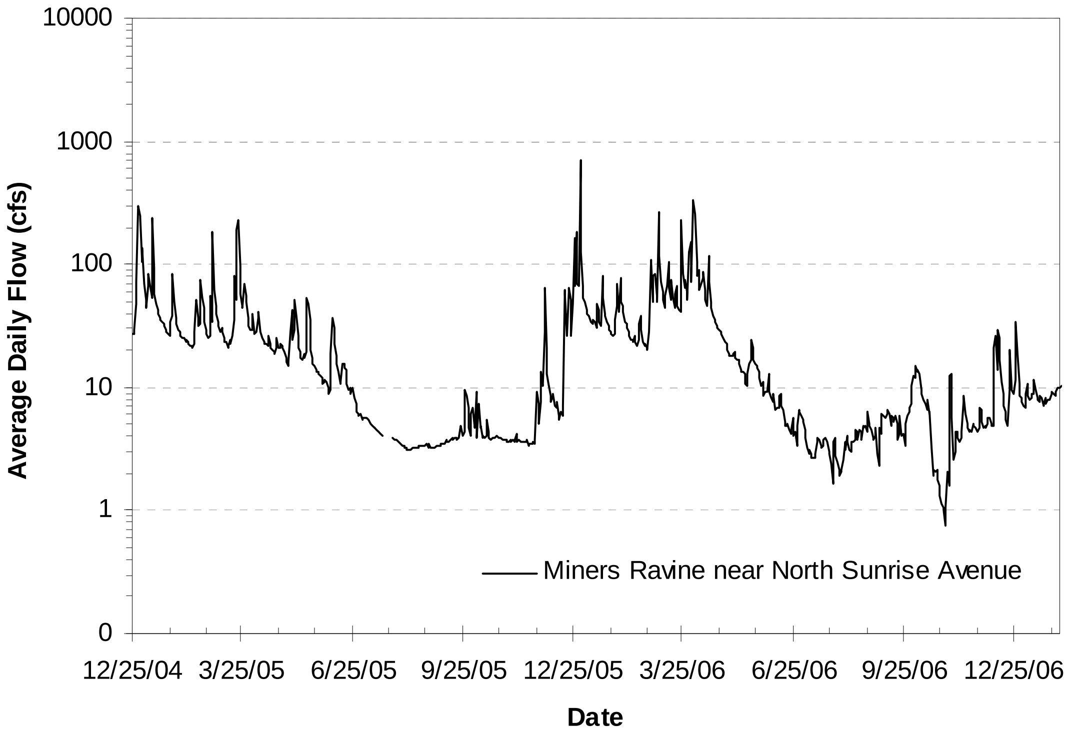

FIGURE 3-6
AVERAGE DAILY FLOWS IN MINERS RAVINE NEAR NORTH SUNRISE AVENUE

3.2.1.3 Zone 5

The Zone 5 service area receives water deliveries diverted from Auburn Ravine. As described above, streamflow in Auburn Ravine is supplemented through diversions from the American, Bear, and Yuba rivers, as well as treated effluent from the City of Lincoln's WWTP. Due to these supplemental sources to flow in Auburn Ravine, monthly average streamflow for Auburn Ravine under existing management conditions vary considerably from estimated natural flow conditions (**Table 3-4**). Up to 50 cfs of water pumped from the North Fork American River are conveyed to Auburn Ravine in Zone 1 by PCWA for diversion in Zone 5. PCWA may also divert water purchased from PG&E at YB 136 for deliveries to Zone 5 customers. Auburn Ravine is seasonally dammed at Moore Dam, where flows are diverted to Moore Canal. Further downstream, flows are diverted from Auburn Ravine at the Pleasant Grove Dam to the Pleasant

Grove Canal. PCWA Zone 5 customers receive deliveries conveyed either directly from Auburn Ravine or diverted to Moore or Pleasant Grove canals. In addition to these diversions to PCWA's Zone 5 service area, several dams and diversions on Auburn Ravine provide for water deliveries to NID customers.

3.2.2 Water Quality

This section presents the results of seasonal water quality monitoring efforts during routine operations, describes general trends observed, and presents some stronger trends and potential relationships among different water quality parameters. As previously mentioned, more extensive sampling would be required to accurately derive quantitative results. Therefore, the information in this section is descriptive and should be used for qualitative discussion purposes only. The data are described below by watershed within each zone, and discussed with respect to basic physical and chemical parameters, major ions, and trace elements.

Water quality is expected to vary over space and time in the PCWA canal and associated stream systems. Spatially, in the upstream areas of the canal system, the canal water is expected to more closely resemble the quality of source water from the Yuba and Bear rivers. As water flows farther downstream through the canal system, it encounters many factors that affect its quality, including debris in the canal channels, irrigation return flows and additional watershed contributions from property along the canals, and water storage in mid-system reservoirs. Water pumped from the American River through the ARPS contributes to flow in the PCWA canal system during certain times of the year, and additional Yuba and Bear supplies can be added to the PCWA system at various points. As water reaches tributaries and streams and flows further from the canal outlets, it encounters many factors characteristic of the stream's watershed that affect its quality, including irrigation return flows, runoff, ponds, tributaries, and in-channel vegetation. Residual constituents from historical activities in the basin, such as hydraulic mining, quarries, a pulp mill, and large agricultural areas, could affect canal and stream water quality.

These water quality results can be compared to Federal and State water quality criteria and objectives stipulated in the National Toxics Rule (NTR), California Toxics Rule (CTR), and Porter-Cologne Water Quality Control Act, described in **Chapter 4**. The U.S. EPA National Recommended Ambient Water Quality Criteria for Freshwater Aquatic Life (NTR) and Criteria for Priority Toxic Pollutants in the State of California (CTR) are shown in **Tables 3-5** and **3-6**, respectively. Normally, two types of limits are presented in the NTR and CTR; chronic and acute. These limits are presented as Criteria Maximum Concentrations (CMC) to protect aquatic organisms from short-term or acute exposures (expressed as 1-hour average or instantaneous maximum concentrations) to pollutants. Criteria Continuous Concentrations (CCC) are intended to protect aquatic organisms from long-term or chronic exposures (expressed as 4-day or 24-hour average concentrations). Of the constituents measured in study area streams, cadmium, copper and zinc have freshwater CMC and CCC limits.

TABLE 3-5
NATIONAL RECOMMENDED AMBIENT WATER QUALITY CRITERIA FOR FRESHWATER AQUATIC LIFE

Parameter	Maximum or Acute Concentration (CMC) (1-hour Average) in µg/L	Continuous or Chronic Concentration (CCC) (4-day Average) in µg/L	Pollutant Type
Aluminum[1]	750	87	Non Priority
Alkalinity[3]		20,000	Non Priority
Cadmium[2]	2.0	0.25	Priority
Copper [2]	13	9	Priority
Iron[3]		1000	Non Priority
Zinc[2]	120	120	Priority
Dissolved Oxygen[3]	Warmwater and Coldwater Matrix (Document N)		Non Priority
TSS and Turbidity[3]	Narrative Statement (Document F)		Non Priority
Temperature[3]	Species-dependent Criteria (Document M)		Non Priority
Hardness[3]	Narrative Statement		Non Priority
pH[3]	6.5-9.5 in pH units		Non Priority

Source:
U.S. EPA 2006.
Notes:
[1] Total recoverable aluminum for waters with pH between 6.5 and 9.0.
[2] Expressed in terms of dissolved metal in water column as a function of hardness (mg/L). The value given here corresponds to a hardness of 100 mg/L. Criteria values for other hardness may be calculated based on information in Appendix B- Parameters for Calculating Freshwater Dissolved Metals Criteria
That Are Hardness-Dependent.
[3] U.S. EPA 1986.
Key:
CCC = Criteria Continuous Concentration (estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect)
CMC = Criteria Maximum Concentration(an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect)
µg/L = microgram per liter

TABLE 3-6
CRITERIA FOR PRIORITY TOXIC POLLUTANTS IN THE STATE OF CALIFORNIA (CALIFORNIA TOXICS RULE) FOR SELECT PARAMETERS

Parameter Name	Freshwater CMC (µg/L)	Freshwater CCC (µg/L)
Cadmium[1]		2.2
Copper[1]	13	9
Zinc[1]	120	120

Source: EPA 40 Code of Federal Regulations Part 131
Note:
1 The California Toxics Rule for the maximum concentration for Cadmium does not apply to the Sacramento River
Key:
CCC = Criteria Continuous Concentration
CMC = Criteria Maximum Concentration
µg/ = micrograms per liter l

Under the Porter Cologne Water Quality Control Act, the Water Quality Control Plan for the Sacramento and San Joaquin Rivers (Basin Plan) presents the following designated beneficial uses established for the Sacramento River; Colusa Basin Drain to the "I" Street Bridge, or Hydrologic Unit Number 520 (RWQCB 2007):

- **Municipal Domestic Supply (MUN) -** Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.

