4 Environmental Setting

California contains a wide variety of bioregions, from desert environments below sea level, to coastal areas, to alpine areas of 14,000 feet or more in elevation. The diversity of geography colliding with temperature and moisture leads to a significant diversity of biological resources. California has the highest total number of species and the highest number of endemic species within its borders than any other state. California also has the highest number of rare species (species typically listed under the federal Endangered Species Act [ESA] or the California ESA), and about one-third of those species are at risk, meaning these species have the potential for local or global extinction.

4.1 Bioregions of California

California is divided geographically into bioregions (CBC 2008), classified by relatively large areas of land or water, which contain characteristic, geographically distinct assemblages of natural communities and species. The biodiversity of flora, fauna, and ecosystems that characterize a bioregion tend to be distinct from that of other bioregions. California is divided into 10 bioregions: Modoc, Klamath/North Coast, Sacramento Valley, Bay Area/Delta, Sierra, San Joaquin Valley, Central Coast, Mojave Desert, South Coast, and Colorado Desert (Figure 1).

4.1.1 Modoc Bioregion (CERES 2011a)

The Modoc Bioregion, an area of stark contrast to the rest of the state, extends across California's northeast corner from Oregon to Nevada, and south to the southern border of Lassen County. From many vantage points, the view to the west is of forests and mountains, while the vista to the east is high desert characteristic of Nevada. Much of this sparsely populated bioregion of forests, mountains, high desert, valleys, piney woodlands, and volcanic remains in its natural state.

Location, People, Cities

Bounded by Oregon on the north and Nevada on the east, the Modoc bioregion extends westward across the Modoc Plateau, encompassing the Lassen and Modoc national forests. It includes all or part of seven counties: Modoc, and Lassen, and the eastern end of Shasta, Siskiyou and Tehama, northern edges of Butte and Plumas. Because bioregions have only fuzzy lines and can take in portions of several counties, it is difficult to estimate their populations precisely. But the rural nature of the Modoc Bioregion is reflected in the populations of the two counties totally contained within its boundaries: Modoc, 10,700, and Lassen, 29,800. According to 1990 census figures, Modoc has the smallest population of all 10 bioregions, with fewer than 81,000. The largest cities are Alturas, the Modoc County seat; Susanville, the Lassen County seat; Burney in eastern Shasta County, and Maglia in northern Butte County.

The Northern Paiute and the Paiute-Shoshone tribes are native to this bioregion. Indian reservations include Fort Bidwell, Alturas, Cedarville, Likely, and Lookout Rancherias; and Pit River, all in Modoc County.

Main highways are U.S. Highway 395 and state routes 299, 139, 89, 44, and 36.

Figure 1: California Bioregions

Industries

Ranching remains the major agricultural industry, and timber is a significantly large employer.

Climate and Geography

The climate features hot, dry summers and cold, moist winters with snow at higher elevations. Geography is varied in the Modoc Bioregion, with volcanic areas and wetlands to the west and high desert to the east. Lassen Volcanic National Park, which is studded with lakes and crowned by 10,457-foot Lassen Peak; Tule Lake, and Clear Lake National Wildlife Refuges, Ahjumawi Lava Springs State Park, and Lava Beds National Monument are on the western side. The eastern side, which resembles its neighbor, Nevada, has desert alkali lakes, Honey Lake Valley, and Modoc National Wildlife Refuge. The last volcanic activity at Mount Lassen was in 1915.

The bioregion includes Modoc and Lassen National Forests and part of the Klamath National Forest. The largest lakes are Lake Almanor in Plumas County, Eagle Lake in Lassen County, Lower Klamath Lake in Siskiyou County, and Goose Lake in Modoc County. The Pit River flows southwest from the rugged Warner Mountains in eastern Modoc and Lassen counties across the Modoc Plateau and into the Sacramento River.

Plants and Wildlife

Juniper and sagebrush cover much of the eastern side of the Modoc Bioregion, while yellow and Jeffrey pine, white fir, mixed conifer, cedar, and aspen are common in the more mountainous and forested areas to the west. Rare plants include yellow arrowleaf, balsam root, long-haired star tulip, spiny milkwort, Ash Creek ivesia, Raven's lomatium, and woolly stenotus.

Wildlife include bald eagles, antelope, greater sandhill cranes, ospreys, Canada geese, black-crowned night herons, mule deer, muskrats, pronghorn, cinnamon teal, northern pintails, Swainson's hawks, sage grouse, rainbow trout, marmots, hummingbirds, great horned owls, black bears, coyotes, porcupine, Modoc sucker, goshawk, bank swallow, Shasta crayfish, sage grouse, and Lost River sucker.

4.1.2 Klamath/North Coast Bioregion (CERES 2011b)

The Klamath/North Coast Bioregion in California's northwestern corner extends roughly one-quarter of the way down the 1,100-mile coast and east across the Coastal Range and into the Cascades. This bioregion is famous for its rocky coastline, salmon fishing, and lush mountain forests of spectacular ancient redwoods and Douglas fir. Redwood National Park and numerous state parks, rivers, wilderness areas, and four national forests are in this bioregion.

Location, Cities, People

Ten counties make up the Klamath/North Coast Bioregion: Del Norte, most of Siskiyou, Humboldt, Trinity, Mendocino, Lake, and the northwestern portions of Shasta, Tehama, Colusa, and Glenn. Its boundaries are the Oregon border on the north, and the southern borders of Lake and Mendocino counties on the south. Despite the huge area of this bioregion, its population is only about 410,000 according to 1990 census figures. The bioregion extends from the Pacific Coast eastward more than halfway across California to the Modoc Plateau and the Sacramento Valley floor. The Hoopa Valley, Yurok, Karok, Paiute-Shoshone, and Pomo-Kato Indians are native to various parts of this bioregion.

The largest cities are Redding -- a Northern California crossroad on Interstate 5 -- and Eureka, a Humboldt County seaport. Smaller cities include Clearlake, Ukiah, Arcata, Fort Bragg, Yreka, Mendocino, and Crescent City. Main highways are I-5, U.S. 101, and state Highways 36, 299, 96, and 3, which cross mountains and can be steep and winding.

Industries

Along the coast, redwood trees hundreds or thousands of years old are a cherished natural resource and major tourist attraction. These forests are home to the endangered marbled murrelet, a seabird that nests in old-growth, and the threatened northern spotted owl, whose decline prompted severe reductions in federal timber harvest sales to preserve its habitat. Listing of the owl under the federal Endangered Species Act and other 1990s environmental actions caused economic impacts upon the once-booming timber industry, such as forcing closure of many sawmills and dislocation of workers. Communities once dependent on timber activities are being forced to diversify their economies, and are encouraging the growth of tourism, improving infrastructure, and seeking ways to attract and accommodate new businesses. Cattle ranching, dairy farming, and fishing are popular traditional industries of the bioregion.

Climate and Geography

Much of the Klamath/North Coast Bioregion is covered by forest -- the Klamath, Shasta-Trinity, Six Rivers, and Mendocino National Forests, Jackson State Forest, and private forests, including the famous Headwaters ancient redwood forest in Humboldt County. This mountainous bioregion includes the North Coast Range and the Klamath, Siskiyou, Marble, Salmon, Trinity, and Cascade mountains. The Klamath/North Coast is the state's wettest climate, with rainfall distribution varying widely from an average annual 38 inches at Fort Bragg to 80 or more inches in the King Range National Conservation Area. The coastal climate is cool, moist, and often foggy, with rainy winters at lower elevations and snow in the higher mountains. Inland the climate is drier with low rainfall in winter and hot, dry summers.

Major rivers include the Eel, Trinity, Klamath, Russian, Smith, Salmon, Scott, Mad, and Mattole, which flows into the Pacific Ocean near seismically active Cape Mendocino. Clear Lake, Whiskeytown Lake, Clair Engle, and the western part of Shasta are the largest lakes in the bioregion.

Plants and Wildlife

Vegetation includes mixed conifer habitat of white fir, Douglas fir, ponderosa pine, Sierra lodgepole pine, incense cedar, sugar pine, red pine, Jeffrey pine, mountain hemlock, knobcone pine, western red cedar, red alder, redwood, tanoak, Pacific madrone, and chaparral. Rare plants include Sebastopol meadowfoam, Burke's goldfields, Humboldt Bay owl's clover, Calistoga ceanothus, Baker's navarretia, coast lily, swamp harebell, Tracy's sanicle, Snow Mountain willowherb, marsh checkerbloom, pale yellow stonecrop, Scott Mountain phacelia, McDonald's rock cress, Klamath Mountain buckwheat, Oregon fireweed, Adobe lily, dimorphic snapdragon, Colusa layia, Indian Valley brodiaea, and Stebbins' lewisia.

Wetlands provide places for resting, nesting, feeding and breeding for native and migrating birds and waterfowl. Wildlife in the bioregion includes deer, fox, black bear, mountain lion, California clapper rail, Aleutian Canada geese, Roosevelt elk, osprey, fisher, bank swallow, Coho salmon, king salmon, otis blue butterfly, bald eagle, Point Arena mountain beaver, Swainson's hawk, willow flycatcher, western sandpiper, and Oregon silverspot butterfly. Rare species include northern spotted owl, marbled murrelet, American peregrine falcon, Lotis blue butterfly, Trinity bristle snail, red-legged frog, Siskiyou Mountains salamander, Pacific fisher, Del Norte salamander, Karok Indian snail, wolverine, goshawk, and Chinook salmon.

4.1.3 Sacramento Valley Bioregion (CERES 2011c)

The Sacramento Valley Bioregion, a watershed of the Sierra Nevada, is rich in agriculture, but is also significant as the seat of California's state government. Lying halfway between the Pacific Ocean and the Sierra Nevada, the Sacramento Valley affords convenient travel time to San Francisco and Lake Tahoe. The bioregion encompasses the northern end of the great Central Valley, stretching from Redding to the southeast corner of Sacramento County. Its southern boundary borders the northern edge of the Sacramento-San Joaquin River Delta. Sacramento, the home of California's state Capitol, sits at the confluence of the Sacramento and American Rivers.

Location, Cities, People
The broad, flat valley that comprises this bioregion touches nine counties, including all of Sutter, most of Sacramento, and Yolo, and portions of Butte, Colusa, Glenn, Placer, Shasta, Tehama, and Yuba counties. Sacramento, with a population of about 400,000, is the bioregion's largest city and ranks seventh in the state behind Fresno, Long Beach, San Francisco, San Jose, San Diego, and Los Angeles. Other large cities, all smaller than Sacramento, include Redding, Chico, Davis, West Sacramento, and Roseville. More than 1.5 million people inhabit this bioregion, making it the fourth most populous of the 10 bioregions, based on 1990 census figures. The cultural roots of the region date from Native American inhabitants, such as the Wintun Indians, to 19th century settlers who established and worked the farms and ranches.

Two of the state's major interstate highways, I-5, the state's main north-south artery, and transcontinental I-80, intersect in Sacramento. Other main highways include U.S. Highway 50, and State Highways 99, 44, 113, 70, and 20.

Industries
Agriculture and state government are important industries in the Sacramento Valley bioregion, but only three of the counties -- Sutter, Yolo, and Colusa -- rank among California's top 20 agricultural producers. Still, the valley is known for tomatoes, rice, and olives, among other prominent crops produced in the plentiful fields and orchards.

Food canneries, high-technology, and biotechnology play a significant role. The bioregion once had a substantial military presence with three Air Force bases, but downsizing changed the picture, closing Mather, then adding McClellan to the closure list, but sparing Beale. Shipping is important in the port of West Sacramento.

Climate and Geography

The changing of the seasons is more evident in the Sacramento Valley than in the coastal regions to the west. Summer hot spells that drive daytime temperatures into triple digits are relieved by cooling "Delta breezes" that carry moist air from San Francisco Bay eastward through the Delta and into the Sacramento area. The brief, mild autumn ends when tule fog blankets the valley for much of the winter season from December into February, keeping temperatures chilled. Except during droughts, rainfall is frequent in winter, but snowfall is unusual because temperatures, particularly in the daytime, normally remain well above freezing.

The Sacramento Valley is flat for the most part, but is situated within view of mountains, which are particularly visible on clear days. To the west, the coastal range foothills loom on the horizon, while the snow-capped peaks of the Sierra Nevada can be seen to the east.

The valley's two major rivers -- the Sacramento and American -- carry water that originates in the Sierra Nevada south and west into the Sacramento-San Joaquin River Delta. The Delta supplies water to about two-thirds of California's 32 million residents. Other rivers include the Cosumnes -- the largest free-flowing river in the Central Valley -- the lower Feather, Bear, and Yuba Rivers.

Plants and Wildlife

Oak woodlands, riparian forests, vernal pools, freshwater marshes, and grasslands provide the major natural vegetation of the Sacramento Valley Bioregion. The Sacramento Valley is the most prominent wintering site for waterfowl, attracting more than 1.5 million ducks and 750,000 geese to its seasonal marshes along the Pacific Flyway. Species include northern pintails, snow geese, tundra swans, sandhill cranes, mallards, grebes, peregrine falcons, heron, egrets, and hawks. Black-tailed deer, coyotes, river otters, muskrats, beavers, ospreys, bald eagles, salmon, steelhead, and swallowtail butterflies are just some of the wildlife that abounds in this bioregion. Species on the endangered species list include the winter-run Chinook salmon, delta smelt, giant garter snake, and the western yellow-billed cuckoo.

4.1.4 Bay Area/Delta Bioregion (CERES 2011d)

The Bay Area/Delta Bioregion is one of the most populous, encompassing the San Francisco Bay Area and the Sacramento-San Joaquin River Delta. Environmentally, the bioregion is the focus of debate over conflicting demands for the water that flows through the Delta, supplying two-thirds of California's drinking water, irrigating farmland, and sustaining fish and wildlife and their habitat. Under a historic accord in 1994, competing interests initiated a process for working together to "fix" the Delta.

Location, Cities, People

The bioregion fans out from San Francisco Bay in a jagged semi-circle that takes in all or part of 12 counties, including the state's top six in family income: Marin, Contra Costa, Santa Clara, Alameda, Solano, San Mateo, as well as the counties of San Francisco, Sonoma, Napa, San Joaquin, and parts of Sacramento, and Yolo. Major cities include San Francisco, Santa Rosa, Oakland, Berkeley, Vallejo, Concord, and San Jose. Though of moderate size, the Bay-Delta Bioregion is the second most populous bioregion, next to the South Coast, with 6.6 million people, based on the 1990 census.

The Bay Area/Delta Bioregion extends from the Pacific Ocean to the Sacramento Valley and San Joaquin Valley bioregions to the northeast and southeast, and a short stretch of the eastern boundary joins the Sierra Bioregion at Amador and Calaveras counties. The bioregion is bounded by the Klamath/North Coast on the north and the Central Coast Bioregion to the south.

Major highways are Interstate 80, which concludes its transcontinental journey in San Francisco, I-280, I-580 and I-680, U.S. 101. State highways include 1, 12, 24, 29, 84, 92, 113, 116, 121, and 128.

Industries

Prominent industries of this bioregion include banking, high-technology and biotechnology, wine-making, fishing, shipping, oil refining, dairy farming, beer brewing, and fruit ranching. The Pacific coastal area of this bioregion features Point Reyes National Seashore, John Muir Woods National Monument, Golden Gate National Recreation Area, and numerous state parks and state beaches.

Climate and Geography

The temperatures in this Mediterranean climate don't vary much year-around. The coast experiences relatively cool, often foggy summers, mild falls, and chilly, rainy winters. Further inland, hot dry summers and warm autumns are followed by mild, wet winters. Snowfall is rare. The bioregion is mostly hilly with low coastal mountains and several peaks rising above 3,000 feet, including Mt. Diablo at 3,849 feet, in a state park. Coastal prairie provides grazing for wild and domestic animals, including dairy cattle.

The bioregion is named for its two major watersheds, San Francisco Bay and the Delta. Major rivers include the Russian, Gualala, Napa, Petaluma, and Alameda, and Putah Creeks. A network of reservoirs and canals comprise the State Water Project delivery system. Lake Berryessa in Napa County is the largest lake.

Plants and Wildlife

The habitats and vegetation of the Bay Area/Delta Bioregion are as varied as the geography. Coastal prairie scrub, mixed hardwoods and valley oaks are found among the rolling hills and mountains that descend to the ocean. Redwoods abound in Santa Cruz County. Coastal salt marsh lies around San Francisco Bay, and freshwater marshes are found in the Delta. Eucalyptus, manzanita, northern coastal scrub, California buttercups, goldfields, and Tiberon mariposa lily also are popular in the bioregion. Rare plants include Marin western flax, Baker's manzanita, Point Reyes checkerbloom, and Sonoma sunshine. Salt and freshwater marshes provide pickleweed, great bulrush, saltbush, and cattail.

Wetlands in the Bay-Delta -- brackish and freshwater -- furnish resting, nesting, feeding and breeding places for birds and waterfowl along the Pacific Flyway. These marshes, rich in biodiversity, are popular and necessary wintering spots for migrating birds.

Birds include canvasback, western grebe, black-crowned night heron, great egret, snowy egret, California brown pelican, white pelican, gull, acorn woodpecker, golden eagle, western bluebird, Caspian tern, American avocet, and cedar waxwing. Marine life includes Chinook salmon, harbor seal, sea lion, leopard shark, and bat ray. Other wildlife includes grey fox, mule deer, bobcat, raccoon, Pacific tree frog, and the swallowtail and painted lady butterfly.

Endangered species include the California least tern, California black rail and clapper rail, Smith's blue butterfly, salt marsh harvest mouse, California freshwater shrimp, northwestern pond turtle, and tidewater goby.

4.1.5 Sierra Bioregion (CERES 2011e)

The Sierra Bioregion is a vast and rugged mountainous area extending some 380 miles along California's eastern side and largely contiguous with Nevada. Named for the Sierra Nevada mountain range it encompasses, the Sierra Bioregion includes magnificent forests, lakes, and rivers that generate much of the state's water supply. It shares Lake Tahoe with Nevada and features eight national forests, three national parks -- Yosemite, Kings Canyon and Sequoia -- numerous state parks, historical sites, wilderness, special recreation and national scenic areas, and mountain peaks, including 14,495-foot Mt. Whitney.

Location, Cities, People

Eighteen counties, or their eastern portions, comprise the Sierra Bioregion: Alpine, Amador, Butte, Calaveras, El Dorado, Fresno, Inyo, Kern, Madera, Mariposa, Mono, Nevada, Placer, Plumas, Sierra, Tulare, Tuolumne, and Yuba. The bioregion extends from the northern edge of the Plumas National Forest south to Tejon Pass in the Tehachapi Mountains about 30 miles southeast of Bakersfield. The northern half of the Sierra Bioregion is bordered by the Nevada state line to the east and the Sacramento Valley floor to the west. The southern half of the Sierra extends westward from the Nevada state line and the western edge of the Bureau of Land Management's California Desert Conservation Area to the San Joaquin Valley floor. California's historic Mother Lode region of 19th century Gold Rush fame is in the Sierra Bioregion.

Scattered throughout the mountains are small cities such as Truckee, Placerville, Quincy, Auburn, South Lake Tahoe, and Bishop. The Sierra Nevada Ecosystem Project (SNEP) fixed the Sierra population at 650,000, which is consistent with 1990 census figures.

Major routes for vehicular traffic are Interstate 80, U.S. Highways 50 and 395, and state highways 4, 49, 70, 88, 89, 108, 120, and 178. Some mountain roads at higher elevations are closed in winter because of snow, and highways frequently require chains or snow tires for travel.

Industries

High tech has emerged as a significant industry in the Sierra, introducing satellite, on-line, and computer software companies and stimulating entrepreneurial small businesses. This growing segment of the economy joins staples such as hydropower, tourism and recreation. Other industries include logging, cattle ranching, and -- in the northern Sierra foothills -- apple orchards and wineries.

Climate and Geography

The climate varies with the elevation, offering cold snowy winters and cool summers at higher elevations and rainy winters and mild summers in the foothills. Summers are dry. Snowy winters in the northern Sierra are crucial to California's water supply, which depends heavily upon spring snowmelt to feed the reservoirs of the State Water Project and a portion of the federal Central Valley Project. The projects supply about two-thirds of California's water for drinking, irrigation, and industrial use. Snowfall also is welcomed by the ski industry and a myriad of other businesses that serve and supply skiers. Mild dry mountain summers accommodate outdoor sports and activities, but when high pressure areas push temperatures upward and gusty winds blow, California is vulnerable to wildfires that consume thousands of acres of brush and timber every year.

National forests of the Sierra Bioregion are the Plumas, Tahoe, Sierra, Eldorado, Stanislaus, Sequoia, Inyo, and Toiyabe. Major rivers include the American, Feather, Yuba, Cosumnes, Tuolumne, Merced, San Joaquin, Kern, Owens, Kings, Carson, Truckee, Walker, and Stanislaus. Mono Lake east of Yosemite is famous for its peculiar tufa formations rising from the lake bed.

Plants and Wildlife

The Sierra Bioregion is rich in biodiversity, containing over half the plant species found in California and more than 400 of the state's terrestrial wildlife species, or about two-thirds of the birds and mammals and half the reptiles and amphibians. The variety of habitat types include annual grassland, blue oak savannah, chaparral, ponderosa pine, black oak woodland, mixed conifer, red fir, riparian, alpine meadow, Jeffrey pine, sagebrush, and bitter brush.

Animals that inhabit the Sierra Bioregion include lodgepole chipmunk, mountain beaver, California mountain king snake, black bear, wolverine, California big horn sheep, Pacific fisher, mule deer, and mountain lion. The California Golden Trout -- the state fish -- is native to the Southern Sierra. Birds include the northern goshawk, mountain chickadee, pine grosbeak, California spotted owl, mountain quail, willow flycatcher, bald eagle, and great grey owl.