- **Agricultural Supply (AGR)** for Irrigation **–** Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation (including leaching of salts), stock watering, or support of vegetation for range grazing.

- **Water Contact Recreation (REC-1) –** Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, waterskiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs.

- **Non-contact Water Recreation (REC-2) –** Uses of water for recreational activities involving proximity to water, but where there is generally no body contact with water, nor any likelihood of ingestion of water. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

- **Warm and Cold Freshwater Habitat (WARM and COLD) –** Resident does not include anadromous fish. Any segments with both COLD and WARM beneficial use designations will be considered COLD water bodies for the application of water quality objectives.

- **Warm and Cold Migration of Aquatic Organisms (MIGR) –** More specifically referring to striped bass, sturgeon, and shad.

- **Warm and Cold Fish Spawning, Reproduction, and/or Early Development (SPWN) –** More specifically referring to salmon and steelhead.

- **Wildlife Habitat (WILD) -** Uses of water that support terrestrial or wetland ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats or wetlands, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

- **Navigation (NAV) -** Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels.

Of the water quality constituents measured in study area streams, water quality objectives for the Sacramento River watershed, from Keswick Dam to the I Street Bridge in the City of Sacramento, have been established concerning thresholds for the basic parameters of dissolved oxygen, pH, electrical (specific) conductivity, and turbidity (**Table 3-7**), as well as the ions and trace elements of barium, copper, iron, and zinc (**Table 3-8**). This segment of the Sacramento River is also on the 303d list of impaired water bodies for mercury and diazinon, an organophosphate pesticide. Organophosphate pesticides are not used by PCWA and not discussed further in this report.

TABLE 3-7
BASIN PLAN WATER QUALITY OBJECTIVES FOR BASIC PARAMETERS ASSOCIATED WITH BENEFICIAL USES

Parameter	Water Quality Criterion	Units	Applicable Water Bodies
Dissolved Oxygen	>85% saturation (Monthly median of the mean daily DO concentration in mg/L) >75% saturation (95th percentile concentration) 7.0 (Minimum level for waters with designated COLD beneficial uses)	(mg/L)	Surface water bodies outside the legal boundaries of the Delta.
pH[1]	6.5-8.5 Changes in normal ambient pH levels shall not exceed 0.5 in fres waters with designated COLD or WARM beneficial uses		All
Turbidity[2]	Will not increase by greater than 20%		

Source: Central Valley RWQCB, 2007
Notes:
[1] Changes in normal ambient pH levels shall not exceed 0.5 in freshwaters with designated COLD or WARM beneficial uses
[2] Where natural turbidity is between 5 and 50 NTU
Key:
DO = dissolved oxygen
mg/L = milligram per liter

TABLE 3-8
BASIN PLAN WATER QUALITY OBJECTIVES FOR TRACE ELEMENTS ASSOCIATED WITH BENEFICIAL USES

Parameter	Maximum Concentration	Unit
Barium[2]	100	µg/L
Copper[2]	10	µg/L
Iron[2]	0.3	mg/L
Zinc[2]	10	µg/L

Source: Central Valley RWQCB, 2007
Notes:
[1] These concentrations are based on a hardness of 40 mg/L. Where deviations from 40 mg/L of water hardness occur, the objectives (mg/L) shall be determined by the following formula:
$Cu = e^{(0.905)(\text{Ln hardness})-1.612} \times 10^{-3}$
$Zn = e^{(0.830)(\text{Ln hardness})-0.289} \times 10^{-3}$
$Cd = e^{(1.160)(\text{Ln hardness})-5.777} \times 10^{-3}$
[2] Metal objectives are dissolved concentrations
Key:
These objectives are applicable to the Sacramento River from Keswick Dam to the I Street Bridge at City of Sacramento (13, 30); American River from Folsom Dam to the Sacramento River (51); Folsom Lake (50); and the Sacramento-San Joaquin Delta.
mg/L = milligrams per liter
µg/L = micrograms per liter

3.2.2.1 Zone 3

The water quality of Canyon Creek is likely representative of other streams within the western Sierra Nevada montane forest area. Because the creek is located deep within a steep canyon characterized by coarse loam soils, it may be particularly vulnerable to erosion through scouring of the banks from high flows during the wet season, which increases the potential for naturally high sediment loads in streams. Although much of the land around Canyon Creek is rural, water quality conditions may be affected by historic mining activities in the area. Eleven of the 24 major watersheds in the Sierra had portions in which mercury was found, and eight watersheds were found with traces of copper detected (Sierra Nevada Alliance 2006). In addition, 50 percent of these major watersheds were found to have elevated concentrations of nutrients, and 29 percent were found to be affected by pesticides (Sierra Nevada Alliance 2006).

Water quality was evaluated at one site in Zone 3, Boardman Canal below Lake Alta (YB96). Lake Alta is located near the top of the PCWA water delivery system, at an elevation of 3,543 feet above mean sea level (msl). Releases from Lake Alta are delivered to Boardman Canal, which is the main conveyance feature in Zone 3.

The following sections describe water quality conditions observed during PCWA routine operations within the Zone 3 service area at Boardman Canal below Lake Alta (YB96).

Water Temperature and Dissolved Oxygen

Water temperature results for YB96 from baseline water quality monitoring events are shown in **Figure 3-7**. These water temperatures are of the coldest for all canal sampling locations because this site is the most upstream location within the canal system and is located at an elevation of 3,543 feet msl, which is significantly higher than the other sampling locations.

An inverse relationship between water temperature and DO was observed, shown in **Figure 3-7**, exhibiting higher DO levels when water temperatures were lower. In the PCWA canal system, DO levels were highest in late fall and decreased through winter and into spring. These DO results are of the highest among all canal sampling locations.

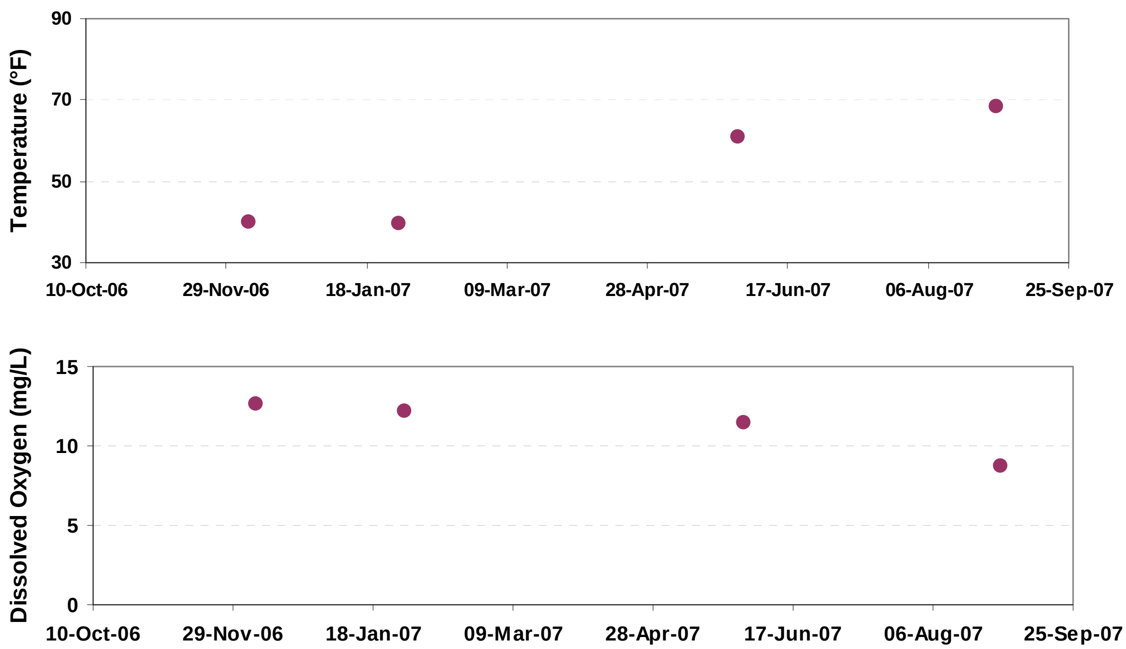

FIGURE 3-7
WATER TEMPERATURE AND DISSOLVED OXYGEN RESULTS FROM SEASONAL MONITORING EVENTS AT BOARDMAN CANAL BELOW LAKE ALTA

pH, Alkalinity, and Hardness

As shown in **Figure 3-8**, values for pH remained relatively close to the neutral level of 7.0, and were relatively constant in the canal system regardless of season, varying between pH 7.0 and pH 7.58. Results for pH at YB96 were closest to "neutral" among the water quality monitoring sites within the PCWA raw water distribution system.