4.1.6 San Joaquin Valley Bioregion (CERES 2011f)

The San Joaquin Valley Bioregion in the heart of California is the state's top agricultural producing region. The bioregion is bordered on the west by the coastal mountain ranges. Its eastern boundary joins the southern two-thirds of the Sierra bioregion, which features Yosemite, Kings Canyon, and Sequoia National Parks.

Location, Cities, People

Eight counties comprise the San Joaquin Valley bioregion, including all of Kings County, most of Fresno, Kern, Merced, and Stanislaus counties, and portions of Madera, San Luis Obispo, and Tulare counties. This growing bioregion, the third most populous out of ten, has an estimated 2 million people, according to 1990 census data. The largest cities are Fresno, Bakersfield, Modesto, and Stockton. Some of California's poorest cities are in Fresno, Kern, and Tulare counties. At its northern end, the San Joaquin Valley bioregion borders the southern end of the Sacramento Valley bioregion. To the west, south, and east, the bioregion extends to the edges of the valley floor. Native people of the bioregion include the Mono and Yokut Indians. Native lands include the Tule River Indian Reservation in Tulare County, Cold Springs Rancheria, and Table Mountain and Big Sandy Reservations in Fresno County, and Santa Rosa Rancheria in Kings County.

Interstate 5 and State Highway 99 are the major north-south roads that run the entire length of the bioregion. Other main routes include State Highways 33, 41, 43, 65, 132, 140, 178, 180, and 198.

Industries

The San Joaquin Valley is California's leading agricultural producing bioregion, and five of its counties -- Fresno, Kern, Tulare, Merced, and Stanislaus-- rank among the state's top 10 counties in farm production value. Oil and gas also are important industries in the San Joaquin bioregion. The deepest wells and about half of the largest oil fields are found in Kern County, as is the Elkhorn Hills Naval Petroleum Reserve. Lemoore Naval Air Station west of Visalia also is in this bioregion.

Climate and Geography

Well-suited for farming, the bioregion is hot and dry in summer with long, sunny days. Winters are moist and often blanketed with heavy fog. The broad, flat valley is ringed by the Diablo and Coast Ranges on the west and the Sierra Nevada foothills on the east. Habitat includes vernal pools, valley sink scrub and saltbush, freshwater marsh, grasslands, arid plains, orchards, and oak savannah. The growth of agriculture in the Central Valley has converted much of the historic native grassland, woodland, and wetland to farmland.

The major river is the San Joaquin, with tributaries of the lower Stanislaus, Tuolumne, Merced, and Fresno rivers. The California Aqueduct extends the entire length of the bioregion. The southern portion of the bioregion includes the Kings, Kaweah, and Kern rivers, which drain into closed interior basins. No significant rivers or creeks drain into the valley from the Coast Range.

Plants and Wildlife
Historically, millions of acres of wetlands flourished in the bioregion, but stream diversions for irrigation dried all but about 5 percent. Precious remnants of this vanishing habitat are protected in the San Joaquin Valley bioregion in publicly owned parks, reserves, and wildlife areas. Seasonal wetlands are found at the Kern National Wildlife Refuge west of Delano, owned by the U.S. Fish and Wildlife Service. It attracts a variety of ducks, shorebirds, and song birds, as well as peregrine falcons.

The Tule Elk State Reserve west of Bakersfield, owned by the state Department of Parks and Recreation, features the habitat of the tule elk -- natural grassland with ponds and marshes. The reserve sustains four endangered species -- the San Joaquin kit fox, blunt-nosed leopard lizard, San Joaquin antelope squirrel, and Tipton kangaroo rat -- the threatened plant Hoover's woolystar, and other rare species, such as western pond turtles, tricolored blackbird, and northern harrier. Endangered species of the bioregion also include the California tiger salamander, Swainson's hawk, and giant and Fresno kangaroo rat. Other rare species include the western yellow-billed cuckoo and valley elderberry longhorn beetle.

About one-fifth of the state's remaining cottonwood and willow riparian forests are found along the Kern River in the South Fork Wildlife Area. Great blue herons, beavers, coyotes, black bears, mountain lions, red-shouldered hawks, and mule deer can be seen in the wildlife area. Other wildlife viewing sites are Millerton Lake State Recreation Area west of Madera, Little Panoche Wildlife Area near Los Banos, and the Valley Grasslands of Merced County, which attract 500,000 to 1 million birds each winter to lands owned by the state Departments of Fish and Game and Parks and Recreation, Fish and Wildlife Service, and privately. The San Luis Dam and Reservoir area, jointly operated by the state Department of Water Resources and U.S. Bureau of Reclamation, draws wintering bald eagles, abundant ducks, gopher snakes, San Joaquin kit foxes, and black-tailed deer.

Rare plants in the bioregion include Mason's lilaeopsis, San Joaquin woollythreads, and California hibiscus.

4.1.7 Central Coast Bioregion (CERES 1996)

The Central Coast Bioregion features coastal scenery, with a mild, seasonally moist, and sometimes foggy climate that favors rich farmland and vineyards. This highly agricultural region is famous for artichokes, garlic, and an array of fruits and vegetables. Other industries include wine-making, dairy, and cattle ranching. The coast supports a brisk fishing industry, and oil production along the southern end of the bioregion.

Industries
The bioregion extends some 300 miles from just north of Santa Cruz to just south of Santa Barbara, and inland to the floor of the San Joaquin Valley. It encompasses the counties of Santa Cruz, Monterey, San Benito, Santa Barbara, and portions of Los Angeles, San Luis Obispo, Fresno, Merced, Stanislaus, and Ventura. The region includes military installations Fort Ord, Camp Roberts, and Vandenburg Air Force Base. The geography offers coastal mountain ranges including the Santa Lucia and Santa Ynez, and

coastal sand dunes. Vegetation includes chaparral, mixed hardwood and redwood forests in the bioregion's northern coastal area, and oak woodlands. The Los Padres National Forest covers much of the southern portion of the bioregion. The Salinas and Cuyama rivers feed the bioregion's two major watersheds.

4.1.8 Mojave Desert Bioregion (CERES 2011g)

The Mojave Bioregion is one of California's largest bioregions and a desert showcase. The eastern boundary is contiguous with the borders of Nevada and Arizona. To the north and west, the Mojave borders the Sierra bioregion, and to the south, it is bounded by the South Coast and Colorado Desert bioregions.

Location, Cities, People
Seven counties make up the Mojave bioregion: nearly all of San Bernardino, most of Inyo, the southeastern tips of Mono and Tulare, the eastern end of Kern, northeastern desert area of Los Angeles, and a piece of northern-central Riverside County. The largest cities are Palmdale -- one of California's fastest-growing communities -- Victorville, Hesperia, Ridgecrest, and Barstow. The Mojave Bioregion, historically a sparsely populated expanse of desert, had nearly 612,000 people as of the 1990 census, but is growing rapidly, as urban congestion and housing costs push people farther into the open areas.

Native Americans lands in the Mojave bioregion include the Chemehuevi Indian Reservation on the Colorado River, Twentynine Palms Indian Reservation, Fort Mojave Indian Reservation, and Fort Mojave Trust Lands, which both straddle the California-Nevada border.

Industries
The Mojave bioregion is the home of three national parks -- Death Valley, East Mojave, and Joshua Tree -- under the National Park Service. The state Department of Parks and Recreation manages the Providence Mountains State Recreational Area near Goffs in eastern San Bernardino County, and the U.S. Fish and Wildlife Service operates Havasu National Wildlife Refuge on the Colorado River near Lake Havasu.

Military installations include Edwards Air Force Base in Kern, Los Angeles, and San Bernardino counties; Twentynine Palms Marine Corps Air Ground Combat Center, Fort Irwin Military Reservation, Inyokern Naval Ordnance Test Station, and China Lake U.S. Naval Ordnance Test Station in San Bernardino, Inyo, and the eastern end of Kern counties. Much of the desert is under the U.S. Bureau of Land Management, which manages the Desert Tortoise Natural Area northeast of Palmdale, and Harper Lake near Barstow. The BLM has created a multi-agency, multi-species plan for the desert that designates certain areas for habitat, multiple uses, and development. It is designed to conserve habitat, foster economic development, and streamline the permitting process for development.

Major highways in the bioregion are Interstates 15, 40, U.S. Highway 395, and State Highways 18, 58, 62, and 127, and 247.

Mining -- including lucrative gold mining -- is a major industry in the Mojave bioregion. Off-road vehicle riding is a popular sport in the desert, which offers many trails across the plains and through the scrub. Ranching and livestock grazing are significant economic interests in this bioregion.

Climate and Geography
The Mojave bioregion is the western extension of a vast desert that covers Southern Nevada, the southwestern tip of Utah, and 25 million acres of Southern California -- one quarter of the state. The climate is hot and dry in summer. Winters are cool to cold, depending on the elevation, with occasional rainstorms that can quickly turn a gulch or dry lake into a flash flood zone.

The landscape is mostly moderately high plateau with elevations averaging 2,000 to 3,000 feet and isolated peaks that exceed 6,000 and 7,000 feet. Though appearing barren and remote, the desert teems with biodiversity, and more than 90 percent is within three miles of a paved road or off-road vehicle track.

Palm oases provide water for wildlife, as do many streams and springs. In prehistoric times, the bioregion contained great desert lakes, which have long since evaporated and seeped underground. This bioregion has the lowest elevation in North America, 282 feet below sea level in Death Valley National Park. The Mojave, Amargosa, and Colorado Rivers are the largest rivers in this mostly arid bioregion.

Plants and Wildlife
Common habitats of the Mojave bioregion are: desert wash, Mojave creosote bush, scattered desert saltbush, Joshua tree scrub, alkali scrub, palm oasis, juniper-pinyon woodland, and some hardwood and conifer forests at higher elevations. Cottonwood willow riparian forest is rare habitat in this bioregion, as is alkali marsh and open sandy dunes.

Rare animals include the Mohave ground squirrel, prairie falcon, Le Conte's thrasher, Nelson's bighorn sheep, gray vireo, desert tortoise, pale big-eared bat, Amargosa vole, and Mohave tui chub, an olive-brown and silver fish, and the cottontail marsh pupfish, found only in Death Valley National Park. Parks and recreation areas that provide water are the home of snowy plovers, least sandpipers, killdeer, white pelicans, teal, and thousands of migratory wading shore birds, as well as eagles, harriers, falcons, owls, coyotes, badgers, great blue herons, least Bell's vireos, red-tailed hawks, and Canada geese.

Rare plants include white bear poppy, Barstow woolly sunflower, alkali mariposa lily, Red Rock poppy, Mojave monkeyflower, and Stephen's beardtongue.

4.1.9 Colorado Desert Bioregion (CERES 2011h)

The Colorado Desert Bioregion in the southeastern corner of California extends from the Mexican border north to San Bernardino County and the southern edge of the Joshua

Tree National Park, east to the Colorado River and Arizona, and west into Riverside and San Diego counties. This agriculturally rich bioregion is semi arid, but heavily irrigated.

Location, Cities, People

With a population of about 375,000, according to 1990 census figures, the Colorado Desert is the second least populous of the ten bioregions. Only the Modoc Bioregion has fewer people. The bioregion encompasses all of Imperial County, the southeastern portion of Riverside County, the eastern end of San Bernardino County, and the eastern portion of San Diego County. Its most prominent cities are Palm Springs, Rancho Mirage, El Centro, and the smaller, but landmark communities of Blythe, Coachella, and Calexico. The bioregion is home to the Fort Yuma Indian Reservation in Imperial County and Arizona, the Colorado River Indian Reservation in Riverside County, and the Campo and Manzanita Indian Reservations in San Diego County. Imperial County has the state's lowest median family income.

Major highways are Interstate 10 in Riverside County, Interstate 8 in Imperial and San Diego counties, and State Highways 111 and 115 in Imperial County.

Industries

Picacho State Recreation Area on the Arizona border, operated by the state Department of Parks and Recreation, offers boat rides on the Colorado River from which can be seen migratory cormorants, mergansers, white pelicans, and wintering bald eagles. Trails into the rugged backcountry lead to the habitat of desert bighorn sheep, feral burros, golden eagles, and nesting prairie falcons.

The Salton Sea National Wildlife Refuge features open water, salt marshes, freshwater ponds, and desert scrub, which attract nearly 400 bird species, including great roadrunners, Gambel's quail, Albert's towhees, endangered Yuma clapper rails, egrets, plovers, northern pintails, Canada geese, snow geese, rough-legged hawks, peregrine falcon, terns, yellow-headed blackbirds, hooded orioles, and white-faced ibises. The refuge is operated by the state Departments of Fish and Game and Parks and Recreation, and the U.S. Fish and Wildlife Service.

Dos Palmas Preserve, near Indio, owned by the U.S. Bureau of Land Management, offers a lush desert oasis with a restored wetlands that accommodates endangered desert pupfish. The preserve attracts an array of wildlife, such as hooded orioles, warblers, snowy egrets, ospreys, American avocets, and horned lizards. The western fringe of the Imperial National Wildlife Refuge, located mostly in Arizona, is also in this bioregion.

Imperial County is one of California's top-ranking agricultural counties and a producer of cotton. Military installations include the Chocolate Mountains Naval Aerial Gunnery Range and the Naval Desert Test Range.

Climate and Geography

The Colorado Desert is the western extension of the Sonoran desert that covers southern Arizona and northwestern Mexico. It is a desert of much lower elevation than the Mojave

Desert to the north, and much of the land lies below 1,000 feet elevation. Mountain peaks rarely exceed 3,000 feet. Common habitat includes sandy desert, scrub, palm oasis, and desert wash. Summers are hot and dry, and winters are cool and moist.

The Colorado River flows along the entire eastern boundary of the Colorado Desert bioregion on its way to Yuma, Ariz., where the two states and Mexico come together. The only other river of significant size in this bioregion is the polluted New River, which flows from Mexico into the Salton Sea, the region's largest body of water, on the border of Imperial and Riverside counties. The Salton Sea was created in 1905 when the Colorado River broke through an irrigation project and flooded a saline lake bed, creating an inland sea, which now lies about 235 feet below sea level and is some 35 miles long and 15 miles wide.

Anza Borrego Desert State Park, located mostly in eastern San Diego County, but jutting into Imperial County, is the bioregion's largest recreation area, covering 600,000 acres. It offers more than 225 bird species and dozens of mammals, amphibians, and reptiles. Bighorn sheep can be seen there, as well as thrashers and owls.

Plants and Wildlife

Other species in the Colorado Desert are Yuma antelope ground squirrels, white-winged doves, muskrats, southern mule deer, coyotes, bobcats, and raccoons. Rare animals include desert pupfish, flat-tailed horned lizard, prairie falcon, Andrew's dune scarab beetle, Coachella Valley fringe-toed lizard, Le Conte's thrasher, black-tailed gnatcatcher, and California leaf-nosed bat.

Rare plants include Orcutt's woody aster, Orocopia sage, foxtail cactus, Coachella Valley milk vetch, and crown of thorns.

4.1.10 South Coast Bioregion (CERES 2011i)

The South Coast Bioregion is an area of starkly contrasting landscapes ranging from rugged coastal mountains, world-famous beaches, rustic canyons, rolling hills, and densely populated cities. The bioregion extends from the southern half of Ventura County to the Mexican Border and east to the edge of the Mojave desert. Two of California's largest metropolitan areas -- Los Angeles and San Diego -- are in this bioregion.

Location, Cities, People

Bounded on the north by the southern end of the Los Padres National Forest, the bioregion extends some 200 miles south to Mexico, east to the Mojave Desert and west to the Pacific Ocean. The bioregion encompasses all or part of six counties: the coastal half of Ventura County, all of Orange County, most of Los Angeles County, the southwestern edge of San Bernardino County, the western end of Riverside County, and the western two-thirds of San Diego County. Major cities include Los Angeles, San Diego, Long Beach, Santa Ana, Anaheim, Riverside, and San Bernardino. The South Coast, home to two of the state's largest cities, is the most populous bioregion with more than 16.1 million people, according to 1990 census figures.

Metropolitan Los Angeles, a major transportation hub, is criss-crossed by a network of freeways that have names as well as numbers. For example, Interstate 5, California's main north-south highway, is known in different segments as the Golden State Freeway, the Santa Ana Freeway, and the San Diego Freeway. Other major routes are Interstates, 8, 10, 15, 110, 210, 405, 605, and 805, U.S. 101, and State Highways 1 (the Pacific Coast Highway), 57, 60, 74, 76, 78, 91, 118, and 126.

As in much of California, the people of the South Coast bioregion reflect the state's cultural history. The Native American population includes many bands of Mission Indians, and the Spanish and Mexican heritage is evident in architecture, geographic names, and a large Spanish-speaking population. Rapid growth, employment opportunity, and a mild, mostly dry climate has attracted immigrants from all over the world, particularly in metropolitan Los Angeles.

Industries

Major industries include oil, agriculture, fishing, shipping, movies and television, banking and finance, computers, and aerospace, which has declined with the ending of the Cold War. Military installations include Camp Pendleton Marine Corps Base, El Toro Marine Corps Air Station, March Air Force Base, Miramar Naval Air Station, North Island Naval Air Station, and Point Mugu Naval Pacific Missile Test Center.

Climate and Geography

The year-round mild climate and varied geographical features of the South Coast contribute to its great popularity. Hot dry summers with predictable wildfires are followed by wet winters with storms that can trigger mudslides on fire-denuded slopes. Smog remains a serious problem in the South Coast bioregion, particularly the Los Angeles basin, but air quality regulations have helped to control it.

The South Coast bioregion is a study in contrasts -- ocean and desert, flatlands and mountains, including 11,500-foot San Gorgonio Peak in Riverside County. Major rivers and their watersheds are: the Santa Clara, Los Angeles, Santa Ana, San Gabriel, San Luis Rey, San Jacinto, Santa Margarita, and San Diego. Publicly owned or managed lands include four national forests: the Angeles, Los Padres, Cleveland, and San Bernardino; numerous parks, state beaches, historic parks; and federal wilderness, recreation and wildlife areas, including Malibu Creek and Point Mugu State Parks, Bolsa Chica Ecological Reserve, Torrey Pines State Reserve, and Sweetwater and Tijuana National Wildlife Refuges. In San Diego, Orange and Riverside counties, the state's Natural Community Conservation Planning (NCCP) pilot program involving local, state, and federal partners is helping to protect the coastal sage scrub habitat of the threatened California gnatcatcher. In the Santa Monica Mountains, the National Park Service, Santa Monica Mountains Conservancy, and state Department of Parks and Recreation are helping to preserve spectacular habitat. In Ventura County, endangered California condors are protected at the Sespe Condor Sanctuary.

Plants and Wildlife

Tremendous urbanization in the South Coast bioregion has brought about the most intense effects on natural resources of any bioregion, resulting in alteration and destruction of habitat and proliferation of exotic or non-native species. In fact, the popular palm tree is not native to the Golden State. Habitat varies widely, from chaparral, juniper-pinyon woodland, and grasslands at lower elevations to mixed hardwood forest, southern oak, southern Jeffrey pine and southern yellow pine at higher levels. Along the coast, where real estate is especially prized, salt marshes and lagoons no longer are common habitat. But efforts are underway from Ventura County to the Mexican border to preserve and restore coastal wetlands.

The bioregion is home to mountain lions, coyotes, badgers, grey foxes, kit foxes, black bears, raccoons, mule deer, hawks, herons, golden eagles, ospreys, peregrine falcons, desert iguanas, dolphins, whales, endangered brown pelicans, and California sea lions. Rare animals include the Stephen's kangaroo rat, monarch butterfly, San Diego horned lizard, Peninsula desert bighorn sheep, orange-throated whiptail, California least tern, Belding's savannah sparrow, least Bell's vireo, Santa Ana sucker, arroyo southwestern toad and Tehachapi pocket mouse.

Rare plants include San Diego barrel cactus, Conejo buckwheat, Plummer's mariposa lily, mountain springs bush lupine, Otay tarplant, Laguna Mountains jewelflower, San Jacinto prickly phlox, and Mt. Gleason Indian paintbrush.

4.2 Hydrologic Regions of California

Hydrologists divide California into 10 hydrologic regions (CalWater 1999) (Figure 2). The regional water boards are defined (for the most part) by the boundaries of these hydrologic regions, as described in Water Code section 13200. Hydrologic regions are further divided into hydrologic units, hydrologic areas, and hydrologic subareas.

4.2.1 North Coast Hydrologic Region

The North Coast hydrologic region covers approximately 12.46 million acres (19,470 square miles) and encompasses the counties of Siskiyou, Del Norte, Trinity, Humboldt, Mendocino, Sonoma, and small areas of Marin. The region, extending from the Oregon border south to Tomales Bay, includes portions of four geomorphic provinces—the northern Coast Range, the Mad River drainage, the Klamath Mountains, and the coastal mountains. The majority of the population is located along the Pacific Coast and in the inland valleys north of the San Francisco Bay Area. The northern mountainous portion of the region is rural and sparsely populated, and most of the area is heavily forested. A majority of the surface water in the North Coast hydrologic region is committed to environmental uses because of the “wild and scenic” designation of most of the region’s rivers. Average annual precipitation in this hydrologic region ranges from 100 inches in the Smith River drainage to 29 inches in the Santa Rosa area.

Water bodies that provide municipal water include the Smith, Mad, and Russian Rivers. Areas providing agricultural water are more widespread than those for domestic, municipal and industrial use, as they occur in all of the hydrologic units within the region. Many of the smaller communities and rural areas are generally supplied by small local surface water and groundwater systems. Water recreation occurs in all hydrologic units on both fresh and salt water, attracting over 10 million people annually. Coastal areas receiving the greatest recreational use are the ocean beaches, the lower reaches of rivers draining to the ocean, and Humboldt and Bodega Bays. The Russian, Eel, Mad, Smith, Trinity, and Navarro Rivers and Redwood Creek provide the most freshwater recreational use.

Groundwater aquifers in the northeastern portion of the North Coast hydrologic region consist primarily of volcanic rock aquifers and some basin-fill aquifers. Coastal basin aquifers are predominantly found in the southern portion of this hydrologic region and along the northern coast. In general, though, a large percentage of this region is underlain by fractured hard rock zones that may contain localized sources of groundwater.

4.2.2 San Francisco Bay Hydrologic Region

The San Francisco Bay hydrologic region covers approximately 2.88 million acres (4,500 square miles) and encompasses the county and city of San Francisco and portions of Marin, Sonoma, Napa, Solano, San Mateo, Santa Clara, Contra Costa, and Alameda. Significant geographic features include the Santa Clara, Napa, Sonoma, Petaluma, Suisun-Fairfield, and Livermore valleys; the Marin and San Francisco peninsulas; San Francisco, Suisun, and San Pablo bays; and the Santa Cruz Mountains, Diablo Range, Bolinas Ridge, and Vaca Mountains of the Coast Range. Major rivers in this hydrologic region include the Napa and Petaluma, which drain to San Francisco Bay. Although this is the smallest hydrologic region in the state, it contains the second largest human population.

Coastal basin aquifers are the primary type of aquifer system in this region. They can be found along the perimeter of San Francisco Bay extending southeast into the Santa Clara Valley, as well as in the Livermore Valley. The northeastern portion of this region, which includes the eastern Sacramento–San Joaquin Delta, is underlain by a portion of the Central Valley aquifer system. The remaining areas in this region are underlain by fractured hard rock zones.

4.2.3 Central Coast Hydrologic Region

The Central Coast hydrologic region covers approximately 7.22 million acres (11,300 square miles) in central California, and includes all of Santa Cruz, Monterey, San Luis Obispo, and Santa Barbara Counties, most of San Benito County, and parts of San Mateo, Santa Clara, and Ventura Counties. Groundwater is the primary source of water in the region, accounting for approximately 75% of the annual supply. Most of the freshwater in this region is found in coastal basin aquifers, with localized sources of groundwater also occurring in fractured hard rock zones throughout the region.

4.2.4 South Coast Hydrologic Region

The South Coast hydrologic region includes all of Orange County; most of San Diego and Los Angeles Counties; parts of Riverside, San Bernardino, and Ventura Counties; and a small portion of Kern and Santa Barbara Counties. Because it is the most populous area of the state, it is divided into three water quality control regions. Region 4, Los Angeles, encompasses portions of Ventura and Los Angeles counties. Region 8, Riverside, encompasses portions of San Bernardino, Riverside, and Orange Counties. Region 9, San Diego, encompasses portions of Orange, Riverside, and San Bernardino Counties. Approximately half of California's population, or about 17 million people, live within the boundaries of the South Coast hydrologic region. This, combined with its comparatively small surface area of approximately 6.78 million acres (10,600 square miles) gives it the highest population density of any hydrologic region in California. Major population centers include the metropolitan areas surrounding Ventura, Los Angeles, San Diego, San Bernardino, Orange County, and Riverside. Water use efficiency measures and water recycling efforts play a significant role in addressing increasing water use from population growth.

Groundwater is what supplies approximately 23% of the region's water in normal years and about 29% in drought years. Like the Central Coast hydrologic region, the majority of aquifers in this region are coastal basin aquifers. In the eastern central portion of the region includes lies a small section of basin and range aquifer and the remainder of the region is comprises fractured hard rock zones.

4.2.5 Central Valley Hydrologic Region

The Central Valley hydrologic region is the largest in California, and encompasses the three subregions described below.

4.2.5.1 Sacramento River Hydrologic Subregion

The Sacramento River hydrologic subregion, which corresponds to roughly the northern third of the Central Valley Regional Board, covers 27,246 square miles and includes all or a portion of 20 predominately rural northern California counties. The subregion extends from the crest of the Sierra Nevada in the east to the summit of the Coast Range in the west, and from the Oregon border north downstream to the Sacramento–San Joaquin River Delta (Delta). It includes the entire drainage area of the Sacramento River, the largest river in California, and its tributaries.

Groundwater in the northern half of this hydrologic subregion is, for the most part, contained in volcanic rock aquifers and some basin-fill aquifers. The southwestern half of this subregion is underlain by part of the Central Valley aquifer system. The remaining areas that comprise the southeastern half of the subregion and portions of the northern half of the subregion are underlain by fractured hard rock zones. Surface water quality in this hydrologic subregion is generally good. Groundwater quality in the Sacramento River subregion is also generally good, although there are localized problems.

4.2.5.2 San Joaquin River Hydrologic Subregion

The San Joaquin River hydrologic subregion is bordered on the east by the Sierra Nevada and on the west by the coastal mountains of the Diablo Range, and extends from the southern boundaries of the Delta to the northern edge of the San Joaquin River in Madera. It consists of the drainage area of the San Joaquin River, which at approximately 300 miles long is one of California's longest rivers. The San Joaquin River hydrologic subregion, which corresponds to roughly the middle third of the Central Valley Regional Water Board, covers approximately 9.7 million acres (15,200 square miles). Roughly half of the Delta is within this hydrologic region, which extends south from just below the northeastern corner of Sacramento County and east to include the southern third of El Dorado County, almost all of Amador County, all of Calaveras, Mariposa, Madera, Merced, Stanislaus, and Tuolumne counties, the western slope of Alpine County, and the portions of the Delta in Contra Costa, Alameda, and San Joaquin Counties.

A portion of the Central Valley aquifer system underlies nearly all of the eastern half of this subregion, while the western half of this subregion consists of fractured hard rock zones. The groundwater quality throughout this hydrologic region is generally good and usable for most urban and agricultural uses, although localized problems occur.

4.2.5.3 Tulare Lake Hydrologic Subregion

The Tulare Lake hydrologic subregion is located in the southern end of the San Joaquin Valley, and includes all of Tulare and Kings Counties and most of Fresno and Kern Counties. Major cities include Fresno, Bakersfield, and Visalia. The region, which corresponds to approximately the southern third of the Central Valley Regional Water Board, covers approximately 10.9 million acres (17,000 square miles). A small area at the southern end of this region is underlain by basin and range aquifers, while a majority of the western half is underlain by a portion of the Central Valley aquifer system The eastern half, once again, consists of fractured hard rock zones.

4.2.6 Lahontan Hydrologic Region

The Lahontan hydrologic region encompasses two subregions: the North Lahontan, extending north from the Oregon border near Mono Lake on the east side of the Sierra, and the South Lahontan, extending south to the crest of the San Gabriel and San Bernardino mountains and the divide between watersheds draining south toward the Colorado River and those draining northward.

4.2.6.1 North Lahontan Hydrologic Subregion

The North Lahontan hydrologic subregion extends south from the Oregon border approximately 270 miles to the South Lahontan region. Extending east to the Nevada border, it consists of the western edge of the Great Basin, and water in the region drains eastward toward Nevada. Groundwater in the northern half of this subregion is primarily contained in basin-fill and volcanic rock aquifers, with some fractured hard rock zones. The southern half of this region is dominated by fractured hard rock zones, but small segments of basin and range aquifers also exist in this part of the subregion. The subregion, corresponding to approximately the northern half of the Lahontan Regional Water Board, covers approximately 3.91 million acres (6,110 square miles) and includes portions of Modoc, Lassen, Sierra, Nevada, Placer, El Dorado, Alpine, Mono, and Tuolumne Counties.

In general, the water quality in the North Lahontan hydrologic region is good. In basins in the northern portion of the region, groundwater quality is widely variable. The groundwater quality along these basin margins tends to be of higher quality, but the potential for future groundwater pollution exists in urban and suburban areas where single-family septic systems have been installed, especially in hard rock areas. Groundwater quality in the alpine basins ranges from good to excellent.

4.2.6.2 South Lahontan Hydrologic Subregion

The South Lahontan hydrologic subregion in eastern California, which includes approximately 21% of the state, covers approximately 21.2 million acres (33,100 square miles). This region contains both the highest (Mount Whitney) and lowest (Death Valley) surface elevations of the contiguous United States. It is bounded on the west by the crest of the Sierra Nevada and on the north by the watershed divide between Mono Lake and East Walker River drainages; on the east by Nevada and the south by the crest of the San Gabriel and San Bernardino mountains and the divide between watersheds draining south toward the Colorado River and those draining northward. The subregion includes all of Inyo County and parts of Mono, San Bernardino, Kern, and Los Angeles Counties.

This subregion contains numerous basin and range aquifers, separated by fractured hard rock zones. Although the quantity of surface water is limited in the South Lahontan hydrologic subregion, the quality is very good, being greatly influenced by snowmelt from the eastern Sierra Nevada. However at lower elevations, groundwater and surface water quality can be degraded, both naturally from geothermal activity, and as a result of human-induced activities. Drinking water standards are most often exceeded for TDS, fluoride, and boron content.

Groundwater near the edges of valleys generally contains lower TDS content than water beneath the central part of the valleys or near dry lakes.

4.2.7 Colorado River Hydrologic Region

The southeast portion of California consists of the Colorado River hydrologic region, which contains 12% of the state’s land area. The Colorado River forms most of the region’s eastern boundary except for a portion of Nevada at the northeast, and extends south to the Mexican border. The region includes all of Imperial County, approximately the eastern one-fourth of San Diego County, the eastern two-thirds of Riverside County, and the southeastern one-third of San Bernardino County. It includes a large portion of the Mojave Desert and has variable arid desert terrain that includes many bowl-shaped valleys, broad alluvial fans, sandy washes, and hills and mountains. Aquifers in this region are nearly all of the basin and range type.

4.3 Groundwater

Groundwater is water located beneath the ground surface in soil pore spaces and in the fractures of geologic formations. Groundwater is the largest single source of freshwater available for human use—domestic use, drinking water, agriculture, and industrial uses (USGS 1999). Since 1987, 82% of water supply wells in California that were newly constructed, reconditioned, or deepened, were drilled for individual domestic uses (DWR 1998).

The uppermost portion of the earth's crust can be divided into the unsaturated zone and the saturated zone. The unsaturated zone is where available spaces between soil pores are filled with air, other gases, and some water and where the water that is present adheres to the surfaces of the sediment grains and cannot be easily extracted (Bachman *et al.* 2005). Farther down is the saturated zone where all available spaces are filled with water (e.g., aquifers). This is where available groundwater lies.

4.3.1 Unconfined versus Confined Groundwater

Aquifers are typically saturated zones (soils fully inundated by water) that provide an economically feasible quantity of water to a well or spring. The two ends of the spectrum of aquifer types are confined and unconfined. Unconfined aquifers are sometimes also called water table aquifers because their upper boundary is the water table. Typically (but not always) the shallowest aquifer at a given location is unconfined, meaning it does not have an impermeable confining layer acting as a lid (an aquitard or an aquiclude, with extremely low permeability) between it and the surface. Unconfined aquifers usually recharge (i.e., receive water to replace the water that is removed or flows out) either directly from the ground surface as runoff held by lakes, creeks, and streams that infiltrates into the aquifer or through precipitation that infiltrates directly through the soil.

In an unconfined aquifer, water that infiltrates directly from the surface can transport contaminants with it. Concentrations of some contaminants may be reduced by the soil to some extent depending on how porous the soil is and the nature of the contaminant. Where the soil is sandy or porous, water flows more quickly below the surface and fewer contaminants are removed before reaching groundwater.

Confined aquifers are typically found below unconfined aquifers, separated by an aquitard or aquiclude (barrier). Under natural conditions in a confined aquifer, the layers of minimally permeable or impermeable clay or rock above and below the aquifer protect the water from contact with some surface contaminants and somewhat restrict the water's movement. The recharge area for a confined aquifer, where surface water (and associated contaminants) infiltrates the land and resupplies the aquifer, may be miles from a well that draws water from it. Wells, however, can cause cross contamination by short-circuiting the natural flow pathway and by introducing surface contaminants into deeper groundwater.

The term "perched" refers to groundwater accumulating above a low-permeability unit or strata, such as a clay layer. This term is generally used to refer to a small local area of groundwater that collects at an elevation higher than a regionally extensive aquifer. The difference between perched and unconfined aquifers is their size; a perched aquifer is smaller and more locally contained whereas an unconfined aquifer more broadly underlies a larger area.

4.3.2 Unconsolidated Alluvium versus Fractured Hard Rock

In non-mountainous areas (or near rivers in mountainous areas), the main aquifers are typically unconsolidated alluvium—loose gravel, sand, and silt with pore spaces between the grains. These aquifers are typically composed of mostly horizontal layers of materials deposited by water processes (rivers and streams), which in cross-section appear to be layers of alternating coarse and fine materials. Coarser soil materials, because of the high energy needed to move them, tend to be found nearer their source (mountain fronts or rivers), while fine-grained soil material can travel farther from the source (to the flatter parts of the basin or overbank areas). Because coarse soils are located closer to the source, aquifers in these areas are often unconfined or may break through to the land surface (usually in springs or riverbeds).

In mountainous and hilly areas, the main water-bearing features are typically fractured hard rock formations. A thin layer of sediments, soil, or weathered rock frequently covers the hard rock formations. Cracks or fractures typically form in hard rock and are the result of different types of stress on the rock (i.e., folding, fault movement, weathering, heating, cooling). Fractures may be large or small and may run vertically or horizontally. They may be a few millimeters to hundreds of meters long and range in width from less than a millimeter to several centimeters. In carbonate rocks (limestone and dolomite) the fractures may be enlarged into caverns when the rock is dissolved by water. Most fractures are found in the upper few hundred feet of rock, although deep fractures are common. The width of fractures tends to diminish with depth.

Groundwater can percolate through the thin layer of soil and enter cracks or fractures of hard rocks, such as granite, greenstone, and basalt. The water does not actually penetrate the rocks because no pore space is present between the grains of the rock. However, some of these rocks have fractures in them that can store and transmit water over large distances and yield water to wells. The amount of groundwater that may be yielded to wells that intersect the fractures depends on the size and location of the fractures, the interconnection of the fractures, and the amount of collected soil material that may fill the fractures. Water can also be stored in lava tubes in volcanic rock and in solution openings in carbonate rocks. Some sedimentary rocks, like sandstone, are hard but can still absorb some water into their pores. These rocks may also have fractures that contain water.

4.3.3 Groundwater Aquifers in California

California has five major aquifers or aquifer systems (Figure 2) and large areas that do not represent principal aquifers but that may contain locally important groundwater sources (Figure 2, areas in gray) (Planert and Williams 1995). Although four of the aquifers consist of basin-fill deposits (unconsolidated or semiconsolidated alluvium), the characteristics of these deposits vary, depending on differences in geology, physiography, and climate. Below is a general description of each of the major aquifers in California.

4.3.3.1 Basin and Range Aquifers

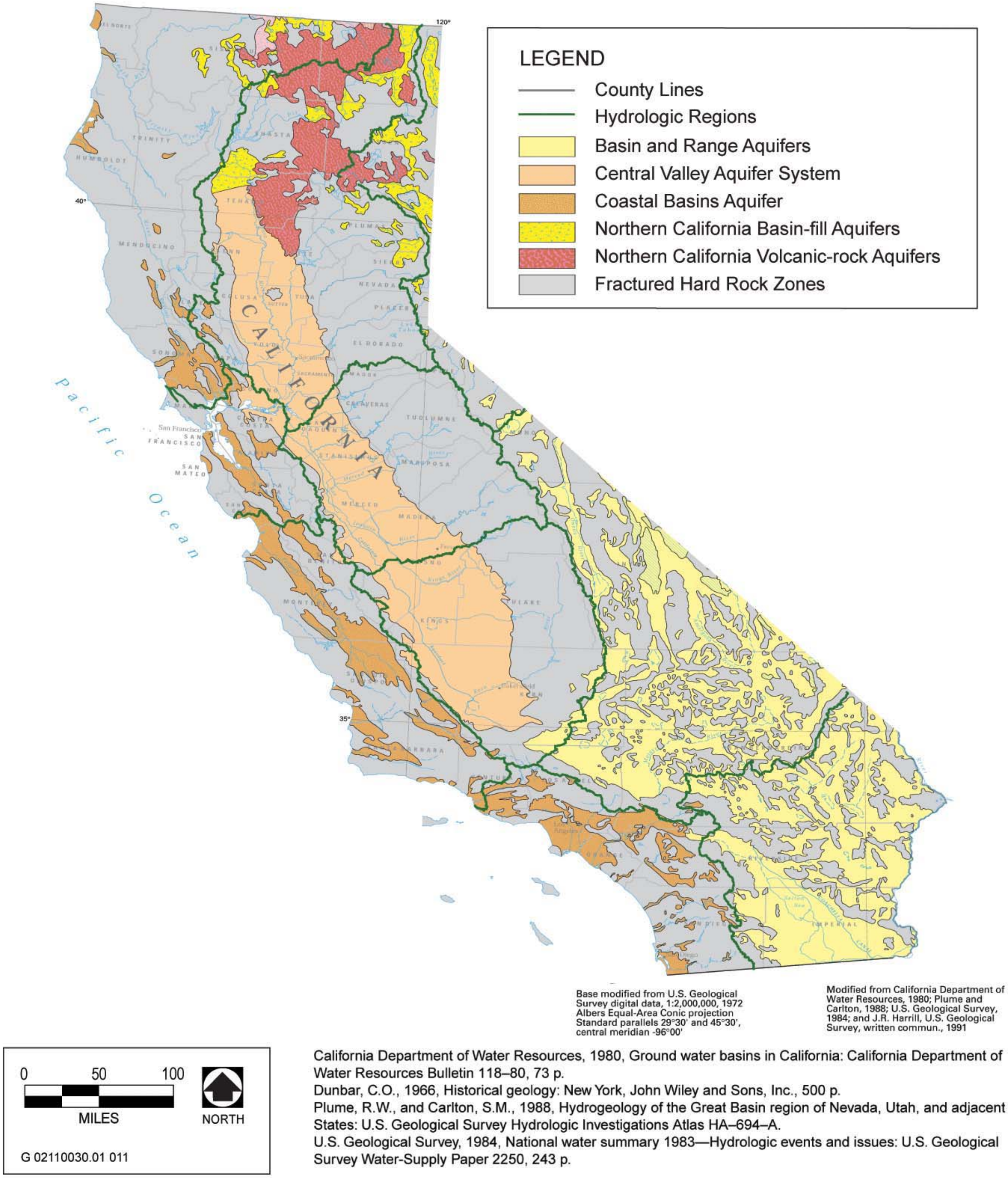
The basin and range aquifers in California contain two principal aquifer types: basin-fill aquifers and carbonate-rock aquifers. These aquifers underlie parts of eastern and southern California, including the White and Inyo Mountains, the Owens Valley, Mono Lake, Death Valley, and the Mojave and Colorado Desert regions. The most permeable basin-fill deposits are present in depressions created by block faulting and originate from alluvial-fan, lake-bed, or fluvial (river-formed) deposits. The carbonate-rock aquifers underlie alluvial basins and occur in carbonate rock that is highly fractured and locally brecciated (i.e., contains angular fragments of older rocks cemented together).

4.3.3.2 Central Valley Aquifer System

The Sacramento and San Joaquin Valleys compose the Central Valley, which is a basin comprising thousands of feet of sedimentary deposits. The Central Valley aquifer system, which underlies the Central Valley, is the largest basin-fill aquifer system in California. It is a single heterogeneous aquifer system formed primarily of sand and gravel with large amounts of fine-grained materials, such as silt and clay, occurring in beds and lenses scattered vertically and horizontally throughout the system. Water in the upper few hundred feet of this aquifer system is typically unconfined. With increasing depth, the numerous overlapping lens-shaped clay beds result in increasing confinement of groundwater.

4.3.3.3 Coastal Basin Aquifers

The California coastal region is characterized by mountain ranges and intermontane valleys that formed as a result of folding, faulting of marine sediments, and associated vulcanism. The terrestrial, marine, and volcanic rocks deposited in the intermontane valleys compose the Coastal Basin aquifers. These aquifers consist of continental deposits of sand and gravel that, in some cases, are interbedded with confining units of fine-grained material, such as silt and clay. Natural movement of water in these aquifers is generally parallel to the long axis of the basin because of impermeable rocks that commonly form a barrier between the basin and the sea. However, in a few coastal basins the coastal barrier is absent and the natural direction of flow is perpendicular to the long axis of the basin, from the inland mountains to the sea.



Base modified from U.S. Geological Survey digital data, 1:2,000,000, 1972
Albers Equal-Area Conic projection
Standard parallels 29°30' and 45°30',
central meridian -96°00'

Modified from California Department of Water Resources, 1980; Plume and Carlton, 1988; U.S. Geological Survey, 1984; and J.R. Harrill, U.S. Geological Survey, written commun., 1991

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Dunbar, C.O., 1966, Historical geology: New York, John Wiley and Sons, Inc., 500 p.
Plume, R.W., and Carlton, S.M., 1988, Hydrogeology of the Great Basin region of Nevada, Utah, and adjacent States: U.S. Geological Survey Hydrologic Investigations Atlas HA–694–A.
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Figure 2: California Hydrologic Regions and Aquifers

4.3.3.4 Northern California Basin-Fill Aquifers

The northern California basin-fill aquifers comprise an assemblage of intermontane valley aquifers in unconsolidated alluvium that have similar hydrogeologic characteristics. These valleys are located mostly in the Cascade Mountains, the northern Sierra Nevada, and the Modoc Plateau. Groundwater in these valleys is contained mostly in alluvial-fan and lake deposits that fill the basins and may be under unconfined or confined conditions depending on the depth and the amount of fine-grained materials present.