The geology and soils of the region typically exhibit low pH and low concentrations of $CaCO_3$, a mineral that contributes to alkalinity and raises pH. However, many of the streams in the PCWA raw water service area are associated with xerofluvents, soils with up to pH 8.5, and some of the only soils in Placer County containing $CaCO_3$ (up to 5 percent) (USDA-NRCS 2007). As shown in **Figure 3-8**, alkalinity values at YB96 varied between 14 and 23 mg/L $CaCO_3$, which are similar to the values exhibited at the other canal sampling locations, described below. The highest alkalinity value of 23 mg/L $CaCO_3$ at YB96 is associated with the lowest pH value during the spring sampling event at that site. Calculated hardness values coincide with alkalinity values, with the exception of the summer sampling event, which was calculated to be lower than the measured alkalinity value. This could indicate the hardness is completely $CaCO_3$-derived.

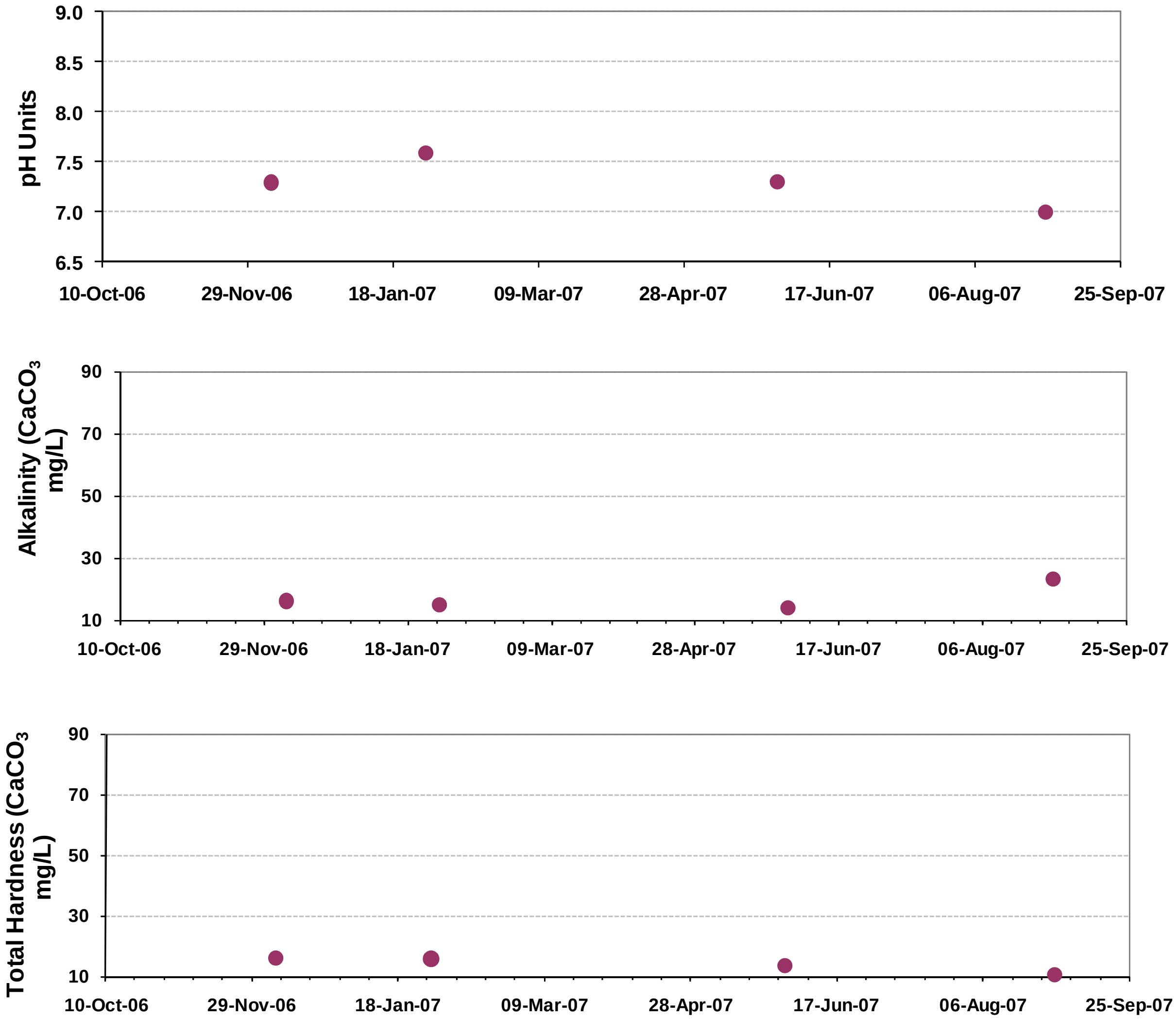

FIGURE 3-8
PH, HARDNESS, AND ALKALINITY RESULTS FROM SEASONAL MONITORING EVENTS AT BOARDMAN CANAL BELOW LAKE ALTA

Total Suspended Solids and Turbidity

All TSS values at YB96 were below detection limits (10 mg/L) during baseline sampling events. Turbidity was relatively low and constant in the PCWA canal system during routine operations activities. As shown in **Figure 3-9**, turbidity values at YB96 ranged between 8.0 and 15.7 nephelometric turbidity units (NTUs). Overall TSS and turbidity at the Boardman Canal below Lake Alta were low for seasonal baseline sampling events.

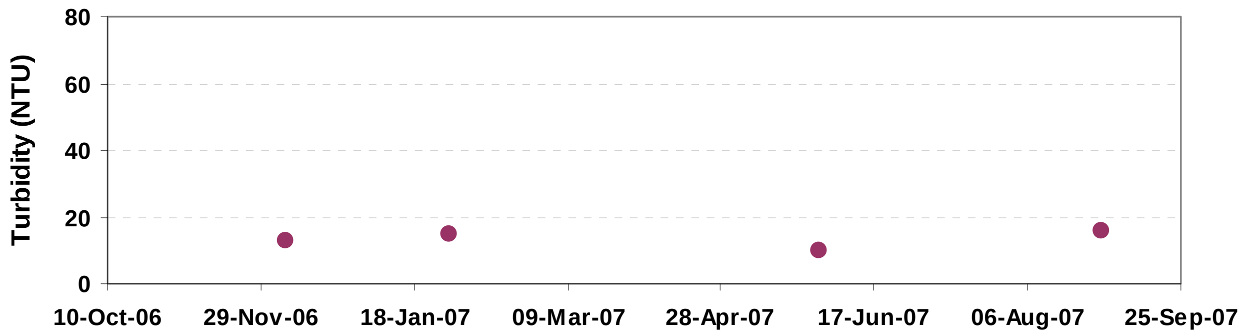

FIGURE 3-9
TOTAL SUSPENDED SOLIDS AND TURBIDITY RESULTS FROM SEASONAL MONITORING EVENTS AT BOARDMAN CANAL BELOW LAKE ALTA

Specific Conductivity and Ions

SC in water sampled in the Boardman Canal below Lake Alta was highest in fall and winter and decreased in spring and summer, as shown in **Figure 3-10**. With the exception of the summer result, these results were the highest among all other canal sampling locations.