4.3.3.5 Northern California Volcanic-Rock Aquifers

The northern California volcanic-rock aquifers are located in the Modoc Plateau and the Cascade Mountains in volcanic terranes. These aquifers are not distinct, identifiable aquifers because they contain water in fractures, volcanic pipes, tuff beds, rubble zones, and interbedded sand layers.

4.3.3.6 Fractured Hard Rock Zones

The remaining areas in California are areas that lack sufficient basin-fill sediments or permeable consolidated rock. Although these areas do not represent principal aquifers, they frequently have localized sources of groundwater that may provide water to individual wells. One-quarter of all public supply wells are in these areas.

4.4 Soils

The relative effectiveness of the OWTS dispersal system in the treatment and removal of contaminants, especially pathogens, is dependent on the complex physical, chemical, and biochemical characteristics of the soil and the characteristics of the OWTS wastewater contaminants. Various properties of soil play a role in the transformation, retention, and degradation of contaminants in OWTS effluent after the effluent enters the soil through the dispersal field. An understanding of these soil properties is necessary to understand the mechanisms involved in the environmental fate and transport of OWTS pollutants of concern.

As contaminants flow downward and laterally through the soil, they may be changed through a variety of processes (e.g., filtered, absorbed, volatilized, neutralized, adsorbed, hydrolyzed, attenuated, reduced/oxidized). They may be broken down by aerobic, facultative, and anaerobic organisms, which may include organisms such as bacteria, fungi, protozoa, algae, and earthworms, all of which reduce the organic content of effluent through their metabolic processes.

Soil is complex and variable, and its effectiveness at attenuating contaminants from OWTS effluent is determined by many factors, including depth to groundwater, soil type, soil chemistry, soil texture, soil structure and depth, moisture, and activity in the aerobic vegetative root zone where chemical and organic substances are taken up or broken down. Specific soil conditions, such as oxygen content, pH, salinity, temperature, and moisture affect the community of soil microorganisms that are essential for breaking down and decomposing OWTS effluent.

4.4.1 Soil Properties

4.4.1.1 Oxidation-Reduction Potential

Oxygen content of the soil will affect the soil's ability to remove additional contaminants before the treated effluent reaches groundwater. Oxidation-reduction potential, or "redox" potential is closely related to oxygen concentration. Low oxygen concentrations usually lower the redox potential, and higher concentrations raise it. Redox potential is the tendency of a chemical compound or substance to acquire electrons and thereby be reduced. In solution with water, the reduction potential of a chemical compound is the tendency of the substance to either gain or lose electrons when it is subject to the introduction of a new compound. A solution with a higher reduction potential will have a tendency to gain electrons from other compounds (i.e., oxidize them) and a solution with a lower reduction potential will have a tendency to lose electrons to other compounds (i.e., reduce them).

4.4.1.2 Redoximorphic Features

Redoximorphic features include iron nodules and mottles that form in seasonally saturated soils by the reduction, translocation, and oxidation of iron and manganese oxides (USEPA 2002). The presence of one or more of these features in the soil indicates that the surrounding soil is periodically or continuously saturated and has been anaerobic for a period of time. Saturated soils prevent reaeration of the vadose zone below dispersal fields and reduce the hydraulic gradients necessary for adequate drainage, which can lead to surfacing effluent. Therefore, OWTS siting where soil shows redoximorphic features may indicate a high water table and potential for wastewater to surface during high rainfall or OWTS failure.

On the other hand, the absence of redoximorphic features is not an indication that the soil has not been saturated. Redoximorphic features in soil largely result from oxidation-reduction reactions that are biochemically mediated and therefore do not occur in soils with low amounts of organic carbon, high pH (more than 7 standard pH units), low soil temperatures, or low amounts of iron, or where the groundwater is aerated.

4.4.1.3 Soil pH

The pH scale is a measure of the acidity or alkalinity of a solution in terms of its relative concentration of hydrogen ions. The pH scale ranges from 0 to 14, with pH 7 (the hydrogen ion concentration in pure water) being neutral. Most soils are in the range between pH 3 and pH 10. Acidic conditions involve a pH less than 7; alkaline conditions involve a pH greater than 7.

Complexation (the process of binding or stabilizing metallic ions by means of creating an inert compound) by organic matter in natural waters and wastewater systems occurs when an organic chemical binds to a receptor, and this process is affected by the pH of the solution (Manahan 1994). Acidic conditions can reduce the sorption of metals in soils, leading to increased risk of metals entering groundwater.

4.4.1.4 Cation Exchange Capacity

Because the amount of naturally occurring organic matter in the soil below the infiltrative surface is typically low (USEPA 2002), the cation exchange capacity (CEC) of the soil and the soil solution pH control the mobility of metals below the infiltrative surface. The CEC represents the number of cations that can be adsorbed to a unit mass of soil and is normally expressed as milliequivalents per 100 grams dry soil. In general, soils with higher clay content and more organic matter have higher CEC values and so more cations per unit mass will attach to the soil molecules, resulting in a higher degree of metals retention from effluent (Table 4-1).

Table 4-1: Cation Exchange Capacity for Different Soil Textures

Soil Texture	CEC (milliequivalents per 100 grams of soil)
Sands (light colored)	3-5
Sands (dark colored)	10-20
Loams	10-15
Silt loams	15-25
Clay and clay loams	20-50
Organic soils	50-100

Source: WSU 2004

4.4.1.5 Soil Texture and Structure

Soil texture describes the relative proportion of different mineral particle grain sizes in a soil. Coarse-textured soils contain a large proportion of sand, medium textures are dominated by silt, and fine textures are primarily clay. The soil texture consists primarily of sand, silt, and clay particles of less than 2 millimeters in diameter, and the proportion and size of each constituent affect the soil’s filtration capacity and permeability (Figure 3). Soil structure is defined by the way individual particles of sand, silt, and clay are assembled. Single particles when assembled appear as larger particles. These are called aggregates. Aggregation of soil particles can occur in different patterns, resulting in different soil structures. Soil texture and structure play an important role in the formation of micro- and macropores respectively, and along with other chemical, biological and physical components of the soil, they affect the porosity of the soil, and thus, the flow and residence time of water in the soil.

The infiltration or percolation rate, measured as hydraulic conductivity (k), is the rate at which water flows through a soil horizon (Table 4-2). High porosity soils typically have larger pores and as a result give rise to fast-draining soils that can accommodate a higher application rate of OWTS effluent to the dispersal field than slow-draining soils. However, fast-draining soils often have less treatment capacity because the physical, chemical, and biochemical processes of contaminant attenuation within the vadose zone have less time to work on contaminants in the effluent, especially pathogens. A coarse soil of sand particles mixed with rock, for instance, is not well suited for filtering contaminants from effluent because wastewater moves quickly through the large pore spaces created by the large particle sizes without adequate retention time for remediation by all of the chemical, biological, and physical processes that may reduce some effluent contaminants. An extreme example of this circumstance would be a case where most of the soil mantle is fractured rock. Here, little if any treatment is likely as the water flows rapidly through the soil mantle until it contacts groundwater. Slower draining soils provide more time for the chemical, biological, and physical processes to attenuate contaminants, but require lower application rates per unit area. Therefore, a fine-grained soil with a moderate percentage of silts and clays is more suitable for filtering as it slows the flow of the wastewater, allowing chemical, biological, and physical processes more time to act on the effluent. An extreme example of this case would be expansive, fine-grained clay. Although it filters contaminants from effluent extremely well, it does not allow the effluent to move very rapidly through the soil, which in more extreme instances leads to ponding, eventual failure of the dispersal field, and surfacing effluent.

Table 4-2: Porosity and hydraulic Conductivity for Representative Substrate Types

Material	Porosity (%)	Hydraulic Conductivity (K), cm/sec
Unconsolidated Deposits		
Gravel	25–35	1–100
Sand	30–45	10^{-4}–10^{-1}
Silt	35–45	10^{-6}–10^{-4}
Clay	40–55	10^{-9}–10^{-6}
Rocks		
Karst limestone	15–40	10^{-4}–10^{-1}
Limestone, nonkarst	5–15	10^{-6}–10^{-4}
Sandstone	10–25	10^{-7}–10^{-4}
Shale	0–10	10^{-11}–10^{-7}
Crystalline rock (fractured)	1–10	10^{-6}–10^{-4}
Crystalline rock (unfractured)	0–2	10^{-11}–10^{-9}

Note: Porosity is the ratio of pore volume to total volume

Hydraulic conductivity is the rate of flow in centimeters per second (cm/sec) per unit time per unit cross-sectional area. 1 cm/sec equals 23.62 inches per minute.

Source: Adapted from Schnoor 1996.

4.4.1.6 Biomat Formation

In an ideal system, a biomat forms at the wastewater-soil interface, or infiltrative surface. This layer of biological growth and inorganic matter may extend as far as 1 inch into the soil matrix. It provides physical, chemical, and biological treatment of the OWTS effluent as effluent migrates toward groundwater. The density and composition of the biomat also controls the rate at which wastewater can move through the infiltrative zone of coarse to medium-textured soils into the vadose zone (see below for more information on the vadose zone). Biomats may not exercise the same degree of control in fine-textured soils, as these soils may be more restrictive to flow than the biomat.

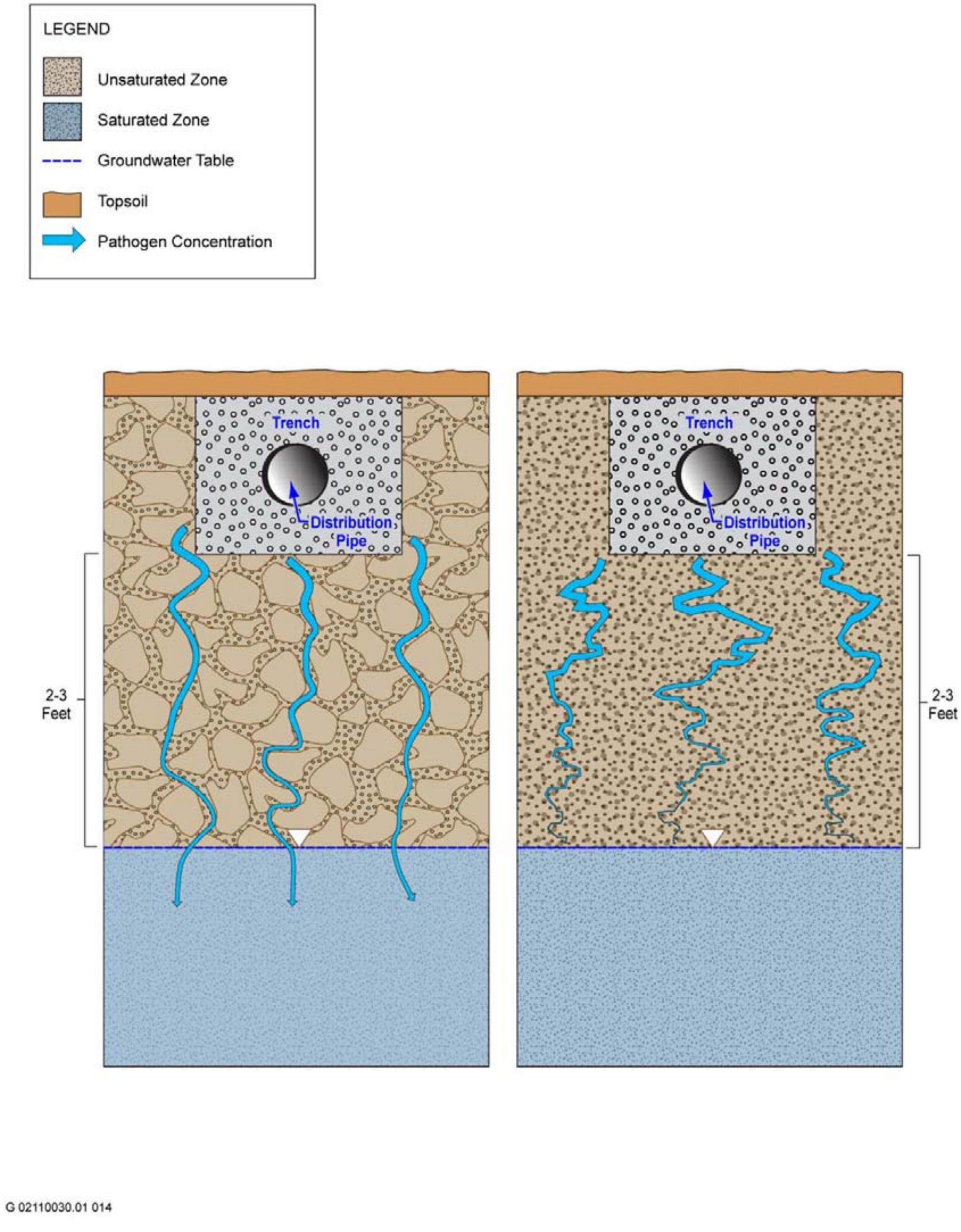


Figure 3: Soil Texture and OWTS Function

4.4.1.7 Depth of Unsaturated Soil below the Dispersal Field

One of the most important soil characteristics is the thickness of the unsaturated soil below the infiltrative surface. This zone of unsaturated soil between the ground surface and the groundwater table is known as the vadose zone. A conventional OWTS eventually discharges to groundwater and usually relies on the vadose zone to maximize the treatment potential of the wastewater before the effluent enters the groundwater, although some pollutants will usually remain. The vadose zone typically contains more microorganisms than the saturated zone and has a higher rate of contaminant adsorption. The unsaturated soil allows air to diffuse into the open soil pores to supply oxygen to the microbes that grow on the surface of the soil particles. The OWTS effluent is under a negative pressure potential (less than atmospheric pressure) in the vadose zone because of the capillary and adsorptive forces of the soil matrix. This negative soil moisture potential forces the effluent into the finer pores and over the surfaces of the soil particles, increasing adsorption, filtration, and biological treatment of the wastewater.

A larger thickness of unsaturated soil increases residence time in the soil, allowing the above-noted processes more time to maximize any reduction of contaminants that may be possible, pathogens in particular. Saturated soil, on the other hand, increases flow through the larger soil pores, reducing residence time and the filtering effect of the smaller pores. In addition, lack of oxygen or low oxygen concentration in saturated soils reduces aerobic activity and increases less effective anaerobic activity (USEPA 2002, Salvato 1992). For proper OWTS siting (particularly for conventional OWTS that do not have supplemental treatment units), adequate thickness of unsaturated soil below the dispersal field and above groundwater is a crucial element of the treatment process that, in a properly designed and functioning system, allows maximum removal of contaminants that may be possible before effluent reaches groundwater. Failure to provide adequate unsaturated soil thickness can result in inadequate removal of pathogens, leading to violation of water quality objectives for pathogens when those contaminants come into contact with groundwater. Other contaminants pass through to groundwater regardless of the thickness of the unsaturated soil.

4.4.2 Soils of California

California contains 2,031 soil series throughout the state (USDA 2011a). Within soil surveys, these soil series are divided into *soil phases* based on texture of the surface or underlying layers, slope, stoniness, salinity, wetness, depth to groundwater, bedrock, or hardpan, and other characteristics that affect their use (USDA 1988b).

Eighty-five soil surveys were examined for soils rated suitable for septic tank absorption fields (leach fields). Thirty-two surveys conducted prior to 1969 did not include an analysis for septic tank absorption field suitability and the most recent soil survey for the Surprise Valley-Home Camp area was used for this analysis (Figure 4).

Prior to 2006, the Natural Resources Conservation Service (NRCS) (formerly the Soil Conservation Service) used a rating system of slight, moderate, and severe to describe the degree of soil limitations that affect septic tank absorption fields. The limitations are considered *slight* if the soil properties and site features are generally favorable for septic tank absorption fields and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required. The soil properties used to determine soil limitations were: texture, flooding, depth to bedrock, depth to cemented pan, depth to high water table, permeability, slope, and the fraction of the soil greater than 3 inches in diameter (Table 4-3) (USDA 1988b).

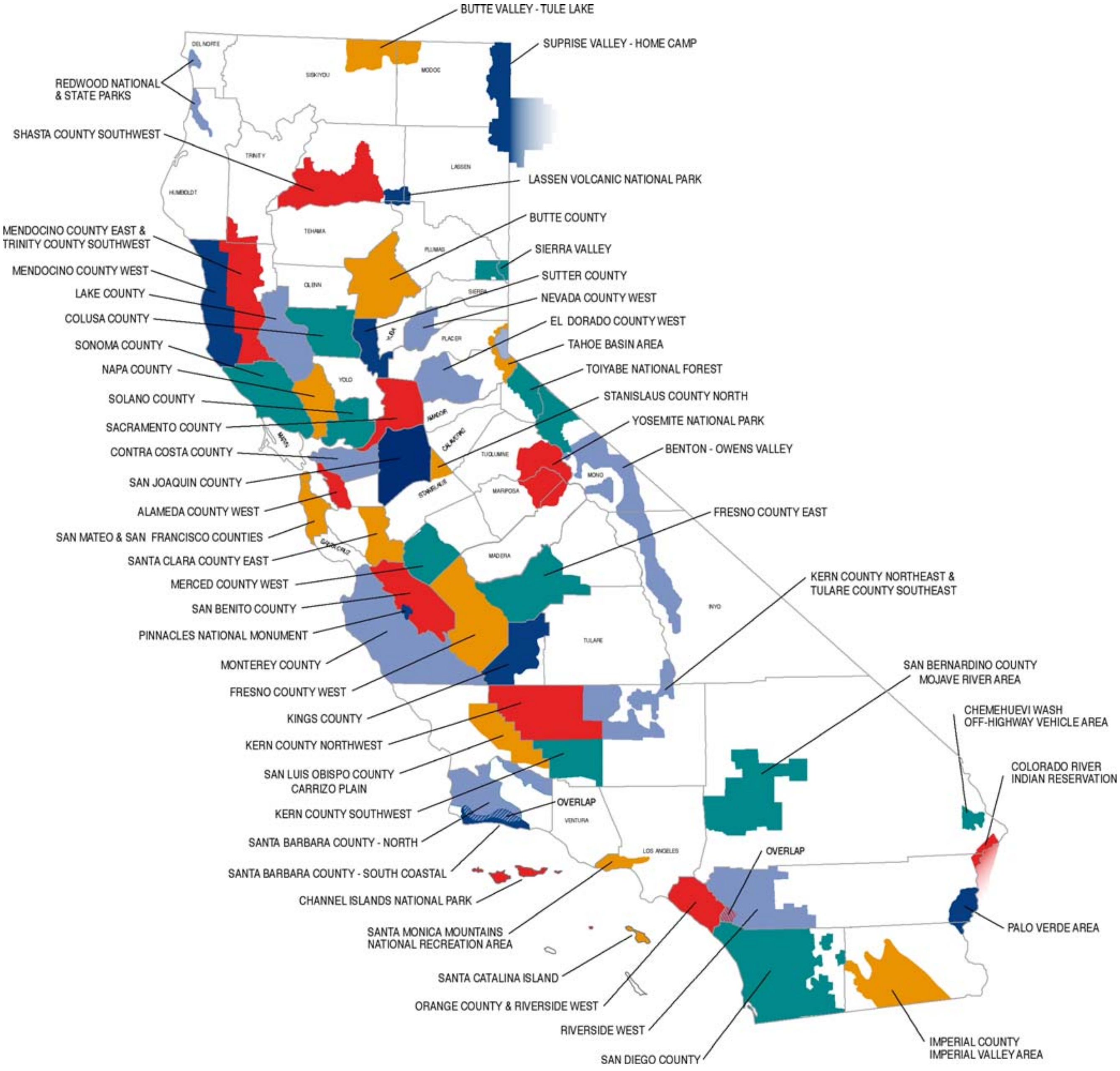


Figure 4: Location of Natural Resources Conservation Service Soil Surveys

More recent soil surveys use numerical ratings to indicate the severity of individual limitations. The ratings are expressed as decimal fractions ranging from 0.00 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on septic tank absorption fields (1.00) and the point at which the soil feature is not a limitation (0.00). No limitation indicates that the soil has features that are very favorable for septic tank absorption fields. Good performance and very low maintenance can be expected. Limitations with a value of more than 0.00 but less than 1.00 can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. Limitations with a value of 1.00 indicate that the soil has one or more features that are unfavorable for septic tank absorption fields. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected (USDA 2006a).

Table 4-3: Criteria Used in Rating Soils for Septic Tank Absorption Fields

		Limits		Restrictive Feature
Property	Slight	Moderate	Severe	
USDA Texture	---	---	Ice	Permafrost
Flooding	None, Protected	Rare	Common	Floods
Depth to Bedrock (In)	>72	40-72	<40	Depth to Rock
Depth to Demented Pan (In)	>72	40-72	<40	Cemented Pan
Depth to High Water Table (Ft)	---	---	+	Ponding
	>6	4-6	0-4	Wetness
Permeability (In/Hr): 24-60”	2.0-6.0	0.6-2.0	<0.6	Percs Slowly
All Layers Below 24”	---	---	>6.0	Poor Filter
Slope (%)	0-8	8-15	>15	Slope
Fraction >3 In (Wt %)*	<25	25-50	>50	Large Stones

*Weighted average to 40 inches.
Source: USDA 1988b

The management considerations (limitations) for septic tank absorption fields are as follows (USDA 2006a):

- Depth to bedrock.—Depth to bedrock affects the construction, installation, and functioning of septic tank absorption fields and affects other site applications. Shallow soils have a limited absorption capacity and have biologically active zones through which waste materials can percolate. If these soils are used as filter fields, environmental and health risks should be considered.

- Depth to pan.—Depth to a cemented pan affects the construction, installation, and functioning of septic tank adsorption fields and other site applications. Shallow soils have a limited absorption capacity and have biologically active zones through which waste materials can percolate. If these soils are used as filter fields, environmental and health risks should be considered.

- Flooding, rare flooding, or very rare flooding.—Flooding can transport waste offsite and pollute surface waters. Flooding limits the use and management of the soil for sanitary facilities.

- Fragments (greater than 3").—Rock fragments larger than 3 inches in diameter impede the workability of the soil and restrict the use of heavy machinery during construction of absorption fields.

- Permeability (Ksat) greater than 6"/hr.—The soil horizon with the maximum Ksat governs the leaching and seepage potential of the soil. If this rate is high, the transmission of fluids through the soil is unimpeded and leaching and seepage may affect environmental, health, and performance.

- Permeability less than 0.6"/hr; permeability from 0.6 to 2"/hr.—The soil horizon with the minimum Ksat governs the rate of water movement through the whole soil. If this rate is low, the transmission of fluids into and through the soil is impeded and runoff, infiltration, and percolation of pollutants may affect environmental, health, and performance.

- Ponding.—Ponding is the condition where standing water is on the soil surface for any period of time. Ponding limits the installation and functioning of most land use applications.

- Saturation.—Soils that have a water table at a shallow depth may become waterlogged during periods of heavy precipitation and are slow to drain. The contamination of ground water is a concern in areas with these soils.

- Seepage in bottom layer.—The Ksat in the bottom layer of the soil governs the leaching and seepage potential of the soil. If this rate is high, the transmission of fluids through the soil and underlying materials is unimpeded. As a result, leaching and seepage may affect environmental, health, and performance.

- Slope.—Steep slopes affect the transmission of fluids through the soil. As a result, piping or seepage may affect environmental, health, and performance.

A total of 6.8% of the acreage surveyed is suitable for septic tank absorption fields (Table 4-4). Percentages of suitable soil for septic tank absorption fields for various areas ranged from 0.0% (San Mateo County [eastern part] & San Francisco County and Santa Monica Mountains National Recreation Area) (USDA 1991b; 2006d) to 63.9% (Palo Verde Area) (USDA 1974c). Soils included as suitable were rated as slight, moderate, slight to moderate, moderate to severe, and slight to severe under the older rating system, and as having no limitations rated as 1.0 under the newer system. All soils rated as severe or having a numeric value of 1.0 in any category were excluded.

Table 4-4: Percent Acreage of Soils Suitable for Septic Tank Absorption Fields from California Soil Surveys

Survey Area	Suitable Soils (Acres)	Total Acreage	Percent of Total	Citation
Alameda County, western part	6,175	144,120	4.3%	USDA 1981a
Benton-Owens Valley Area	121,372	1,070,115	11.3%	USDA 2002
Butte Area	20,249	930,752	2.2%	USDA 2006a
Butte Valley-Tule Lake Area	17,350	436,800	4.0%	USDA 1994
Channel Islands National Park	3,049	124,102	2.5%	USDA 2007a
Chemehuevi Wash Off-Highway Vehicle Area	34,183	94,460	36.2%	USDA 2005
Colorado River Indian Reservation	5,979	42,936	13.9%	USDA 1986a
Colusa County	19,863	737,920	2.7%	USDA 2006b
Contra Costa County	11,170	468,650	2.4%	USDA 1977a
Eastern Fresno Area	336,446	1,109,156	30.3%	USDA 1971a
Eastern Santa Clara Area	14,380	519,280	2.8%	USDA 1974a
El Dorado Area	3,545	539,065	0.7%	USDA 1974b
Fresno County, western part	122,414	1,386,400	8.8%	USDA 2006c

Table 4-4: Percent Acreage of Soils Suitable for Septic Tank Absorption Fields from California Soil Surveys

Survey Area	Suitable Soils (Acres)	Total Acreage	Percent of Total	Citation
Imperial County (Imperial Valley Area)	334,901	989,450	33.8%	USDA 1981b
Kern County (northeastern part) & Tulare County (southeastern part)	1,528	913,000	0.2%	USDA 2007b
Kern County (northwestern part)	495,400	1,371,900	36.1%	USDA 1988a
Kern County (southwest part)	110,175	672,400	16.4%	USDA 2009
Kings County	157,078	892,800	17.6%	USDA 1986b
Lake County	2,755	857,072	0.3%	USDA 1989
Lassen Volcanic National Park	3,168	126,720	2.5%	USDA 2010
Mendocino County (eastern part) & Trinity County (southwestern part)	21,368	1,103,912	1.9%	USDA 1991a
Mendocino County (western part)	17,860	1,042,400	1.7%	USDA 1999
Merced County (western part)	3,810	609,820	0.6%	USDA 1990a
Monterey County	138,470	2,127,360	6.5%	USDA 1978a
Napa County	23,430	485,120	4.8%	USDA 1978b
Nevada County Area	24,744	341,966	7.2%	USDA 1975a
Orange County & Riverside County (western part)	126,445	580,994	21.8%	USDA 1978c
Paolo Verde Area	98,655	154,500	63.9%	USDA 1974c
Pinnacles National Monument	69	27,095	0.3%	USDA 2008a
Redwood National & State Parks	2,740	161,993	1.7%	USDA 2008b
Sacramento County	20,210	629,088	3.2%	USDA 1993
San Benito County	103,372	893,440	11.6%	USDA 1969
San Bernardino County (Mojave River Area)	156,470	1,200,000	13.0%	USDA 1986c
San Diego County	220,669	2,204,880	10.0%	USDA 1973a & b
San Joaquin County	124,750	901,760	13.8%	USDA 1992
San Luis Obispo County (Carrizo Plain Area)	40,781	563,840	7.2%	USDA 2003
San Mateo County (eastern part) & San Francisco County	0	358,735	0.0%	USDA 1991b
Santa Barbara Area (northern)	120,069	830,870	14.5%	USDA 1972
Santa Barbara County (south coastal part)	13,194	218,586	6.0%	USDA 1981c
Santa Catalina Island	42	48,400	0.1%	USDA 2008c
Santa Monica Mountains National Recreation Area	0	182,400	0.0%	USDA 2006d
Shasta County Area	168,175	1,035,000	16.2%	USDA 1974d
Sierra Valley Area	12,417	204,948	6.1%	USDA 1975b
Solano County	30,285	526,720	5.7%	USDA 1977b
Sonoma County	61,451	1,010,560	6.1%	USDA 1990b
Stanislaus County (northern part)	8,024	1,098,024	0.7%	USDA 2007c
Surprise Valley-Home Camp Area	28,008	1,290,985	2.2%	USDA 2011b
Sutter County	6,220	388,480	1.6%	USDA 1988b
Tahoe Basin	6,022	247,704	2.4%	USDA 2007d
Toiyabe National Forest Area	1,203	663,783	0.2%	USDA 2006e
Western Riverside Area	207,130	1,105,940	18.7%	USDA 1971b
Yosemite National Park	874	761,236	0.1%	USDA 2007e
Total	1,557,275	23,000,539	6.8%	

There may be areas within a soil mapping unit identified in a soil survey as unsuitable for septic tank absorption fields that are actually suitable, and conversely there may be areas within a mapped area considered suitable that are not. A site specific evaluation is required to determine the suitability of any specific area for a septic tank absorption field. Overall, most of the soils surveyed in California are poorly suited for septic tank absorption fields.

4.5 Overview of OWTS Use and Siting

OWTS treat wastewater and disperse effluent for the approximately 1.2 million California households and numerous businesses that are not connected to sewer systems and related centralized municipal wastewater treatment plants (CWTRC 2003). (This estimate reflects the number of systems in 1999.) Approximately 10% of all California households, or about 3.5 million people, rely on some type of OWTS to treat and dispose of the wastewater they generate. The annual rate of growth in new OWTS installations is approximately 1%, or 12,000 systems (CWTRC 2003).

OWTS are defined by the U.S. Environmental Protection Agency (USEPA) as systems "relying on natural processes and/or mechanical components that are used to collect, treat, and disperse/discharge wastewater from single family dwellings or buildings" (USEPA 2002). Most OWTS are commonly referred to as "septic systems"; however, many different types of systems exist. Conventional septic systems consist of a septic tank and subsurface dispersal system. A wide range of supplemental treatment devices can also be included in the septic system design to address different site constraints and achieve higher levels of treatment than that provided by conventional septic systems. Descriptions of the design and operation of conventional OWTS and a variety of supplemental treatment devices are provided in the following sections.

Proper site conditions are an important factor in ensuring the optimal functioning of an OWTS. A key issue that has an impact on the effectiveness of a treatment system and that may determine the need for additional treatment is the amount and type of soil available for treatment of the effluent. In practice, this is measured as separation between the bottom of the dispersal field and the groundwater table, bedrock, or impervious soil layer. If the OWTS is properly sited, unsaturated soil (soil above groundwater level) with sufficient depth underlying the dispersal fields can, through absorption, filtration, and other natural processes that break down some effluent pollutants, substantially reduce the levels of human pathogenic organisms (viruses and bacteria) and some chemical compounds in effluent before it reaches the underlying groundwater table or surface water that is hydrologically connected to the groundwater.

The depth and type of unsaturated soil below the dispersal system are the most important factors in the treatment process. The number of pathogens and other pollutants removed through this process increases with the length of time the OWTS effluent is retained in the unsaturated soil layer (i.e., the retention time). Note that, regardless of the length of time that wastewater is retained in the unsaturated soil layer, soil does not provide effective treatment of some soluble compounds that are resistant to biodegradation, such as nitrate.

Domestic wastewater entering septic systems also contains high levels of phosphorus. For properly designed and functioning septic systems, phosphate is removed in the leachfield by binding to porous media (Wilhelm *et al.* 1994, cited in Angenent *et al.* 2006). However, fractured bedrock and thin, sandy soils have limited capacity to bind phosphate, and unfavorable soil and water chemistry or saturation of the soil can allow the phosphate to be mobile (Robertson *et al.* 1998, cited in Angenent *et al.* 2006).

Deep unsaturated soils provide for relatively long retention times and are ideal conditions for promoting die-off of pathogens (viruses and/or bacteria). Such conditions are not present in many areas of California, however. Areas of the state with relatively porous, sandy soils allow OWTS effluent to move into local groundwater and other receiving waters very quickly and, therefore, with little treatment. In areas with underlying fractured and granitic bedrock, it is almost impossible to accurately predict how fast OWTS effluent will travel and the likely pathway that OWTS effluent will take before it reaches groundwater. In areas with poorly draining clay soils, OWTS effluent can pool at the surface, creating potential public health threats through direct human contact and through runoff to receiving waters intended for beneficial uses (e.g., drinking water, fisheries).

The distance to nearby drinking water wells or surface waters is also a key issue. Frequently, properties served by OWTS are also served by private on-site ("domestic") water wells. In other cases, properties with OWTS may be located within the groundwater capture zone of a public drinking water well. Once in the groundwater, OWTS effluent travels as a plume (Robertson 1991). Depending on the direction of groundwater flow, nearby wells may be in the path of the effluent plume.

4.5.1 Conventional OWTS

The vast majority of existing OWTS are conventional systems and are designed to provide "passive" (i.e., minimally mechanical) operation and treatment of domestic wastewater. A conventional OWTS typically consists of a septic tank, a wastewater dispersal system, and the native underlying soil (Figure 5).

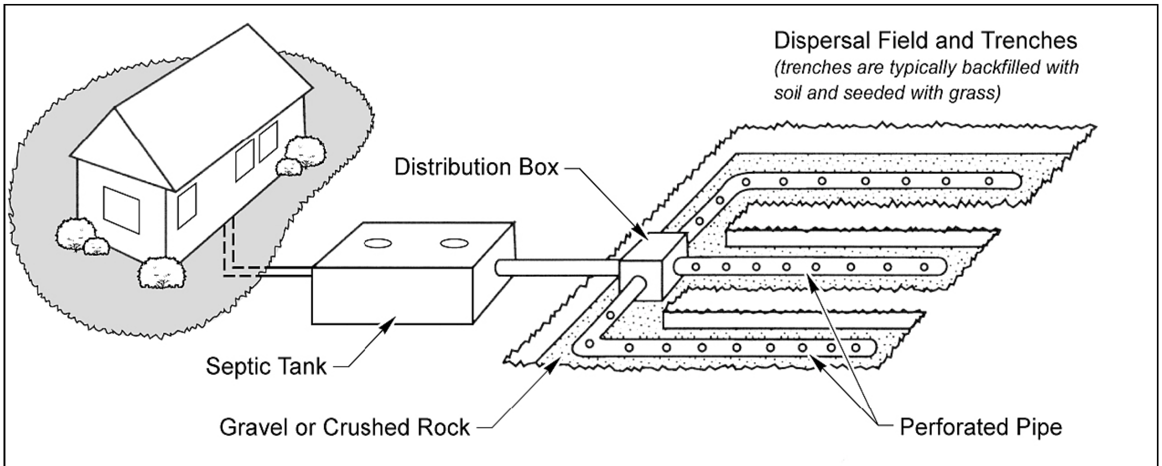
4.5.2 Septic Tank

The septic tank serves a number of important functions, including the following:

- The septic tank removes oils and grease (floatable materials) and settleable solids. The septic tank is designed to provide quiescent conditions over a sufficient period to allow settleable solids to sink to the bottom of the tank and floatable materials to rise to the surface. The result of this primary treatment process is a middle layer of partially clarified effluent that exits the tank and is directed to the dispersal system.

- The septic tank stores settleable and floatable material. Tanks are generously sized according to projected wastewater flow and composition to accumulate sludge (settleable solids) and scum (floatable solids) at the bottom and top of the tank, respectively. Tanks require pumping at infrequent intervals, depending on the rate that sludge and scum accumulate. USEPA indicates that pumping may be needed every 1–7 years (USEPA 2002).

- The septic tank allows digestion or decomposition of organic matter. In the oxygen-deprived (anaerobic) environment found in a septic tank, several types of bacteria break down biodegradable organic molecules for further treatment in the soil or by other unit processes. This digestion can reduce sludge and scum volumes by as much as 40–50%.



Note: This is a schematic diagram that is not to scale

Source: Adapted from EPA 2002

Figure 5: Elements of a Conventional System

4.5.3 Wastewater Dispersal System

The dispersal system is where the septic tank effluent infiltrates the underlying soil. The soil is the final and most important treatment component for pathogen removal in a conventional OWTS.

Infiltrative surfaces are the surfaces in the dispersal system that are designated to accept OWTS effluent. The infiltrative surfaces in dispersal systems are located in either permeable, unsaturated natural soil or imported fill material so wastewater can infiltrate and percolate through the underlying soil to the groundwater. Permeable, unsaturated soil is native soil material that is not inundated by groundwater. As the wastewater infiltrates and percolates through the soil or fill, a variety of physical, chemical, and biochemical processes and reactions can filter or biodegrade some of the organic materials that remain after treatment in the septic tank. Many different dispersal system designs and configurations are used, but all incorporate soil infiltrative surfaces that are located in buried excavations (usually trenches or pits).

Wastewater dispersal systems provide both dispersal and final treatment of the applied wastewater. Wastewater is transported from the dispersal system through the infiltrative surface and the unsaturated zone in the soil. The transition zone between the infiltrative surface and the unsaturated zone is only a few centimeters thick. It is the most biologically active zone and is often referred to as the “biomat.” Material in the wastewater that is rich in carbon is quickly degraded in the biomat, and ammonia and organic nitrogen are converted to nitrate immediately below this zone if sufficient oxygen is present. Free oxygen or combined forms of oxygen (e.g., iron oxide) in the soil must satisfy the oxygen demand generated by the microorganisms degrading the materials. If sufficient oxygen is not present, the metabolic processes of the microorganisms will be reduced or halted and both treatment and infiltration of the wastewater will be adversely affected (Otis 1985). The unsaturated soil surrounding the dispersal system provides a significant pathway for oxygen to enter the biomat, thus sustaining the organisms in the biomat (Otis 1997, Siegrist *et al.* 1986). Also, it is the primary zone where soil particles attract and hold contaminants through chemical and physical absorption (uptake into a solution) and adsorption (attachment onto the surface of particles). Pathogens and most phosphorus are removed in this zone (Robertson and Harman 1999, Robertson *et al.* 1998, Rose *et al.* 1999, Yates and Yates 1988).

Several different designs are used for dispersal systems. They include trenches, beds, seepage pits, at-grade systems, and mounds. Applications of dispersal systems differ in their geometry and location in the soil. Trenches, the most commonly used design for wastewater dispersal systems, have a large length-to-width ratio, whereas beds have a wide rectangular or square geometry. Some jurisdictions require redundancy in the dispersal system (i.e., alternating fields, 100% replacement area) to provide for resting dispersal systems or in cases of failure, respectively.

The infiltration surfaces of dispersal systems may be created in natural soil or imported fill material. Most traditional systems are constructed below the ground surface in natural soil. In some instances, a restrictive horizon (or layer) above a more permeable horizon may be removed and the excavation filled with suitable porous material in which to construct the infiltrative surface (Hinson *et al.* 1994). Infiltrative surfaces may also be constructed at the ground surface (at-grade systems) or elevated in imported fill material above the natural soil surface (mound systems). An important difference between infiltration surfaces constructed in natural soil and those constructed in fill material is that a secondary infiltrative surface (which must be considered in design) is created at the fill/natural soil interface. This secondary infiltrative surface is sometimes the area where OWTS failure occurs because of the inability of that surface to accept wastewater. Despite the differences between the types of dispersal system designs, the mechanisms of treatment and dispersal are similar.

4.5.4 Wastewater Distribution Methods

The method and pattern of wastewater distribution in a dispersal system are important design elements.

4.5.4.1 Gravity Flow versus Pressure Distribution

Gravity flow and pressure distribution are the two most commonly used distribution methods. Gravity flow is the most commonly used method because it is simple and inexpensive. It can be used where there is a sufficient elevation difference between the outlet of the septic tank and the wastewater dispersal system to allow flow to and through the dispersal system by gravity. This method discharges effluent from the septic tank directly to the infiltrative surface as incoming wastewater displaces it from the tank(s). Typically, tank discharges are too low to flow throughout the entire distribution network and the soils near the beginning of the distribution network receive more flow. Thus, distribution can be unequal and localized overloading of the infiltrative surfaces can result, accompanied by poor treatment and soil clogging (Bouma 1975, McGauhey and Winneberger 1964, Otis 1985, Robeck *et al.* 1964). Pressure distribution, on the other hand, discharges wastewater effluent under pressure to the dispersal system. Pressurization causes the filling of the entire distribution network, which results in more uniform distribution of wastewater effluent over the entire dispersal system infiltrative surface.

Dosing, which can be incorporated into both gravity flow and pressure distribution systems, also increases the effectiveness of soil treatment. Dosing accumulates the wastewater effluent in a dose tank from which the water is periodically discharged in "doses" to the dispersal system by either a siphon (gravity-flow) or pump (pressure distribution). The treated wastewater is allowed to accumulate in the dose tank and is discharged when a predetermined water level, water volume, or elapsed time is reached. Dosing outperforms gravity displacement methods because the regulated volume and timing of doses provides opportunities for the subsoil to drain and re-aerate before the next dose arrives, resulting in more effective soil treatment of the discharged effluent (Bouma and Daniels 1974, Hargett *et al.* 1982, Otis *et al.* 1977). Pressure-dosing combines the benefits of pressure distribution and dosing. It achieves uniform distribution, which results in more complete use of the infiltrative surface, and also aids in maintaining unsaturated flow below the infiltrative surface, which results in wastewater retention times in the soil that are long enough to affect treatment and promote subsoil re-aeration.

4.5.4.2 Porous Media-Filled versus Aggregate-Free Trenches

Typically, a porous medium is placed below and around the distribution piping of the subsurface dispersal system. The porous medium keeps open the infiltrative area exposed to the wastewater and provides additional treatment surfaces. This approach is similar in most subsurface dispersal system designs, except when drip distribution or aggregate-free designs are used. In addition, the medium also supports the excavated sidewalls, provides storage of peak wastewater flows, minimizes erosion of the infiltrative surface by dissipating the energy of the influent flow, and provides some protection for the piping from freezing and root penetration.

Traditionally, washed gravel or crushed rock, typically ranging from three-quarters of an inch to 2½ inches in diameter, has been used as the porous medium. In addition to natural aggregates, gravel-less systems have been widely used as an alternative dispersal system medium. These systems take many forms, including open-bottomed chambers, fabric-wrapped pipe, and synthetic materials such as expanded polystyrene foam chips. Systems that provide an open chamber are sometimes referred to as "aggregate-free" systems, to distinguish them from others that substitute lightweight media for gravel or stone. Aggregate-free systems are essentially a half pipe placed in the trench with its inverted side down. These systems can provide a suitable substitute in locales where gravel is not available or affordable. Some systems (polyethylene chambers and lightweight aggregate systems) can also offer substantial advantages over the traditional gravel in terms of reduced site disruption because their light weight makes them easy to handle without the use of heavy equipment. This can reduce labor costs, limit damage to the property by machinery, and allow construction on difficult sites where conventional media could not reasonably be used. Reduced sizing of the infiltrative surface is often promoted as another advantage of the open chamber system. This is based primarily on the premise that these systems do not “mask” the infiltration surface as gravel- or other media-filled systems do where the media is in direct contact with the soil (Siegrist *et al.* 2004).

4.5.4.3 Shallow Dispersal

The most biologically active area in a soil column is the aerobic environment at or near the ground surface. An aerobic environment (oxygen rich) is desired for most wastewater treatment and dispersal systems. Aerobic decomposition of wastewater solids is significantly faster and more complete. Maximum delivery of oxygen to the infiltration zone is most likely to occur when dispersal systems are shallow (USEPA 2002).