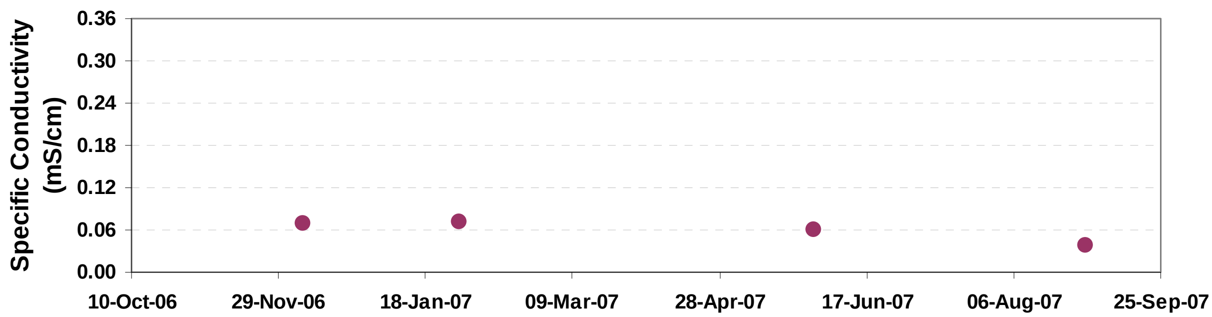

FIGURE 3-10
SPECIFIC CONDUCTIVITY RESULTS FROM SEASONAL MONITORING EVENTS AT BOARDMAN CANAL BELOW LAKE ALTA

As shown in **Figure 3-11**, calcium concentrations at YB96 display similar trends to that of SC, in which results were higher in fall and winter than in spring and summer. Seasonal calcium results at the Boardman Canal below Lake Alta were very low and ranged from 3.1 to 4.3 mg/L.

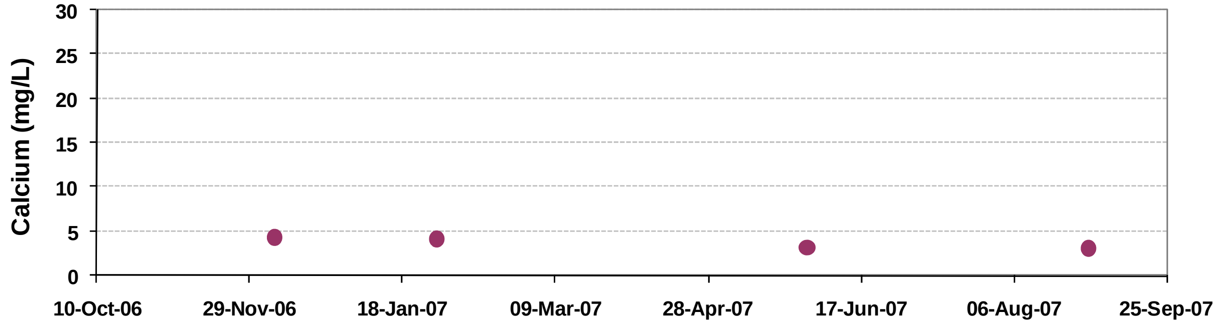

FIGURE 3-11
CALCIUM RESULTS FROM SEASONAL MONITORING EVENTS AT BOARDMAN CANAL BELOW LAKE ALTA

Iron was low at the YB96 site under routine operations, as shown in **Figure 3-12**. Concentrations ranged from 0.081 to 0.16 mg/L.

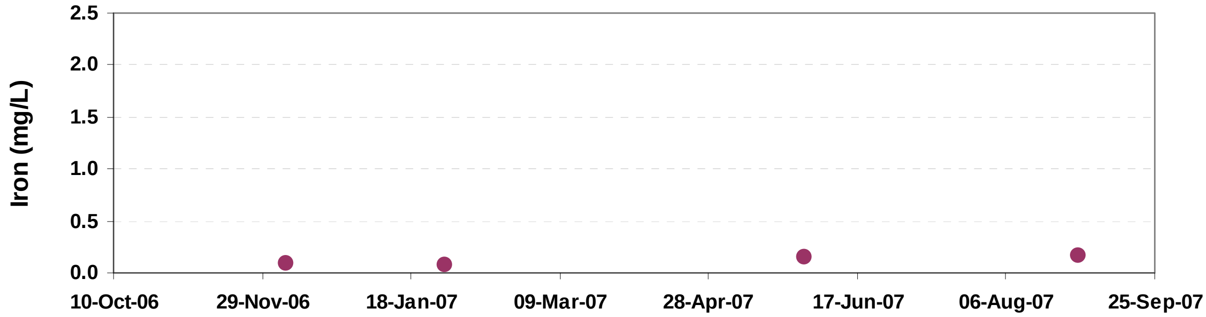

FIGURE 3-12
IRON RESULTS FROM SEASONAL MONITORING EVENTS AT BOARDMAN CANAL BELOW LAKE ALTA

As shown in **Figure 3-13,** magnesium concentrations observed at YB96 were low, with values ranging from 0.73 to 1.4 mg/L. Results did not vary greatly over different seasons, which is similar to results for calcium.

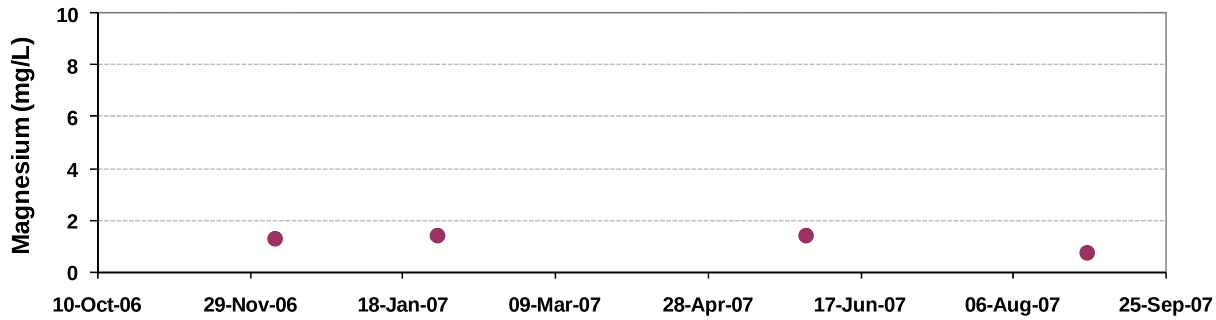

FIGURE 3-13
MAGNESIUM RESULTS FROM SEASONAL MONITORING EVENTS AT BOARDMAN CANAL BELOW LAKE ALTA

No potassium results were detected, with a detection limit of 1.0 mg/L, at Boardman Canal below Lake Alta during routine canal operations.

Figure 3-14 shows that sodium values range from 2.2 to 6.6 mg/L, with the lowest value in the summer and the highest value in the winter. Although sodium concentrations were very low at the Boardman Canal below the Lake Alta site, they were higher than all other canal sampling locations, with the exception of the summer, which exhibited the lowest value.

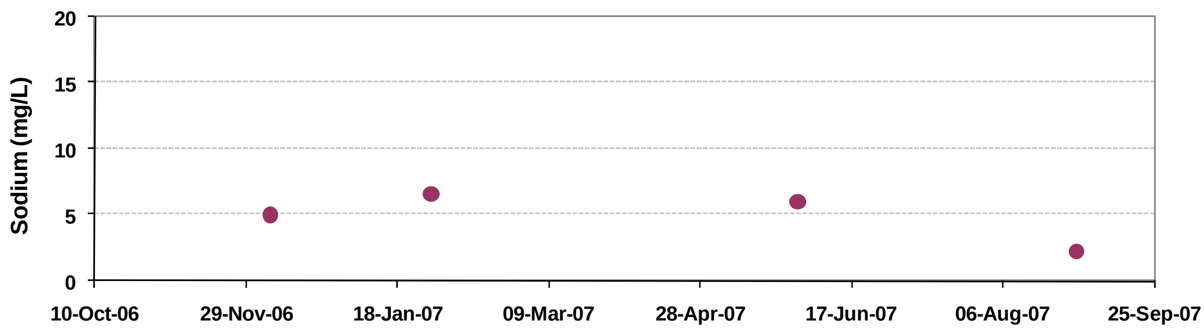

FIGURE 3-14
SODIUM RESULTS FROM SEASONAL MONITORING EVENTS AT BOARDMAN CANAL BELOW LAKE ALTA

Chloride was present in the canal system at low levels during baseline sampling, as shown in **Figure 3-15**. Observed chloride concentrations at YB96 ranged from 1.9 to 9.5 mg/L. Similar to sodium concentrations at Boardman Canal below Lake Alta, chloride levels were elevated above concentrations in the remainder of the canal system, with the exception of summer baseline samples, when concentrations were lowest.