Shallow dispersal methods, primarily drip distribution, which was derived from drip irrigation technology, is a method of pressure-dosed distribution capable of delivering small, precise volumes of wastewater effluent to the infiltrative surface. It is the most efficient of the distribution methods, and although it requires supplemental treatment, it is well suited for all types of dispersal system applications.

A drip line pressure network consists of several components:

- dose tank,
- pump,
- prefilter,
- supply manifold,
- pressure regulator (when turbulent, flow emitters are used),
- drip line,
- emitters,
- vacuum release valve,
- return manifold,
- flush valve, and
- controller.

The drip line is normally a flexible polyethylene tube that is a half-inch in diameter with emitters attached to the inside wall spaced 1–2 feet apart along its length. Because the emitter passageways are small, friction losses are large and the rate of discharge is low (typically from 0.5 to nearly 2 gallons per hour). Usually, the drip line is installed in shallow (less than 1 foot deep), narrow trenches 1–2 feet apart and only as wide as necessary to insert the drip line using a trenching machine or vibratory plow. The trench is backfilled without any porous medium so that the emitter orifices are in direct contact with the soil. The distal ends of each drip line are connected to a return manifold. The return manifold is used to regularly flush the drip line.

Because of the unique construction of drip distribution systems, they cause less site disruption during installation, are adaptable to irregularly shaped lots or other difficult site constraints, and use more of the soil mantle and take advantage of plant uptake (absorption into the roots of plants) for treatment because of their shallow placement in the ground.

4.5.4.4 Mound

A mound system is a wastewater dispersal system placed above the natural surface of the ground (Figure 6). These systems are often used when a site has high groundwater, the soils are too shallow, or drainage is poor and thus conditions are unsuitable for the more common dispersal system described above. A mound is a layered structure consisting of a topsoil cap, a layer of sand or sandy loam, a geotextile layer, rock aggregate beds or trenches, a low-pressure distribution system, and an absorption area. In pressure-dosed mounds, primary treated effluent is dispersed into carefully chosen fill of permeable, well-drained sands, which contain a high volume of free air within the pore space.

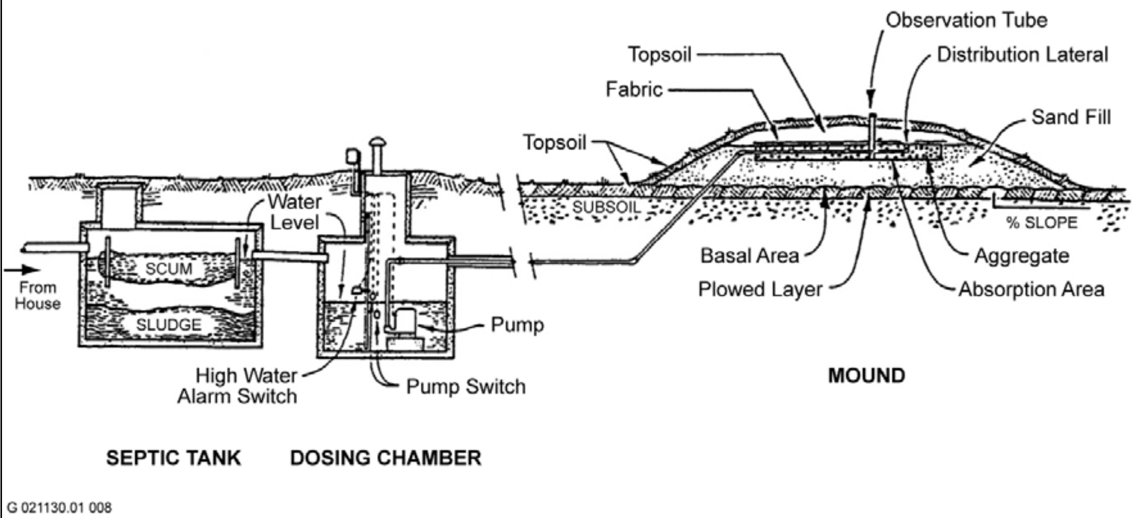


Figure 6: Elements of a Typical Mound System

Source: ASAE, Converse, and Tyler 1998, cited in USEPA 2002

Because the effluent is distributed over a large area of sand, it moves slowly through the fill material and is in contact with air as it percolates downward. An elevated mound system is built above the native soil to achieve the required separation distance between the infiltrative surface and the limiting soil condition of the site. A mound has 1–2 feet of treatment media. The main goal is to preserve and use the natural soil conditions at the site. The wastewater must move into unsaturated soil for the microbes in the soil and in the biomat to feed on the waste and nutrients in the wastewater.

4.5.4.5 At-Grade System

The at-grade system is another example of a shallow dispersal system. They are typically used when sites have soils that are too deep to justify a mound and too shallow to permit a more conventional subsurface dispersal system. Unlike the mound, where a layer of sand material exists between the bottom of the absorption area and the ground surface, the ground surface is the bottom of the trench or infiltrative surface in an at-grade system.

4.5.4.6 Evapotranspiration/Infiltration

The evapotranspiration/infiltration (ETI) process is a subsurface system designed to disperse effluent by both evapotranspiration and infiltration into the soil. Evapotranspiration is defined as the combined effect of water removal from a medium by direct evaporation and by plant transpiration. This system is typically preceded by a pretreatment tank to remove settleable and floatable solids. Supplemental treatment may be used to minimize clogging of the ETI system piping and media.

The influent to the ETI unit enters through a series of distribution pipes to a porous bed. The surface of the sand bed is planted with water-tolerant plants. Effluent is drawn up through fine media by capillary wicking and evaporated or transpired into the atmosphere, and allowed to percolate into the underlying soil.

ETI systems are best suited for arid (evaporation exceeds precipitation) climates. These systems are often selected when site characteristics dictate that conventional methods of effluent dispersal are not appropriate (e.g., unprotected aquifer, high water table, shallow bedrock, tight soils). ETI systems can be employed to reduce the infiltrative burden on the site during the growing season. Such applications can also result in reduction of some nutrients, which are transferred to the overlying vegetation (USEPA 1999).

4.5.4.7 Seepage Pit

Another type of subsurface dispersal system widely used in some areas of California is the seepage pit. However, seepage pits are not permitted in some jurisdictions because their depth and relatively small horizontal profile create a greater pollutant loading potential to groundwater relative to other subsurface infiltration methods (USEPA 2002).

A seepage pit consists of a deep vertical circular hole with a porous-walled inner chamber, usually of pre-manufactured concrete rings with precut holes or notches, and a filling of gravel between the chamber and the surrounding soil. Seepage pits are generally installed in sandy or gravel-type soils. They are typically 4–12 feet in diameter and 10–40 feet deep. These dispersal systems operate as septic tank effluent enters the inner chamber and is temporarily stored there until it gradually seeps into the surrounding sidewall soil. Because seepage pits are often buried deep, they typically experience progressive biomat growth. As the biomat grows denser in the lower level, the effluent rises to a higher level, where it filters through the as-yet-unclogged sections of the sidewall.

4.5.5 Treatment Effectiveness of Conventional OWTS

If properly sited (i.e., with suitable soil and groundwater separation conditions), designed, and installed, conventional systems are capable of nearly complete removal of suspended solids, biodegradable organic compounds, and fecal coliform bacteria. However, other pollutants may not be removed as effectively. For example, conventional systems are expected to remove no more than 10–40% of the total nitrogen in domestic wastewater. Other pollutants that may not be completely removed include pharmaceuticals, other synthetic organic chemicals and viruses.

4.5.5.1 Septic Tank Outlet (Effluent) Filters and Pump Vaults

An effluent filter in a septic tank is a screen device installed at the septic tank outlet to catch solid particles before they enter the dispersal field. About half of all State and local agencies currently require the use of an effluent filter with a septic tank; most older septic tanks were not constructed with filters. The use of an effluent filter can significantly improve effluent quality and protect dispersal field functioning by preventing carryover of solids to the dispersal field. Most manufacturers offer models of filters that are located inside the septic tank (attached to the outlet) or systems that are located outside of the septic tank in a separate tank (i.e., pump vault). Most systems are also available with an integrated pump, for use with septic tanks designed with effluent pump systems or other pressure distribution systems. The effluent filters must be cleaned at regular intervals, as recommended by the manufacturer and depending on usage, to remove accumulated solids from the screen to prevent system backups into the building served by the OWTS.

4.5.5.2 Septic Tank Additives

Approximately 1,200 septic tank additives are promoted as being able to improve the operation of septic tanks, reduce odors associated with septic systems, or unclog soil adsorption systems. These products fall into three general categories: inorganic compounds (usually strong acids or alkalis), organic solvents (often chlorinated hydrocarbons), and biological additives (bacteria or enzymes). Most studies have concluded that these products are not effective and in some cases are detrimental to OWTS (USEPA 2002).

Inorganic compounds, such as hydrogen peroxide or other strong alkalis or acids, can adversely affect biological decomposition processes, degrade soil structure, and cause structural damage to treatment systems. Organic solvents are commonly used as degreasers but pose significant risks to groundwater and wastewater treatment processes by destroying populations of helpful microorganisms in the treatment system. Biological additives, such as bacteria and extracellular enzymes mixed with surfactants or nutrient solutions, do not significantly enhance normal biological decomposition processes in the septic tank and may increase loadings of biochemical oxygen demand (BOD), total suspended solids (TSS), and other contaminants (USEPA 2002). Use of other products advertised to control septic odors by killing bacteria run counter to the purpose and function of septic tanks, which are designed to promote anaerobic bacterial growth.

Another variety of consumer product is marketed for its ability to remove phosphorus, a nutrient that, when available in sufficient quantities in surface waters, can result in nuisance algal blooms that may cause low oxygen conditions and fish mortality. This product can destroy the microbial population in the septic tank by eliminating the system’s capacity to buffer (or adjust to) changes in pH, which can result in a drop in pH and can severely compromise the function of additional wastewater treatments (i.e., supplemental treatment units) in the treatment train.

4.5.6 Supplemental Treatment Units

Supplemental treatment units are “active” operation devices incorporated into the treatment train of an OWTS following the septic tank, or in place of the septic tank, to provide additional wastewater treatment before the wastewater enters the dispersal system. OWTS with supplemental treatment units achieve a higher level of treatment than conventional OWTS. Currently, some but not all local agencies allow and regulate the use of OWTS with supplemental treatment units, usually to address site or soil limitations that would otherwise substantially reduce the ability of a conventional OWTS to effectively treat wastewater constituents (especially pathogens [bacteria and viruses] and nitrogen) to meet local and regional water board requirements. This section provides descriptions of several varieties of active wastewater treatment systems: aerobic treatment units, anoxic systems, and disinfection systems. These are the major types of supplemental treatment units employed in California (SWRCB 2002).

4.5.6.1 Aerobic Treatment Units

Aerobic treatment units (ATUs) are a broad category of pre-engineered wastewater treatment devices for residential and commercial use. They provide a secondary level of wastewater treatment, which means they are designed to oxidize both organic material and ammonium-nitrogen (to nitrate-nitrogen), decrease suspended solids concentrations, and reduce concentrations of pathogens. ATUs may provide treatment using suspended-growth elements (activated sludge process), attached-growth elements (i.e., trickling biofilters), or in the case of hybrid aerobic systems, suspended-growth processes combined with attached-growth.

Although they reduce concentrations of pathogens beyond the level allowed by a septic tank alone, most ATUs do not sufficiently reduce pathogens on their own to meet regulatory requirements. Additional disinfection can be achieved through chlorination, ultraviolet (UV) radiation, ozonation, and/or soil filtration. Increased nitrogen removal (denitrification) can be achieved by modifying the treatment process to incorporate an anaerobic/anoxic step or by adding the following treatments to the treatment train.

- **Suspended-Growth Aerobic Treatment Units:** In a suspended-growth aerobic treatment unit, microorganisms maintained in suspension using aeration provide aerobic treatment of the wastewater. Such designs typically consist of aeration, clarification, sludge return processes, and sludge wasting processes. The principal types of processes are classified as continuous flow reactor, sequencing batch reactor, and membrane bioreactor.

- **Attached-Growth Aerobic Treatment Units (Trickling Biofilters):** Treating wastewater by trickling it over a biofilter is among the oldest and most well-characterized technologies for aerobic treatment. The trickling biofilter system basically consists of a medium (sand, gravel, or synthetic) on which a microbial community develops (biofilm), a container or lined excavated pit to house the medium, a system for applying the wastewater to be treated to the medium, and a system for collecting and distributing the treated wastewater.

- **Hybrid Aerobic Treatment Units:** Hybrid ATUs combine suspended- and attached-growth elements.

4.5.6.2 Anoxic Systems

Anoxic treatment processes are characterized by the absence of free oxygen from the treatment process. Many aerobic treatment systems use anoxic or anaerobic stages to accomplish specific treatment objectives. Anoxic processes are typically used for the removal of nitrogen from wastewater through a process known as denitrification. Denitrification requires that nitrogen first be converted to nitrate, which typically occurs in an aerobic treatment process, such as a trickling filter or suspended-growth process. The nitrified water is then exposed to an environment without free oxygen. Organisms in this anoxic system use the nitrate and release nitrogen gas. Efficient denitrification processes need a carbon source that is readily biodegradable.

4.5.6.3 Disinfection Systems

Waterborne pathogens found in the United States include some bacteria, protozoans, and viruses. The process of disinfection destroys pathogenic and other microorganisms in wastewater and can be used to reduce the possibility of pathogenic organisms entering the environment.

Currently, the effectiveness of disinfection is measured by the use of indicator bacteria. Indicator bacteria are selected groups of microorganisms that indicate the possible presence of disease-causing pathogens. It is difficult to detect all types of pathogenic organisms in water because of the wide array of microbes that occur in the natural environment. As a solution, indicator organisms that are easy to detect are typically used.

A number of methods are available to disinfect wastewater. The most common types of on-site disinfection units use chlorine tablets, ultraviolet radiation, and ozonation. These approaches and their effectiveness are summarized below.

Chlorination

Chlorine is a powerful oxidizing agent and has been used as an effective disinfectant in water and wastewater treatment for a century. For small on-site wastewater treatment systems, the most common type of disinfection equipment is the tablet chlorinator because it does not require electricity, is easy to operate and maintain, and is relatively inexpensive.

Chlorinated water may inhibit the performance of subsequent soil treatment in the dispersal system because of its toxicity to soil microorganisms. In some cases, chlorination has been used to inhibit biological growth in trickling filter systems. In areas where water is distributed for irrigation, chlorine is used to prevent the spread of disease through wastewater.

There have been few field studies of tablet chlorinators, but those conducted for post-sand filter applications show significant fecal coliform reductions (2–3 logs per 100 milliliters) (USEPA 2002).

Ultraviolet Radiation

UV light is an effective disinfectant for water and wastewater. The germicidal properties of UV irradiation have been recognized for many years, and the technology is widely available and well characterized. UV is germicidal in the wavelength range of 250–270 nanometers. The effectiveness of UV irradiation highly depends on the quality of the wastewater to be treated. Wastewater particles have the ability to absorb UV radiation, yet only UV radiation that which reaches the surface of the microorganisms is effective in destroying microorganisms. Lower levels of turbidity and suspended solids in the wastewater therefore lead to greater microorganism inactivation and result in improved disinfection.

Ozonation

Ozone is a strong oxidant that has been used for the disinfection of water and wastewater. Because ozone is not chemically stable, it must be generated on-site near the point of use, making the system more complex than tablet chlorinators. It has been used in combination with other compounds for advanced oxidation treatment of wastewater. Ozone is used primarily for medium and large treatment facilities; however, ozone disinfection may become feasible for small systems in the future.

4.5.7 Community Systems

Community systems, also known as shared systems, cluster systems, and community septic systems, are OWTS for serving more than one property owner. Either a conventional OWTS or an OWTS with supplemental treatment can be used in a community system, depending on the type of soil underlying the dispersal field, the depth to groundwater, the proximity to wells or sensitive surface water resources, and other factors. Because the proposed Policy does not address the scale of the treatment systems and focuses instead on the wastewater treatment capabilities of conventional OWTS and supplemental treatment units, community systems are not discussed further in this document because the per capita impact on community systems is not believed to be different from smaller OWTS.

4.6 Estimated Number of OWTS in California

4.6.1 Households Using OWTS in California

From 1970 through 1990, the U.S. Census Bureau, as part of its decennial housing and population census, collected information on the number of housing units using septic systems for sewage disposal. (This information was not collected as part of the 2000 Census.) The percentage of occupied year-round housing units using septic systems in California declined between 1970 and 1980, but stabilized between 1980 and 1990 (Table 4-5). The percentage of housing units on septic systems fell from 12.2% to 10.0% between 1970 and 1980, but declined only slightly, to 9.8%, by 1990. Excluding seasonal and vacant housing units, approximately one million housing units were hooked up to septic systems in 1990.

Table 4-5: Number of Housing Units with On-Site Wastewater Treatment Systems in California, 1970–1990

Year	Number of Housing Units with Septic Tanks or Cesspools	Percent of Total Housing Units	Percent of Total Households
1970	853,013	12.2	12.9
1980	920,690	10.0	10.7
1990	1,092,174	9.8	10.5

Note: Housing unit totals do not include seasonal and vacant housing units.
Sources: Hobbs and Stoop 2002, U.S. Census Bureau 2004

4.6.2 Housing Units Using OWTS in 1999 and 2000

An estimated 1,202,300 housing units were using septic systems in 1999 (CWTRC 2003). This estimate was prepared by adding the number of OWTS installed since 1990 to the number of systems reported by the 1990 Census. The source for the number of systems installed since 1990 came from a survey of officials of public agencies that have jurisdiction for approving and inspecting OWTS in California. The CWTRC study estimated that 9.9% of all housing units in California were using septic systems, virtually the same as the percentage reported by the 1990 U.S. Census (9.8%).

For purposes of comparison, the number of housing units in California using OWTS in 2000 was estimated using data from the 1990 and 2000 U.S. Census. Starting with the number of existing housing units statewide in 2000, as reported by the 2000 U.S. Census, it was then assumed that statewide OWTS usage in 2000, on a percentage basis, was the same as the percentage in 1990 (9.8%). This percentage was applied to the total number of housing units statewide in 2000 to arrive at an estimate of the total number of housing units using OWTS within the state. These units were then distributed among the counties based on each county's percentage share of statewide OWTS in 1990. This methodology resulted in an estimated total of 1,192,900 housing units using OWTS in California in 2000, a result that is only about 0.8% lower than the CWTRC estimate of 1,202,300 housing units with OWTS in 1999. Because the statewide estimates produced by the two methodologies are similar, 1.2 million OWTS was used as the total number of OWTS in use statewide in 2000.

Because of concerns about the accuracy of the survey results on which the CWTRC study based its estimates, both the Census-based and CWTRC estimates were used as a basis for projecting OWTS usage at the county level for both existing (2008) conditions and future baseline (2013) conditions.

4.6.3 Existing Baseline (2008) Conditions

Based on the Census and CWTRC estimates of OWTS usage in 1990 and 1999, two sets of projections of OWTS usage in 2008 were prepared. Both sets of projections, hereafter referred to as the Census-based and CWTRC-based projections, used estimates of the statewide percentage of housing units using OWTS as the basis for estimating OWTS usage in 2008.

The Census-based methodology resulted in a projection of 1,323,500 housing units using OWTS in 2008, and the CWTRC-based method resulted in a 2008 projection of 1,344,300 housing units using OWTS in California, a difference of about 1.6%.

Table 4-6: Projected Housing Units with OWTS in 2008 and 2013

	2008 Projections			2013 Projections		
		Units with OWTS			Units with OWTS	
County	Total Housing Units[1]	Census-Based Estimate[2]	CWTRC-Based Estimate[3]	Total Housing Units[4]	Census-Based Projection[5]	CWTRC-Based Projection[6]
Alameda	577,988	5,167	5,019	651,149	5,614	5,453
Alpine	1,761	547	616	1,942	594	669
Amador	17,296	9,261	10,734	20,216	10,062	11,662
Butte	95,514	49,857	49,550	105,328	54,168	53,834
Calaveras	27,822	15,727	17,195	31,032	17,087	18,682
Colusa	7,890	2,682	2,803	8,557	2,914	3,046
Contra Costa	397,729	11,418	12,548	445,696	12,405	13,633
Del Norte	11,071	5,553	5,848	12,849	6,033	6,354
El Dorado	84,551	31,337	36,462	92,253	34,047	39,615
Fresno	308,259	46,487	47,925	337,429	50,507	52,069
Glenn	10,729	5,223	5,240	11,219	5,675	5,693
Humboldt	59,492	18,620	18,187	62,098	20,230	19,759
Imperial	54,283	7,793	7,437	63,245	8,467	8,080
Inyo	9,233	2,364	2,450	9,302	2,569	2,662
Kern	274,335	56,882	52,485	300,999	61,801	57,023
Kings	42,254	6,149	6,187	53,451	6,681	6,722
Lake	35,215	15,090	15,041	39,138	16,395	16,342
Lassen	13,047	5,990	6,546	18,330	6,508	7,112
Los Angeles	3,428,202	94,328	89,603	3,538,981	102,484	97,351
Madera	48,582	18,592	19,597	55,217	20,200	21,291
Marin	108,084	9,060	10,372	112,107	9,843	11,269
Mariposa	10,124	6,807	7,097	11,406	7,395	7,711
Mendocino	39,660	20,539	22,944	42,541	22,315	24,928
Merced	85,216	16,935	16,772	99,975	18,400	18,223
Modoc	5,113	3,360	3,662	5,127	3,651	3,979
Mono	13,921	2,281	2,684	15,345	2,478	2,916
Monterey	142,028	23,304	23,653	161,543	25,319	25,699
Napa	54,397	10,381	10,567	61,176	11,278	11,480
Nevada	50,536	23,737	25,704	55,830	25,790	27,927
Orange	1,047,364	8,129	7,501	1,123,108	8,832	8,149
Placer	151,540	25,927	26,070	170,762	28,169	28,324
Plumas	15,023	8,987	10,383	14,838	9,764	11,281
Riverside	779,191	117,230	126,617	873,495	127,367	137,566
Sacramento	564,125	20,161	21,119	659,086	21,905	22,945
San Benito	18,276	5,081	5,583	20,399	5,521	6,066
San Bernardino	693,509	151,096	147,596	760,348	164,162	160,359
San Diego	1,152,920	74,653	80,429	1,275,615	81,108	87,383
San Francisco	360,189	756	0	374,953	822	0
San Joaquin	233,597	31,383	31,345	276,639	34,097	34,056
San Luis Obispo	115,232	29,904	29,855	130,078	32,490	32,436
San Mateo	269,592	7,368	7,111	283,804	8,005	7,726
Santa Barbara	155,467	11,893	12,785	168,614	12,921	13,890

County	2008 Projections			2013 Projections		
		Units with OWTS			Units with OWTS	
	Total Housing Units[1]	Census-Based Estimate[2]	CWTRC-Based Estimate[3]	Total Housing Units[4]	Census-Based Projection[5]	CWTRC-Based Projection[6]
Santa Clara	623,202	21,973	21,245	664,852	23,873	23,082
Santa Cruz	104,444	30,978	29,847	112,648	33,657	32,428
Shasta	78,137	32,230	31,885	87,002	35,017	34,642
Sierra	2,259	1,692	1,701	2,339	1,838	1,848
Siskiyou	23,446	10,557	10,913	23,463	11,470	11,857
Sonoma	198,450	49,661	48,483	224,752	53,955	52,675
Stanislaus	180,063	31,161	29,474	199,146	33,856	32,023
Sutter	33,804	12,931	13,050	36,282	14,050	14,178
Tehama	26,472	14,315	15,284	27,462	15,553	16,606
Trinity	8,392	6,500	6,474	8,119	7,062	7,034
Tulare	138,061	37,976	38,283	152,137	41,260	41,594
Tuolumne	30,611	17,825	17,905	34,679	19,366	19,453
Ventura	277,984	17,946	18,674	296,109	19,498	20,289
Yolo	74,893	5,531	5,774	91,935	6,009	6,273
Yuba	27,594	7,408	7,363	29,306	8,049	8,000
Total	13,551,786	1,323,533	1,344,314	14,723,621	1,437,980	1,460,559

Notes and sources:

[1] Estimated for 2008 by adjusting 2006 county-level housing estimates made by the California Department of Finance (2006) by the average annual population growth rate for each county projected by the California Department of Finance (2007) for the 2000–2010 period.

[2] Estimated for 2008 by assuming that future statewide on-site wastewater treatment system (OWTS) usage, on a percentage basis, will be the same as the 1990 Census rate (9.8%). This rate was applied to the projected total number of housing units statewide in 2008 to arrive at an estimate of the total number of housing units using OWTS within the state. These units were then distributed among the counties based on each county's percentage share of statewide OWTS in 1990.

[3] Estimated for 2008 by assuming that future statewide OWTS usage, on a percentage basis, will be the same as the 1999 CWTRC rate (9.9%). This rate was applied to the projected total number of housing units statewide in 2008 to arrive at an estimate of the total number of housing units using OWTS within the state. These units were then distributed among the counties based on each county's percentage share of statewide OWTS in 1999.

[4] Housing unit projections for 2013 were developed by interpolating between 2010 and 2020 population levels for each county, as projected by the California Department of Finance (2007), and then dividing the resulting 2013 population level by the average number of persons per housing unit in each county, as estimated by the California Department of Finance (2006).

[5] Projected to 2013 by assuming that future statewide OWTS usage, on a percentage basis, will be the same as the 1990 U.S. Census rate (9.8%). This rate was applied to the projected total number of housing units statewide in 2013 to arrive at an estimate of the total number of housing units using OWTS within the state. These units were then distributed among the counties based on each county's percentage share of statewide OWTS in 1990.

[6] Projected to 2013 by assuming that future statewide OWTS usage, on a percentage basis, will be the same as the 1999 CWTRC rate (9.9%). This rate was applied to the projected total number of housing units statewide in 2013 to arrive at an estimate of the total number of housing units using OWTS within the state. These units were then distributed among the counties based on each county's percentage share of statewide OWTS in 1999.

4.6.4 Future Baseline (2013) Conditions

Two sets of OWTS usage projections for 2013 were developed, generally using the same two methods employed to develop 2008 projections. In summary, estimates were developed in the following manner:

1. Housing unit projections were developed for 2013.
2. Statewide percentages of OWTS usage from the 1990 Census and the 1999 CWTRC (2003) study were applied to the housing projections.
3. The projections of housing units statewide using OWTS were distributed among the counties based on county shares of statewide OWTS usage in 1990 and 1999.

The methodology used for the 2013 projections differed only in how the projections of total housing units at the county level were developed. For 2013, housing unit projections were developed by interpolating between 2010 and 2020 population levels for each county, as projected by the California Department of Finance (2007), and then dividing the resulting 2013 population levels by the average number of persons per housing unit in each county, as estimated by the California Department of Finance (2006).

This methodology resulted in a Census-based projection of 1,437,980 housing units using OWTS and a CWTRC-based projection of 1,460,559 housing units using OWTS in California in 2013 (Table 4-6), a difference of about 1.6%. These 2013 projections of OWTS usage represent an 8.6% increase in statewide OWTS usage compared to their respective 2008 projections of OWTS usage.

4.6.5 Businesses Using OWTS in California

In addition to household usage, OWTS are used by a small percentage of businesses in the state. No information, however, is available from the U.S. Census Bureau concerning historical or current numbers of businesses using OWTS in California. Sonoma County (2007) conducted a survey of USEPA Class V wells[6] within the county. Sonoma County identified 904 parcels as commercial or industrial in nature and utilizing OWTS (Table 4-7). Of these, 102 OWTS met the USEPA's Class V large-capacity criterion, and 271 OWTS met the USEPA's Class V industrial/commercial criterion. The remaining 531 OWTS were discharging "sanitary" waste from offices, warehouses, retail stores, self-storage facilities, etc. Businesses account for approximately 2% of all OWTS users in Sonoma County (see Table 4-6 for the number of household OWTS in Sonoma County),

The number and percentage of businesses using OWTS vary from county to county depending on many factors, including the size of a county, the number of businesses

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[6] Class V wells are typically shallow "wells," such as shallow disposal systems and dry wells, used to place a variety of fluids directly below the land surface (40 CFR 144.80 (e)). A septic system is considered a Class V well if either one of the following conditions are met:

- The septic system, regardless of size, receives any amount of industrial or commercial wastewater; or
- The septic system receives solely sanitary waste from multiple family residences or a non-residential establishment and has the capacity to serve 20 or more persons per day (also known as large-capacity septic systems).

within a county, and whether businesses in a county are concentrated in sewered areas or spread out in non-sewered areas. Discussions with USEPA staff, however, suggest that the 2% value from Sonoma County is considered to be fairly representative of the percentage of OWTS used by businesses statewide (Elizabeth Janes, USEPA, Region 9, pers. comm., 2007).

Table 4-7: Businesses within Sonoma County Utilizing OWTS

Business Type	Number of Businesses
Auto Sales/Storage (does not involve car fluids)	23
Auto Service	47
Beauty/Barber	2
Camp	15
Care Homes (includes residential treatment centers, group homes)	36
Church/Meeting Hall	49
Food Prep/Bar	104
Hotel/Motel	16
Light Manufacturing/Industrial	84
Misc. (did not fit any category)	37
Mixed Use	15
Multi-Residential	2
Nurseries	41
Poultry Farms	8
Schools	22
Store/Office/Self-Storage	167
Vet/Kennel/Medical	13
Warehouse	14
Winery	175
Unknown	34
Total	**904**

Source: Sonoma County (2007)

4.7 Contaminants of Concern

Groundwater exposed to a contaminant plume emanating from conventional OWTS effluent will likely exceed water quality objectives for nitrate and can contain other dissolved contaminants or pathogens (viruses and/or bacteria) not removed by the OWTS (Robertson 1995). Table 4-8 summarizes the major types of contaminants, or pollutants, found in OWTS discharges and briefly describes the primary reasons why pollutants such as pathogens and nitrogen are a concern.

Table 4-8: Typical Wastewater Pollutants of Concern

Pollutant	Reason for Concern
Total suspended solids and turbidity	In surface waters affected by surfacing on-site wastewater treatment system (OWTS) effluent, suspended solids can cause sludge deposits to develop that smother benthic macroinvertebrates and fish eggs and can contribute to benthic enrichment, toxicity, and sediment oxygen demand. Solids also harbor bacteria. Excessive turbidity resulting from solids that remain suspended can block sunlight, harm aquatic life (e.g., by blocking sunlight needed by plants), and lower the ability of aquatic plants to increase dissolved oxygen in the water column. In drinking water, turbidity is aesthetically displeasing and interferes with disinfection.
Biochemical oxygen demand	Biological stabilization of organics in the water column can deplete dissolved oxygen in surface waters, creating anoxic conditions harmful to aquatic life. Oxygen-reducing conditions in groundwater and surface waters can also cause taste and odor problems in drinking water.
Pathogens	Parasites, bacteria, and viruses can cause diseases through direct and indirect body contact or ingestion of contaminated water or shellfish. A particular threat occurs when OWTS effluent pools on the ground surface or migrates to recreational waters. Some pathogens (e.g., viruses and bacteria) in groundwater or surface waters can travel a significant distance.
Nitrogen	Nitrogen is an aquatic plant nutrient that can contribute to increased growth of aquatic plants and thus the loss of dissolved oxygen in surface waters, especially in lakes, estuaries, and coastal embayments. Algae and aquatic weeds can contribute trihalomethane (THM) precursors to the water column that may generate carcinogenic THMs in chlorinated drinking water. Excessive nitrate-nitrogen in drinking water can cause pregnancy complications for women and methemoglobinemia (blue baby syndrome) in infants. Livestock can suffer health

Table 4-8: Typical Wastewater Pollutants of Concern

Pollutant	Reason for Concern
	problems from drinking water high in nitrogen.
Phosphorus	Phosphorus is an aquatic plant nutrient that can contribute to increased growth of aquatic plants, including algae, which results in a reduction of dissolved oxygen in inland and coastal surface waters. Algae and aquatic weeds can contribute trihalomethane (THM) precursors to the water column that may generate carcinogenic THMs in chlorinated drinking water.
Toxic organic compounds	A variety of regulated organic compounds exist that cause direct toxicity to humans and aquatic life via skin contact and ingestion. Organic compounds present in household chemicals and cleaning agents can interfere with certain biological processes in alternative OWTS. They can be persistent pollutants in groundwater and contaminate down-gradient sources of drinking water. Some organic compounds accumulate and concentrate in ecosystem food chains.
Heavy metals	Heavy metals like lead and mercury in drinking water cause human health problems. In the aquatic ecosystem, they can be also toxic to aquatic life and accumulate in fish and shellfish that might be consumed by humans.
Dissolved inorganic compounds	Chloride and sulfide cause taste and odor problems in drinking water. Boron, sodium, chlorides, sulfate, and other solutes may limit treated wastewater reuse options (e.g., irrigation). Sodium and, to a lesser extent, potassium can be deleterious to soil structure and OWTS dispersal system performance. Total dissolved solids can pollute water to levels that render it unusable for domestic and agricultural purposes.
Endocrine disrupting compounds	The presence of common hormones, drugs, and chemicals contained in personal care products (e.g., shampoo, cleaning products, and pharmaceuticals) in wastewater and receiving water bodies is an emerging water quality and public health issue. Endocrine-disrupting compounds (EDCs) are substances that alter endocrine system function and consequently cause adverse health effects on organisms or their offspring. Only recently has it been recognized that EDCs are present in water bodies of the United States at a high frequency; however, measured concentrations have been low and usually below drinking water standards for compounds having such standards. Specific studies have found EDCs in sufficient quantity that they could potentially cause endocrine disruption in some fish. The extent of human health risks and dose responses to EDCs in concentrations at the low levels found in the environment are still unknown.

Source: Adapted from USEPA 2002 and Tchobanoglous and Burton 1991

4.7.1 Supplemental Treatment Performance

To varying degrees, different treatment components and supplemental treatment units described in section 4.5 reduce the concentrations of contaminants in effluent from OWTS before it is discharged to the dispersal system. Table 4-9 provides estimates of the ranges of typical contaminant concentrations in septic tank effluent with and without effluent filters and the effluent discharged from each major type of supplemental treatment unit.

Table 4-9: Wastewater Constituent Concentrations by Treatment System Type

Treatment System Type	Typical Effluent Constituent Concentrations				
	Biological Oxygen Demand (mg/l)	Total Suspended Solids (mg/l)	Total Nitrogen (mg/l)	Total Phosphorus (mg/l)	Fecal Coliform Bacteria (MPN/100 ml)
Septic Tank					
Without effluent filters	150–250	40–140	50–90	12–20	10^6 to 10^8
With effluent filters	100–140	20–55	50–90	12–20	10^6 to 10^8
Aerobic Treatment Systems					
Suspended growth	<5 to <50	<5 to 60	<5 to 60	<1 to >10	<2 to <4x10^5
Attached growth	<5 to <30	<5 to <30	<10 to >60	<1 to 15	<2 to <10^5
Anoxic systems	<10 to <50	<10 to <60	<10 to <20	<5	<5x10^3

Notes: mg/L = milligram per liter; MPN/100 ml = Most Probable Number per 100 milliliters
Source: Data compiled from Crites and Tchobanoglous 1998, USEPA 2002, and Leverenz, Tchobanoglous, and Darby 2002

Table 4-9 provides a summary of typical effluent concentrations expected after pretreatment using different treatment technologies. This table was prepared based on a review of data presented in Crites and Tchobanoglous (1998), Siegrist *et al.* (2001), and Leverenz, Tchobanoglous, and Darby (2002). The ranges identified in these sources were not always identical. Therefore, the ranges provided represent the low and high end of all the data sources reviewed. Disinfection systems are not included in Table 4-9. Data on disinfection system performance are not readily available in the literature.

Effluent concentration data for some constituents of concern listed in **Table 4-8** are not readily available in the literature. Sources of these constituents, their potential effects, possible source control measures, and factors affecting removal of these constituents by OWTS is discussed in the following narrative.

4.7.2 Occurrence of Other Constituents of Concern

4.7.2.1 Organic Wastewater Compounds

Household, industrial, and agricultural pesticides; pharmaceuticals; and endocrine-disrupting compounds are newly recognized classes of organic compounds that are often associated with wastewater. These organic wastewater compounds are characterized by high usage rates, potential health effects, and continuous release into the environment through human activities (Halling-Sørensen *et al.* 1998, Daughton and Ternes 1999). Organic wastewater compounds can enter the environment through a variety of sources and may not be completely removed in wastewater treatment systems (Richardson and Bowron 1985, Ternes 1998, Ternes *et al.* 1999) resulting in potentially continuous sources of organic wastewater compounds to surface water and groundwater.

The continual introduction of organic wastewater compounds into the environment may have undesirable effects on humans and animals (Daughton and Ternes 1999). Much of the concern has focused on the potential for endocrine disruption (change in normal processes in the endocrine system) in fish. Field investigations in Europe and the United States suggest that selected organic wastewater compounds (nonionic-detergent metabolites, plasticizers, pesticides, and natural or synthetic sterols and hormones) have caused changes in the endocrine systems of fish (Purdom *et al*. 1994, Jobling and Sumpter 1993, Folmar *et al*. 1996, Goodbred *et al.* 1997, Folmar *et al.* 2001).

An additional concern is the introduction of antibiotics and other pharmaceuticals into the environment. Antibiotics and other pharmaceuticals administered to humans and animals are not always completely metabolized and are excreted in urine or feces as the original product or as metabolites (Daughton and Ternes 1999). The introduction of antibiotics into the environment may result in strains of bacteria that become resistant to antibiotic treatment (Daughton and Ternes 1999).

Toxic organic compounds (TOCs), which are usually found in household products like solvents and cleaners, are also of concern. The TOCs that have been found to be the most prevalent in wastewater are 1, 4-dichlorobenzene, methylbenzene (toluene), dimethylbenzenes (xylenes), 1,1-dichloroethane, 1,1,1-trychloroethane, and dimethylketone (acetone). No studies are known to have been conducted to determine toxic organic treatment efficiency in single-family home septic tanks. A study of toxic organics in domestic wastewater and effluent from a community septic tank found that removal of low molecular-weight alkalized benzenes (*e.g.*, toluene, xylene) was noticeable, whereas virtually no removal was noted for higher molecular-weight compounds (DeWalle *et al.* 1985). Removal efficiency was observed to be directly related to tank detention time, which is directly related to settling efficiency. It should be noted that significantly high levels of toxic organic compounds can cause tank (and biomat) microorganisms to die off, which could reduce treatment performance. On-site systems that discharge high amounts of toxic organic compounds might be subject to USEPA's Class V Underground Injection Control Program and to other applicable California environmental regulations and statutes other than AB 885.

4.7.2.2 Dissolved Inorganic Compounds

Total Dissolved Solids

Total dissolved solids (TDS) is a measure of the combined content of inorganic and organic substances that can pass through a filter in water or wastewater. The most common constituents of TDS are calcium, phosphate, nitrates, sodium, magnesium, potassium and chloride. The principal application of TDS is in the study of water quality for streams, rivers and lakes, although TDS is generally considered not as a primary pollutant (*e.g.*, it is not deemed to be associated with health effects), but it is rather used as an indication of the aesthetic characteristics of drinking water.

Nitrates

Nitrate is a salt of nitric acid with an ion composed of one nitrogen and three oxygen atoms (NO_3). It is the naturally occurring chemical that remains after animal or human waste breaks down or decomposes. Excessive nitrate in drinking water can cause pregnancy complications for women and methemoglobenemia in infants.

Chlorides

Chloride concentration in wastewater is an important parameter regarding wastewater reuse applications. In wastewater, chlorides are added through usage. For example, human excreta, contains approximately 6 grams of chlorides per person per day. In areas where the hardness of water is high, use of regeneration-type water softeners will also add large quantities of chlorides. Conventional methods of wastewater treatment do not remove chloride to any substantial extent. In one study, chloride concentrations in septic tank effluent were found to range from <40 to >100 milligrams per liter (mg/l) (Anderson *et al.* 1994).

Sulfides

Sulfate ion occurs naturally in most water supplies and is also present in wastewater. Sulfate is reduced biologically, under anaerobic conditions, to sulfide, which, in turn, can combine with hydrogen to form hydrogen sulfide. Hydrogen sulfide can then be oxidized biologically to sulfuric acid, which can be corrosive to concrete.

Heavy Metals

Studies have found the presence of some metals in septic tank effluent (Otis *et al.* 1978, DeWalle *et al.* 1985). Metals can be present in the domestic waste stream because many commonly used household products contain metals. Aging interior plumbing systems may contribute lead, cadmium, and copper (Canter and Knox 1986). Other sources include vegetable matter and human excreta. Removal of sources of metals from the wastewater stream by altering user habits and implementing alternative disposal practices is recommended. In addition, the literature suggests that improving treatment processes by increasing septic tank detention times, ensuring greater unsaturated soil depths, and improving dose and rest cycles may decrease risks associated with metal loadings from on-site systems (Chang and Page 1985, Evanko and Dzombak 1997**,** Lim *et al.* 2001).

4.8 Impaired Surface Waters

The two major contaminants of surface waters related to OWTS are pathogens and nutrients. There are 641 water bodies included in the 2010 303(d) listing of impaired water bodies of California for pathogens and/or nutrients (Table 4-10)[7]. OWTS have been identified as being a source of the pollution for 33 of these water bodies (SWRCB 2010). However, the listing does not include a comprehensive list of the sources of pollution for each water body. Existing OWTS near the 99 water bodies listed in **Table 4-11** are required to comply with Tier 3 requirements. In addition, water bodies specifically identified by the State Water Board at the time it approves any future 303 (d) List, where a TMDL has not been adopted must comply with Tier 3 requirements.

4.9 OWTS Discharge Prohibition Areas

The State Water Board and Regional Water Boards have broad jurisdiction to protect water quality in the state under the Porter-Cologne Act and delegated provisions of the federal Clean Water Act. Section 303(d) impaired surface water listing, waste discharge requirements (WDRs), and total maximum daily loads (TMDLs) are important tools used to protect water quality and reduce contamination of waters of the state (both groundwater and surface waters).

Where OWTS are specifically identified as being a primary source of contamination, another means of enforcing water quality standards is the adoption by Regional Water Boards of OWTS discharge prohibition areas (Table 4-12). Section 13243 of the California

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[7] The State Water Board approved the 2010 Integrated Report on August 4, 2010. The 2010 Integrated Report includes changes to the 2006 Clean Water Act Section 303(d) list of impaired water bodies and Clean Water Act Section 305(b) report on the quality of waters in California. The 2010 Integrated Report and supporting documents were submitted to the USEPA for final approval on October 13, 2010.

On November 12, 2010, USEPA approved the inclusion of all waters to California's 2008-2010 Section 303(d) list of impaired waters requiring TMDLs and disapproved the omission of several water bodies and associated pollutants that meet federal listing requirements. USEPA is providing the public an opportunity to review its decision to add waters and pollutants to California's 2008-2010 Section 303(d) list. USEPA will consider public comments received and may revise these decisions. The State Water Board will post the final Integrated Report after USEPA approves California's 2008-2010 Section 303(d) list.

The disapproved omissions have been included in Table 4-10.