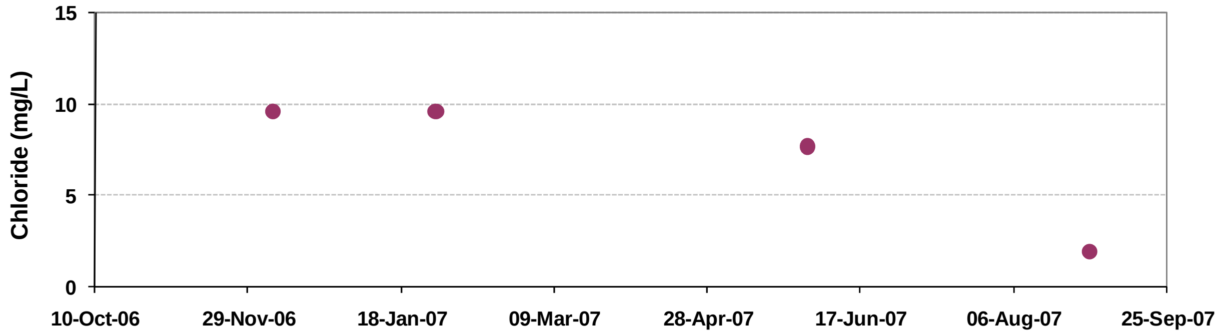

FIGURE 3-15
CHLORIDE RESULTS FROM SEASONAL MONITORING EVENTS AT BOARDMAN CANAL BELOW LAKE ALTA

Similar to potassium levels, no nitrate was detected at Boardman Canal below Lake Alta under baseline conditions. All results were below the detection limit of 0.1 mg/L.

Concentrations of sulfate are very low at the Boardman Canal below Lake Alta during routine operations. Concentrations were below the detection limit of 0.5 mg/L, with the exception of the winter sampling event, when the result was 1 mg/L.

Trace Elements

Elements that typically occur in very low concentrations are referred to as trace elements. At higher concentrations, most trace elements become toxic to plants, animals, or humans. Sources may be natural or urban, agricultural, or municipal. The solubility of most trace elements – whether they adsorb to bottom sediments or remain in the water column – is dependent on oxidation and reduction potential and pH. Water quality sampling in Zone 3 included analyses for several trace elements: barium, cadmium, copper, iron, mercury, and zinc. The toxicity and potential sources of these individual elements are described below with their observed trends.

Figure 3-16 shows aluminum results for the Boardman Canal below the Lake Alta site. These results are among the lowest of the results at the canal sampling locations.

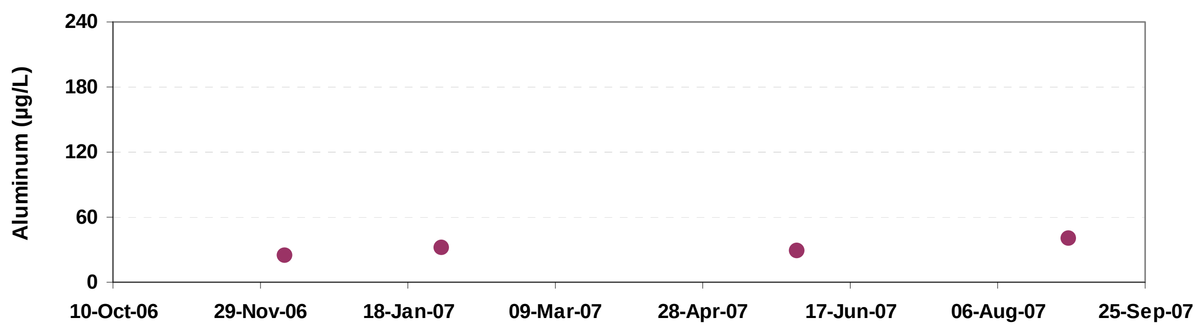

FIGURE 3-16
ALUMINUM RESULTS FROM SEASONAL MONITORING EVENTS AT BOARDMAN CANAL BELOW LAKE ALTA

Compared to other canal sites evaluated for this study, the highest seasonal barium concentrations were observed at Boardman Canal below Lake Alta; all of which were more than an order of magnitude greater than concentrations at sites evaluated elsewhere in the canal system (**Figure 3-17**).

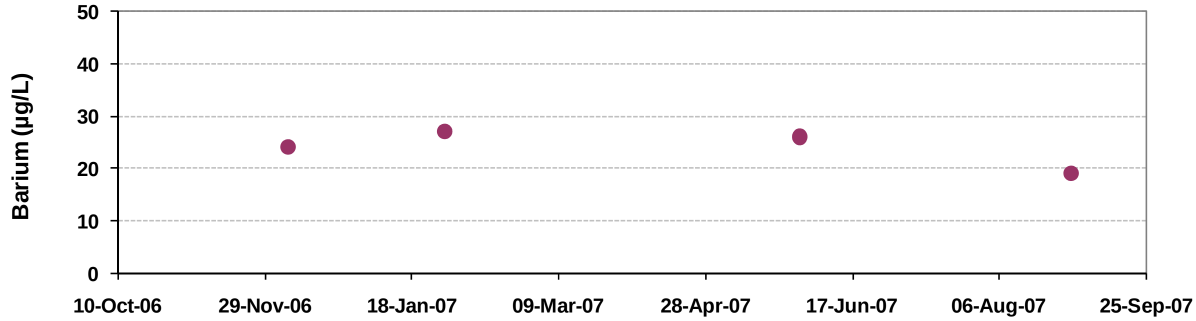

FIGURE 3-17
BARIUM RESULTS FROM SEASONAL MONITORING EVENTS AT BOARDMAN CANAL BELOW LAKE ALTA

All cadmium, copper, and mercury concentrations measured for baseline sampling events at Boardman Canal below Lake Alta were below the detection limits of 0.5, 2, and 0.2 µg/L, respectively. The only detected result for zinc at Boardman Canal below Lake Alta occurred during the winter sampling event, and exhibited the highest concentration, 22 µg/L, of all the canal sites (**Figure 3-18**). Modifications in laboratory measurement procedures for zinc led to the adjustments to the detection limit during the study period, from 5 to 10 to 20 µg/L.

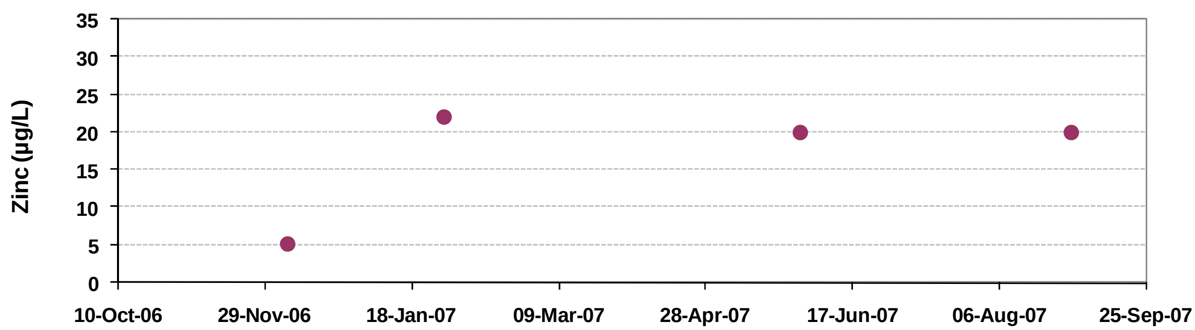

FIGURE 3-18
ZINC RESULTS FROM SEASONAL MONITORING EVENTS AT BOARDMAN CANAL BELOW LAKE ALTA

3.2.2.2 Zone 1

As shown in **Figures 3-2** and **3-3** and listed in **Table 3-1**, five canal sampling locations and nine stream sites were monitored in Zone 1 for baseline sampling events. Water quality results for canal and stream sites are discussed by watershed. Zone 1 watersheds evaluated include Auburn Ravine, Clover Valley Creek, Antelope Creek, Miners Ravine, and Secret Ravine.

Auburn Ravine Watershed

Water quality was evaluated at one sampling location within the Auburn Ravine watershed in Zone 1; Auburn Ravine below Auburn Ravine Tunnel outlet (AUBRAV3).

Water Temperature and Dissolved Oxygen

Water temperature and DO results are shown in **Figure 3-19**. Temperatures at AUBRAV3 display seasonal trends, with lowest temperatures during winter and highest during summer. DO levels remain relatively high throughout the year, ranging between 9.51 to 12.31 mg/L.

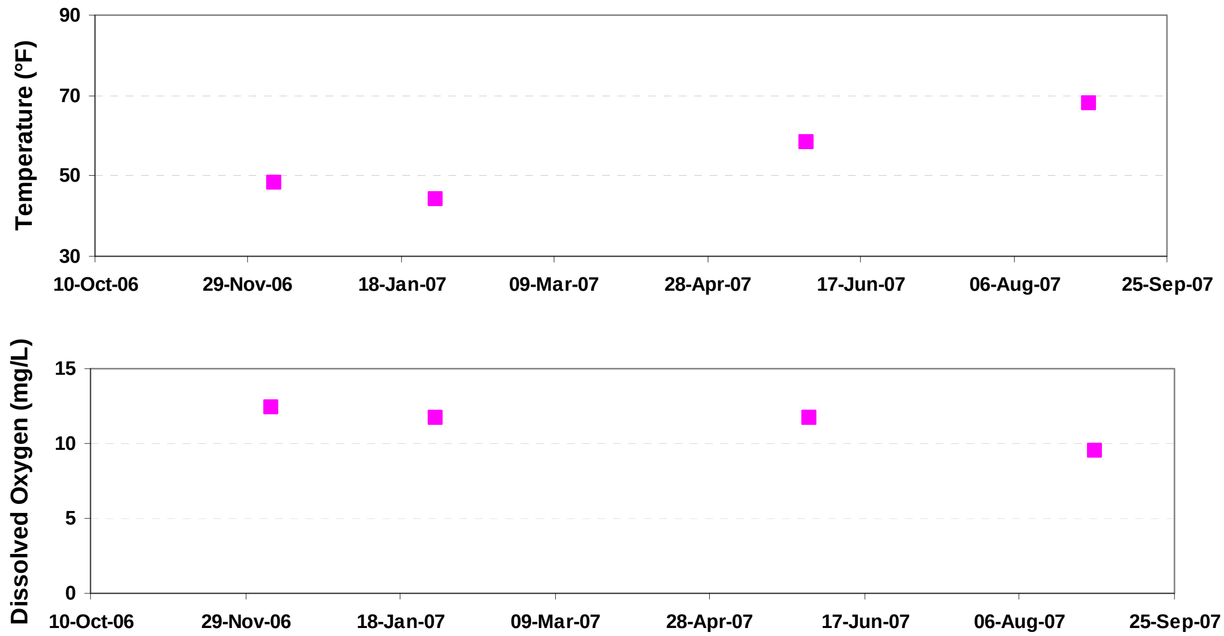

FIGURE 3-19
WATER TEMPERATURE AND DISSOLVED OXYGEN RESULTS FROM SEASONAL MONITORING EVENTS AT AUBURN RAVINE BELOW AUBURN RAVINE TUNNEL OUTLET

Water temperature data collected from other sources include hourly temperature monitoring conducted by Bailey Environmental between April 1999 and August 2003 at Fowler Road, an NID gaging station near Highway 65 in Lincoln, Moore Road, and at Aitken Ranch. Water temperature data from Bailey Environmental show summer values (May 28 to August 4, 2003) ranging from approximately 62 degrees Fahrenheit (°F) to 82 °F, fall values (September 9 to December 28, 2002) ranging from 48 °F to 69 °F, winter values (January 1 to April 27, 2003) ranging from 43 °F to 64 °F, and spring values (May 1 to July 31, 2003) ranging from 50 °F to 73 °F (Sierra Business Council 2003).

Lincoln High School Water Quality Monitoring Program funded by NID, Placer County, and the City of Lincoln, measured high DO values at three different stations along the creek during September 2001, and September and October 2002: Mackenroth Road, Highway 193 Bridge crossing, and the Joiner Parkway Bridge crossing (Sierra Business Council 2003).

pH, Alkalinity, and Hardness

Results for pH, alkalinity, and hardness from AUBRAV3 are shown in **Figure 3-20**. Values for pH at Auburn Ravine below the Auburn Ravine Tunnel outlet ranged from 7.43 to 8.14. Alkalinity values in the streams varied between 25 and 68 mg/L $CaCO_3$, with the highest alkalinity during summer.

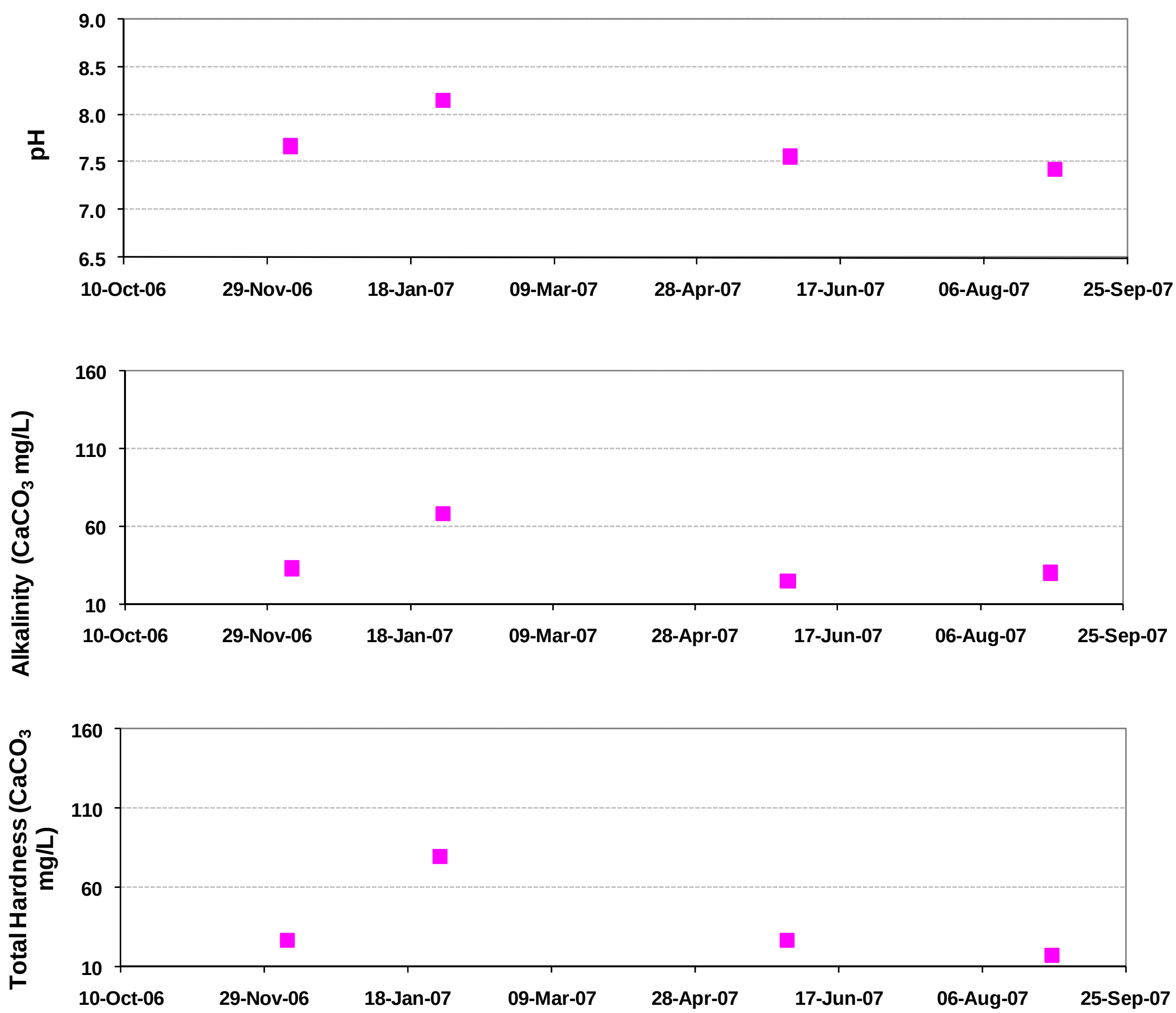

FIGURE 3-20
PH, ALKALINITY, AND HARDNESS RESULTS FROM SEASONAL MONITORING EVENTS AT AUBURN RAVINE BELOW AUBURN RAVINE TUNNEL OUTLET

Data on pH was collected monthly by the California Department of Water Resources (DWR) in the lower portion of the Auburn Ravine watershed reveal a wide range of pH values (5.6 to 7.7). The lower end of this range is considered extremely low for the types of streams found in the Sierra Nevada Foothills (Placer County Planning Department 2003).

Total Suspended Solids and Turbidity

TSS values measured in Auburn Ravine were below detection limit (10 mg/L) during all baseline monitoring events. As shown in **Figure 3-21**, turbidity values measured for AUBRAV3 were all low and consistent during sampling events, with values below 18 NTUs.

Turbidity and TSS in the Auburn Ravine were measured at the Lincoln and Auburn WWTPs under NPDES permit requirements. TSS loads were observed to significantly increase in winter and spring, likely from stormwater runoff. During low flows in Auburn Ravine, turbidity was measured at less than 1 NTU. Turbidity loads of greater than 2 NTUs were measured in the effluent from the Lincoln WWTP during this time (Placer County 2002). Turbidity was also measured in the Auburn Ravine by DWR between January 2001 and January 2002. Turbidity results ranged from 5 to 33 NTUs, with one higher value observed during December 2001 at 136 NTUs.

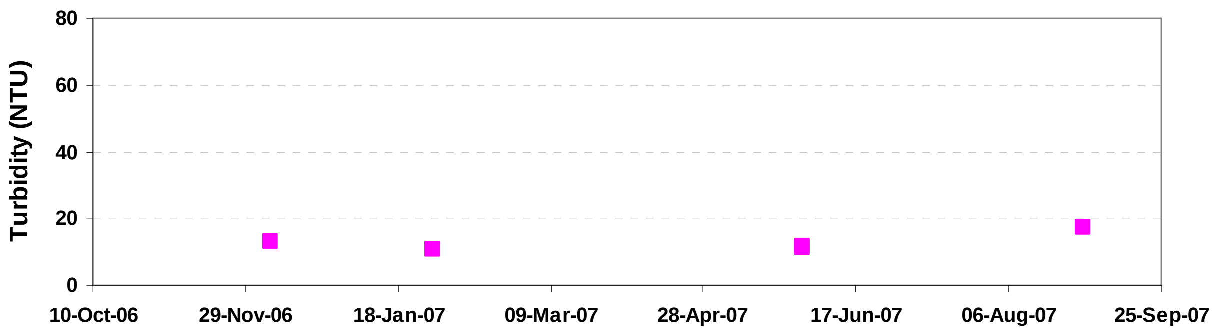

FIGURE 3-21
TURBIDITY RESULTS FROM SEASONAL MONITORING EVENTS AT AUBURN RAVINE BELOW AUBURN RAVINE TUNNEL OUTLET

Specific Conductivity and Ions

SC results for baseline monitoring events at AUBRAV3 were among the lowest of the stream monitoring sites, with the exception of the winter monitoring event, which exhibited the highest SC value across all stream monitoring sites. However, the highest value measured of 0.2 milliSiemens per centimeter (mS/cm) is still considered low (**Figure 3-22**).

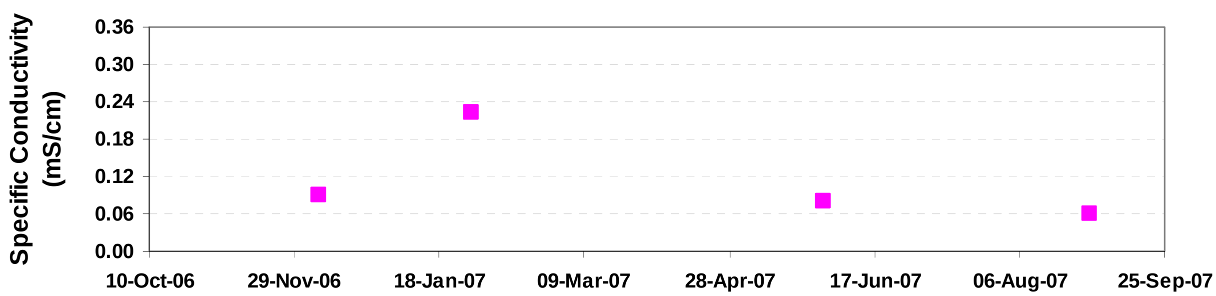

FIGURE 3-22
SPECIFIC CONDUCTIVITY RESULTS FROM SEASONAL MONITORING EVENTS AT AUBURN RAVINE BELOW AUBURN RAVINE TUNNEL OUTLET

Calcium values range from 4.7 mg/L during the summer monitoring event to 16.0 mg/L during the winter event (**Figure 3-23**), and magnesium results range from 1.4 mg/L during the summer monitoring event to 9.7 mg/L during the winter event. Magnesium results display similar trends as for calcium during baseline monitoring events at AUBRAV3, in which seasonal concentrations are highest during the winter monitoring event and lowest during the summer monitoring event (**Figure 3-24**).

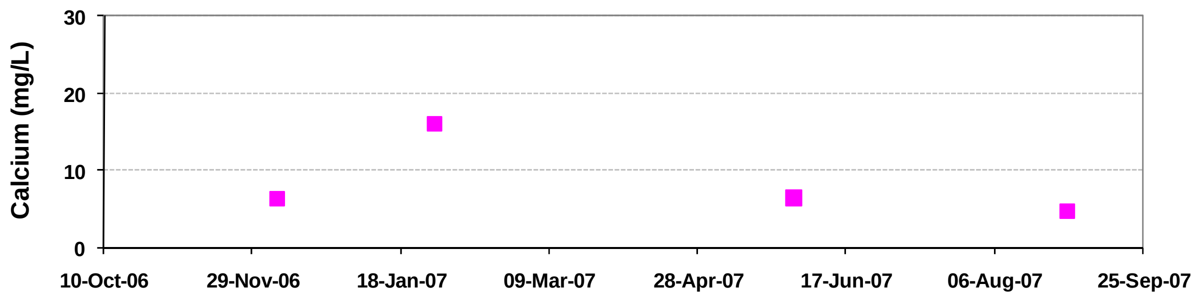

FIGURE 3-23
CALCIUM RESULTS FROM SEASONAL MONITORING EVENTS AT AUBURN RAVINE BELOW AUBURN RAVINE TUNNEL OUTLET

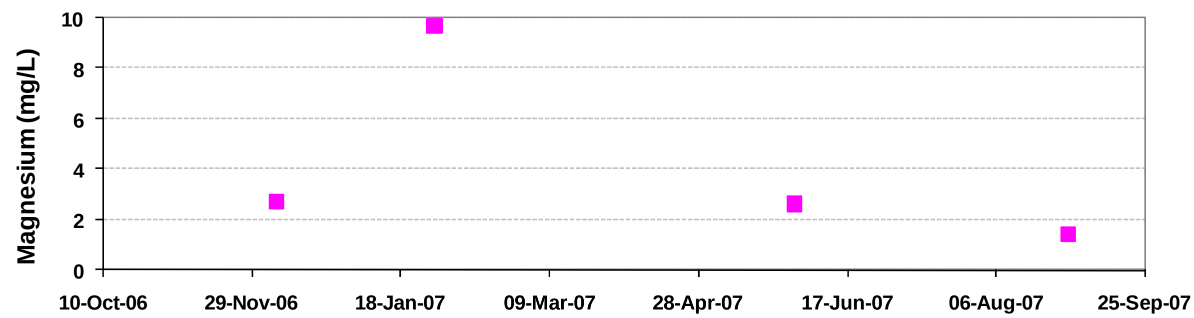

FIGURE 3-24
MAGNESIUM RESULTS FROM SEASONAL MONITORING EVENTS AT AUBURN RAVINE BELOW AUBURN RAVINE TUNNEL OUTLET

Very low iron values were observed at AUBRAV3. As shown in **Figure 3-25**, iron results ranged from 0.08 to 0.21 mg/L.

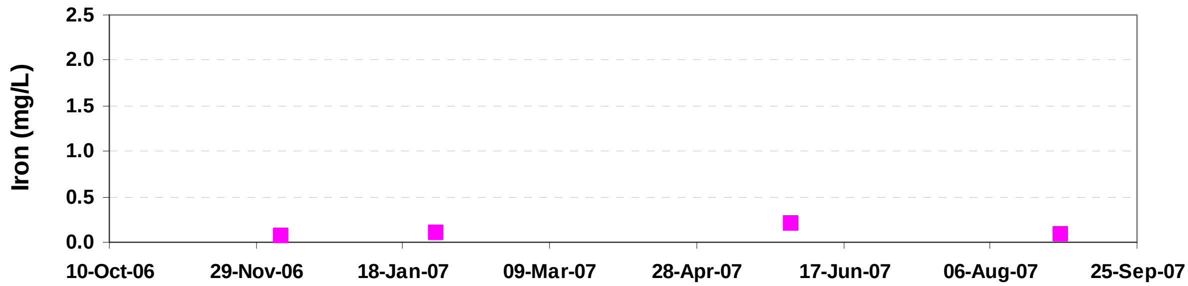

FIGURE 3-25
IRON RESULTS FROM SEASONAL MONITORING EVENTS AT AUBURN RAVINE BELOW AUBURN RAVINE TUNNEL OUTLET

Potassium values at AUBRAV3 were also very low; with concentrations below the detection limit (1.0 mg/L for spring event, 1.4 mg/L for summer event) during the spring and summer monitoring events, to 2.2 mg/L during the winter monitoring event (**Figure 3-26**).

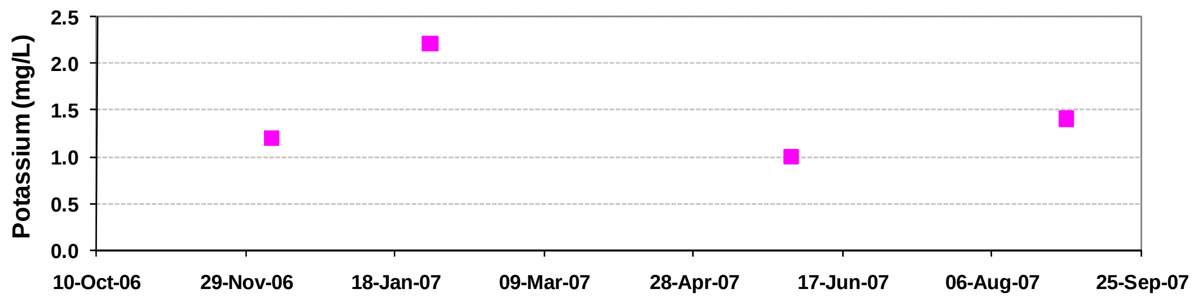

FIGURE 3-26
POTASSIUM RESULTS FROM SEASONAL MONITORING EVENTS AT AUBURN RAVINE BELOW AUBURN RAVINE TUNNEL OUTLET

As shown in **Figure 3-27**, sodium results ranged from 4.0 to 14.0 mg/L at AUBRAV3. The highest sodium values were observed during the winter monitoring event and the lowest values during the summer monitoring event.

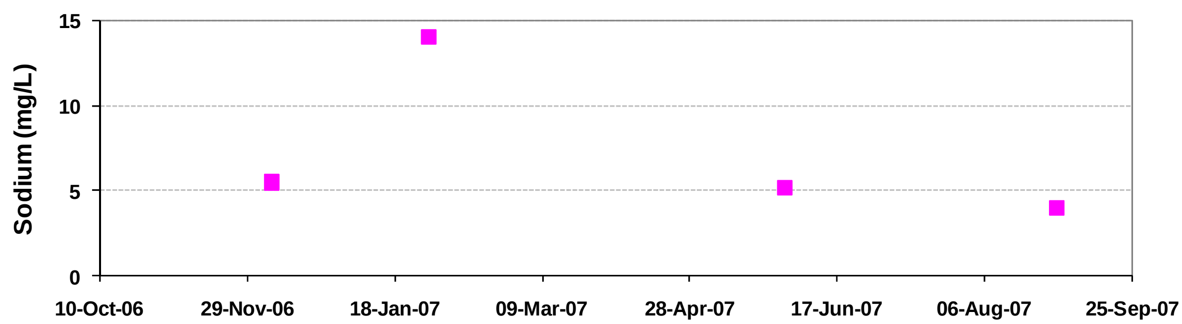

FIGURE 3-27
SODIUM RESULTS FROM SEASONAL MONITORING EVENTS AT AUBURN RAVINE BELOW AUBURN RAVINE TUNNEL OUTLET

Chloride results are similar to those of sodium at AUBRAV3, with values ranging from 3.6 mg/L during the summer monitoring event to 13.0 mg/L during the winter monitoring event (**Figure 3-28**).

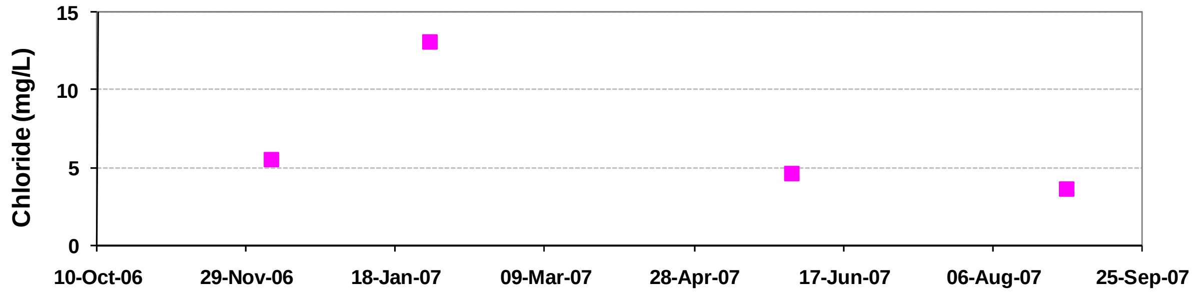

FIGURE 3-28
CHLORIDE RESULTS FROM SEASONAL MONITORING EVENTS AT AUBURN RAVINE BELOW AUBURN RAVINE TUNNEL OUTLET

Sulfate concentrations at AUBRAV3 ranged from 3.3 mg/L during the summer monitoring event to 17 mg/L during the winter monitoring event, as shown in **Figure 3-29**.

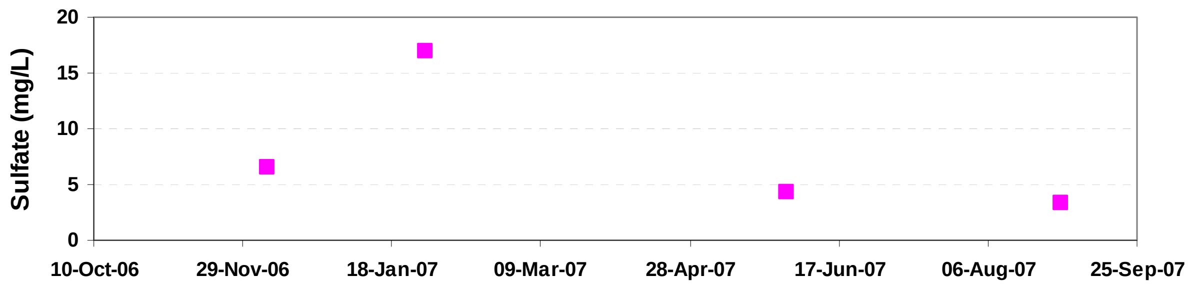

FIGURE 3-29
SULFATE RESULTS FROM SEASONAL MONITORING EVENTS AT AUBURN RAVINE BELOW AUBURN RAVINE TUNNEL OUTLET

As shown in **Figure 3-30**, nitrate results at the AUBRAV3 monitoring site were very low during baseline sampling events. Nitrate concentrations ranged from the detection limit (0.1 mg/L) during the summer monitoring event to 1.3 mg/L during the winter monitoring event.