Water Code stipulates that a “Regional Water Board, in a water quality control plan or in waste discharge requirements, may specify certain conditions or areas where the discharge of waste, or certain types of waste, will not be permitted.” Furthermore, Sections 13280, 13281, and 13283 of the California Water Code specifically address steps necessary for the regional water boards to enact a prohibition of OWTS. With this authority, the State Water Board may approve, revise, or deny adoption of a discharge prohibition area for OWTS for other discharges. An example of this is the Los Osos/Baywood Park Individual and Community Sewage Disposal System Prohibition Area (Resolution 83-13, Central Coast Regional Water Board), which was adopted after the Regional Water Board determined that septic systems were responsible for elevated coliform and nitrate levels in the watershed. There are 61 OWTS discharge prohibition areas in California (Table 4-12).

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients

Water Body Name	Water Body Type	Pollutant Category	TMDL Status
Region 1			
Bodega HU, Estero Americano HA, Americano Creek	River & Stream	Nutrients	TMDL required
Bodega HU, Estero Americano HA, estuary	Estuary	Nutrients	TMDL required
Bodega HU, Estero de San Antonio HA, Stemple Creek/Estero de San Antonio	River & Stream	Nutrients	being addressed by USEPA approved TMDL
Campbell Cove	Coastal & Bay Shoreline	Pathogens	TMDL required
Clam Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Eel River HU, Lower Eel River HA (includes the Eel River Delta)	River & Stream	Nutrients	TMDL required
Hare Creek Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Klamath River HU, Butte Valley HA	River & Stream	Nutrients	TMDL required
Klamath River HU, Lost River HA, Tule Lake and Mt Dome HSAs	River & Stream	Nutrients	being addressed by USEPA approved TMDL
Klamath River HU, Lower HA, Klamath Glen HSA	River & Stream	Nutrients	TMDL required
Klamath River HU, Middle HA and Lower HA, Scott River to Trinity River	River & Stream	Nutrients	TMDL required
Klamath River HU, Middle HA, Iron Gate Dam to Scott River	River & Stream	Nutrients	TMDL required
Klamath River HU, Middle HA, Oregon to Iron Gate	River & Stream	Nutrients	TMDL required
Klamath River HU, Shasta River HA	River & Stream	Nutrients	being addressed by USEPA approved TMDL
Luffenholtz Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Moonstone County Park	Coastal & Bay Shoreline	Pathogens	TMDL required
Pudding Creek Beach	Coastal & Bay Shoreline	Pathogens	TMDL required

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients			
Water Body Name	**Water Body Type**	**Pollutant Category**	**TMDL Status**
Russian River HU, Lower Russian River HA, Guerneville HSA	River & Stream	Pathogens	TMDL required
Russian River HU, Lower Russian River HA, Guerneville HSA, Green Valley Creek watershed	River & Stream	Nutrients & Pathogens	TMDL required
Russian River HU, Middle Russian River HA, Geyserville HSA	River & Stream	Pathogens	TMDL required
Russian River HU, Middle Russian River HA, Laguna de Santa Rosa	River & Stream	Nutrients & Pathogens	TMDL required
Russian River HU, Middle Russian River HA, Santa Rosa Creek	River & Stream	Pathogens	TMDL required
Trinidad State Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Region 2			
Aquatic Park Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Arroyo Las Positas	River & Stream	Nutrients	TMDL required
Candlestick Point	Coastal & Bay Shoreline	Pathogens	TMDL required
Chicken Ranch Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
China Camp Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Crissy Field Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Golden Hinde Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Hearts Desire Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Islais Creek	Estuary	Nutrients	TMDL required
Lagunitas Creek	River & Stream	Nutrients & Pathogens	TMDL required for Nutrients Pathogens being addressed by USEPA approved TMDL
Lake Merced	Lake & Reservoir	Nutrients	TMDL required
Lake Merritt	Lake & Reservoir	Nutrients	TMDL required
Lawsons Landing	Coastal & Bay Shoreline	Pathogens	TMDL required
Marina Lagoon (San Mateo County)	Estuary	Pathogens	TMDL required
McNears Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Millerton Point	Coastal & Bay Shoreline	Pathogens	TMDL required
Mission Creek	Estuary	Nutrients	TMDL required
Napa River	River & Stream	Nutrients & Pathogens	TMDL required for Nutrients Pathogens being addressed by USEPA approved TMDL

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients			
Water Body Name	**Water Body Type**	**Pollutant Category**	**TMDL Status**
Olema Creek	River & Stream	Pathogens	being addressed by USEPA approved TMDL
Pacific Ocean at Baker Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Bolinas Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Fitzgerald Marine Reserve	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Muir Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Pacifica State/Linda Mar Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Pillar Point Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Rockaway Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Venice Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Petaluma River	River & Stream	Nutrients & Pathogens	TMDL required
Petaluma River (tidal portion)	River & Stream	Nutrients & Pathogens	TMDL required
Pomponio Creek	River & Stream	Pathogens	TMDL required
Richardson Bay	Bay & Harbor	Pathogens	TMDL required
San Gregorio Creek	River & Stream	Pathogens	TMDL required
San Pedro Creek	River & Stream	Pathogens	TMDL required
San Vicente Creek	River & Stream	Pathogens	TMDL required
Sonoma Creek	River & Stream	Nutrients & Pathogens	TMDL required for nutrients Pathogens being addressed by USEPA approved TMDL
Suisun Creek	River & Stream	Nutrients	TMDL required
Suisun Marsh Wetlands	Wetland, Tidal	Nutrients	TMDL required
Tomales Bay	Bay & Harbor	Nutrients & Pathogens	TMDL required for nutrients Pathogens being addressed by USEPA approved TMDL
Walker Creek	River & Stream	Nutrients & Pathogens	TMDL required for nutrients Pathogens being addressed by USEPA approved TMDL
Region 3			
Alamo Creek	River & Stream	Pathogens	TMDL required
Alisal Creek (Monterey County)	River & Stream	Nutrients & Pathogens	TMDL required
Alisal Slough (Monterey County)	River & Stream	Nutrients	TMDL required
Aptos Creek	River & Stream	Pathogens	TMDL required
Arana Gulch	River & Stream	Pathogens	TMDL required
Arroyo Burro Creek	River & Stream	Pathogens	TMDL required

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients

Water Body Name	Water Body Type	Pollutant Category	TMDL Status
Arroyo De La Cruz	River & Stream	Nutrients & Pathogens	TMDL required
Arroyo Grande Creek (below Lopez Lake)	River & Stream	Pathogens	TMDL required
Arroyo Paredon	River & Stream	Nutrients & Pathogens	TMDL required
Arroyo Seco River	River & Stream	Pathogens	TMDL required
Atascadero Creek (San Luis Obispo County)	River & Stream	Nutrients & Pathogens	TMDL required
Atascadero Creek (Santa Barbara county)	River & Stream	Nutrients & Pathogens	TMDL required
Beach Road Ditch	River & Stream	Nutrients	TMDL required
Bell Creek (Santa Barbara Co)	River & Stream	Nutrients & Pathogens	TMDL required
Bennett Slough	River & Stream	Nutrients	TMDL required
Blanco Drain	River & Stream	Nutrients	TMDL required
Blosser Channel	River & Stream	Nutrients & Pathogens	TMDL required
Bradley Canyon Creek	River & Stream	Nutrients	TMDL required
Bradley Canyon Creek	River & Stream	Nutrients & Pathogens	TMDL required
Bradley Channel	River & Stream	Nutrients & Pathogens	TMDL required
Branciforte Creek	River & Stream	Pathogens	TMDL required
Canada De La Gaviota	River & Stream	Pathogens	TMDL required
Canada Del Refugio	River & Stream	Pathogens	TMDL required
Carbonera Creek	River & Stream	Nutrients & Pathogens	Nutrients being addressed by USEPA approved TMDL TMDL needed for pathogens
Carnadero Creek	River & Stream	Nutrients & Pathogens	TMDL required
Carneros Creek (Monterey County)	River & Stream	Nutrients & Pathogens	TMDL required
Carpinteria Creek	River & Stream	Nutrients & Pathogens	TMDL required
Carpinteria Marsh (El Estero Marsh)	Estuary	Nutrients	TMDL required
Cholame Creek	River & Stream	Nutrients & Pathogens	TMDL required
Chorro Creek	River & Stream	Nutrients & Pathogens	Both being addressed by USEPA approved TMDL
Chualar Creek	River & Stream	Nutrients & Pathogens	TMDL required
Chumash Creek	River & Stream	Pathogens	TMDL required
Cieneguitas Creek	River & Stream	Nutrients & Pathogens	TMDL required
Corcoran Lagoon	Wetland, Freshwater	Pathogens	TMDL required
Corralitos Creek	River & Stream	Pathogens	TMDL required

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients

Water Body Name	Water Body Type	Pollutant Category	TMDL Status
Cuyama River (above Twitchell Reservoir)	River & Stream	Pathogens	TMDL required
Dairy Creek	River & Stream	Nutrients & Pathogens	Both being addressed with USEPA approved TMDL
Devereux Creek	River & Stream	Nutrients & Pathogens	TMDL required
Elkhorn Slough	Estuary	Nutrients & Pathogens	TMDL required
Esperanza Creek	River & Stream	Nutrients	TMDL required
Espinosa Slough	River & Stream	Nutrients	TMDL required
Estrella River	River & Stream	Pathogens	TMDL required
Franklin Creek (Santa Barbara County)	River & Stream	Nutrients & Pathogens	TMDL required
Furlong Creek	River & Stream	Nutrients & Pathogens	TMDL required
Gabilan Creek	River & Stream	Nutrients & Pathogens	TMDL required
Gallighan Slough	River & Stream	Pathogens	Being addressed by USEPA approved TMDL
Glen Annie Canyon	River & Stream	Nutrients & Pathogens	TMDL required
Goleta Slough/Estuary	Estuary	Pathogens	TMDL required
Greene Valley Creek (Santa Barbara County)	River & Stream	Nutrients	TMDL required
Hanson Slough	River & Stream	Pathogens	Being addressed by USEPA approved TMDL
Harkins Slough	River & Stream	Nutrients & Pathogens	TMDL required for nutrients Pathogens being addressed by USEPA approved TMDL
Little Oso Flaco Creek	River & Stream	Nutrients & Pathogens	TMDL required
Llagas Creek (below Chesbro Reservoir)	River & Stream	Nutrients & Pathogens	Nutrients being addressed by USEPA approved TMDL TMDL required for pathogens
Lockhart Gulch	River & Stream	Nutrients	TMDL required
Lompico Creek	River & Stream	Nutrients & Pathogens	Nutrients being addressed by USEPA approved TMDL TMDL required for pathogens
Los Berros Creek	River & Stream	Nutrients	TMDL required
Los Carneros Creek	River & Stream	Nutrients & Pathogens	TMDL required
Los Osos Creek	River & Stream	Nutrients & Pathogens	Both being addressed by USEPA approved TMDL
Main Street Canal	River & Stream	Nutrients & Pathogens	TMDL required
Majors Creek (Monterey County)	River & Stream	Pathogens	TMDL required
Maria Ygnacio Creek	River & Stream	Pathogens	TMDL required
McGowan Ditch	River & Stream	Nutrients	TMDL required

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients

Water Body Name	Water Body Type	Pollutant Category	TMDL Status
Merrit Ditch	River & Stream	Nutrients	TMDL required
Millers Canal	River & Stream	Nutrients & Pathogens	TMDL required
Mission Creek (Santa Barbara County)	River & Stream	Nutrients & Pathogens	TMDL required
Moore Creek	River & Stream	Nutrients & Pathogens	TMDL required
Moro Cojo Slough	Estuary	Nutrients & Pathogens	TMDL required
Morro Bay	Bay & Harbor	Nutrients & Pathogens	TMDL required for nutrients Pathogens being addressed by USEPA approved TMDL
Moss Landing Harbor	Bay & Harbor	Nutrients & Pathogens	TMDL required
Natividad Creek	River & Stream	Nutrients & Pathogens	TMDL required
Nipomo Creek	River & Stream	Nutrients & Pathogens	TMDL required
Nobel Gulch Creek	River & Stream	Pathogens	TMDL required
North Main Street Channel	River & Stream	Nutrients	TMDL required
Old Salinas River	River & Stream	Nutrients & Pathogens	TMDL required
Old Salinas River Estuary	Estuary	Nutrients	TMDL required
Orcutt Creek	River & Stream	Nutrients & Pathogens	TMDL required
Oso Flaco Creek	River & Stream	Nutrients & Pathogens	TMDL required
Oso Flaco Lake	Lake & Reservoir	Nutrients	TMDL required
Pacheco Creek	River & Stream	Nutrients & Pathogens	TMDL required
Pacific Ocean at Arroyo Burro Beach (Santa Barbara County)	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Avila Beach (Avila Pier)	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Avila Beach (SLO creek mouth)	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Capitola Beach (Santa Cruz County)	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Carpinteria State Beach (Carpinteria Creek mouth, Santa Barbara County)	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Cayucos (Cayucos Creek Mouth)	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at East Beach (mouth of Mission Creek, Santa Barbara County)	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at East Beach (mouth of Sycamore Creek, Santa Barbara County)	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Goleta Beach (Santa Barbara County)	Coastal & Bay Shoreline	Pathogens	TMDL required

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients

Water Body Name	Water Body Type	Pollutant Category	TMDL Status
Pacific Ocean at Hammonds Beach (Santa Barbara County)	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Haskells Beach (Santa Barbara County)	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Hope Ranch Beach (Santa Barbara County)	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Jalama Beach (Santa Barbara County)	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Leadbetter Beach (Santa Barbara County)	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Ocean Beach (Santa Barbara County)	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Olde Port Beach (at restrooms)	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Pismo State Beach (San Luis Obispo County), south of Pismo Pier	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Point Rincon (mouth of Rincon Cr, Santa Barbara County)	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Refugio Beach (Santa Barbara County)	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean at Stillwater Cove Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Pajaro River	River & Stream	Nutrients & Pathogens	Nutrients being addressed by USEPA approved TMDL TMDL required for pathogens
Pennington Creek	River & Stream	Pathogens	TMDL required
Pico Creek	River & Stream	Nutrients	TMDL required
Pinto Lake	Lake & Reservoir	Nutrients	TMDL required
Pismo Creek	River & Stream	Nutrients & Pathogens	TMDL required
Porter Gulch Creek	River & Stream	Pathogens	TMDL required
Prefumo Creek	River & Stream	Nutrients & Pathogens	TMDL required
Quail Creek	River & Stream	Nutrients & Pathogens	TMDL required
Rincon Creek	River & Stream	Pathogens	TMDL required
Salinas Reclamation Canal	River & Stream	Nutrients & Pathogens	TMDL required
Salinas River (lower, estuary to near Gonzales Rd crossing, watersheds 30910 and 30920)	River & Stream	Nutrients & Pathogens	TMDL required
Salinas River (middle, near Gonzales Rd crossing to confluence with Nacimiento River)	River & Stream	Pathogens	TMDL required
Salinas River Lagoon (North)	Estuary	Nutrients	TMDL required
Salsipuedes Creek (Santa Cruz County)	River & Stream	Nutrients & Pathogens	TMDL required

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients

Water Body Name	Water Body Type	Pollutant Category	TMDL Status
San Antonio Creek (San Antonio Watershed, Rancho del las Flores Bridge at Hwy 135 to downstream at Railroad Bridge)	River & Stream	Nutrients & Pathogens	TMDL required
San Antonio River (below San Antonio Reservoir)	River & Stream	Pathogens	TMDL required
San Benito River	River & Stream	Pathogens	TMDL required
San Bernardo Creek	River & Stream	Pathogens	TMDL required
San Jose Creek (Santa Barbara County)	River & Stream	Pathogens	TMDL required
San Juan Creek (San Benito County)	River & Stream	Nutrients & Pathogens	TMDL required
San Lorenzo Creek (Monterey County)	River & Stream	Pathogens	TMDL required
San Lorenzo River	River & Stream	Nutrients & Pathogens	Nutrients being addressed by USEPA approved TMDL TMDL required for pathogens
San Lorenzo River Lagoon	Estuary	Pathogens	TMDL required
San Luis Obispo Creek (above Osos Street)	River & Stream	Pathogens	TMDL required
San Luis Obispo Creek (below Osos Street)	River & Stream	Nutrients & Pathogens	Both being addressed by USEPA approved TMDL
San Luisito Creek	River & Stream	Pathogens	TMDL required
San Pedro Creek (Santa Barbara County)	River & Stream	Pathogens	TMDL required
San Simeon Creek	River & Stream	Nutrients	TMDL required
Santa Maria River	River & Stream	Nutrients & Pathogens	TMDL required
Santa Maria River Estuary	Estuary	Pathogens	TMDL required
Santa Monica Creek	River & Stream	Pathogens	TMDL required
Santa Rita Creek (Monterey County)	River & Stream	Nutrients & Pathogens	TMDL required
Santa Ynez River (below city of Lompoc to Ocean)	River & Stream	Nutrients & Pathogens	TMDL required
Schwan Lake	Lake & Reservoir	Nutrients & Pathogens	TMDL required
Shingle Mill Creek	River & Stream	Nutrients	Being addressed by USEPA approved TMDL
Soda Lake	Saline Lake	Nutrients	TMDL required
Soquel Creek	River & Stream	Pathogens	TMDL required
Soquel Lagoon	Estuary	Pathogens	TMDL required
Stenner Creek	River & Stream	Pathogens	TMDL required
Struve Slough	River & Stream	Nutrients & Pathogens	TMDL required for nutrients Pathogens being addressed by USEPA approved TMDL
Sycamore Creek	River & Stream	Pathogens	TMDL required
Tembladero Slough	River & Stream	Nutrients & Pathogens	TMDL required
Tequisquita Slough	River & Stream	Nutrients & Pathogens	TMDL required
Toro Canyon Creek	River & Stream	Pathogens	TMDL required

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients

Water Body Name	Water Body Type	Pollutant Category	TMDL Status
Toro Creek	River & Stream	Nutrients & Pathogens	TMDL required
Tres Pinos Creek	River & Stream	Pathogens	TMDL required
Tularcitos Creek	River & Stream	Pathogens	TMDL required
Uvas Creek (below Uvas Reservoir)	River & Stream	Nutrients	TMDL required
Valencia Creek	River & Stream	Pathogens	TMDL required
Walters Creek	River & Stream	Pathogens	TMDL required
Warden Creek	River & Stream	Nutrients & Pathogens	Both being addressed by USEPA approved TMDL
Watsonville Creek	River & Stream	Nutrients & Pathogens	TMDL required
Watsonville Slough	River & Stream	Nutrients & Pathogens	TMDL required for nutrients Pathogens being addressed by USEPA approved TMDL
Zayante Creek	River & Stream	Pathogens	TMDL required
Region 4			
Abalone Cove Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Alamitos Bay	Bay & Harbor	Pathogens	TMDL required
Aliso Canyon Wash	River & Stream	Pathogens	TMDL required
Arroyo Seco Reach 1 (LA River to West Holly Ave.)	River & Stream	Pathogens	TMDL required
Arroyo Seco Reach 2 (West Holly Ave to Devils Gate Dam)	River & Stream	Pathogens	TMDL required
Artesia-Norwalk Drain	River & Stream	Pathogens	TMDL required
Avalon Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Ballona Creek	River & Stream	Pathogens	Being addressed by USEPA approved TMDL
Ballona Creek Estuary	River & Stream	Pathogens	Being addressed by USEPA approved TMDL
Bell Creek	River & Stream	Pathogens	TMDL required
Big Rock Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Bluff Cove Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Brown Barranca/Long Canyon	River & Stream	Nutrients	Being addressed by USEPA approved TMDL
Bull Creek	River & Stream	Pathogens	TMDL required
Burbank Western Channel	River & Stream	Pathogens	TMDL required
Cabrillo Beach (Outer)	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Calleguas Creek Reach 1 (was Mugu Lagoon on 1998 303(d) list)	Estuary	Nutrients	Being addressed by USEPA approved TMDL
Calleguas Creek Reach 2 (estuary to Potrero Rd- was Calleguas Creek Reaches 1 and 2 on 1998 303d list)	River & Stream	Nutrients & Pathogens	Nutrients being addressed by USEPA approved TMDL TMDL required for pathogens
Calleguas Creek Reach 3 (Potrero Road upstream to confluence with Conejo Creek on 1998 303d list)	River & Stream	Nutrients	Being addressed by USEPA approved TMDL

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients

Water Body Name	Water Body Type	Pollutant Category	TMDL Status
Calleguas Creek Reach 4 (was Revolon Slough Main Branch: Mugu Lagoon to Central Avenue on 1998 303d list)	River & Stream	Nutrients & Pathogens	Nutrients being addressed by USEPA approved TMDL TMDL required for pathogens
Calleguas Creek Reach 5 (was Beardsley Channel on 1998 303d list)	River & Stream	Nutrients	Being addressed by USEPA approved TMDL
Calleguas Creek Reach 6 (was Arroyo Las Posas Reaches 1 and 2 on 1998 303d list)	River & Stream	Nutrients & Pathogens	Nutrients being addressed by USEPA approved TMDL TMDL required for pathogens
Calleguas Creek Reach 7 (was Arroyo Simi Reaches 1 and 2 on 1998 303d list)	River & Stream	Nutrients & Pathogens	Nutrients being addressed by USEPA approved TMDL TMDL required for pathogens
Calleguas Creek Reach 9A (was lower part of Conejo Creek Reach 1 on 1998 303d list)	River & Stream	Nutrients & Pathogens	Nutrients being addressed by USEPA approved TMDL TMDL required for pathogens
Calleguas Creek Reach 9B (was part of Conejo Creek Reaches 1 and 2 on 1998 303d list)	River & Stream	Nutrients & Pathogens	Nutrients being addressed by USEPA approved TMDL TMDL required for pathogens
Calleguas Creek Reach 10 (Conejo Creek (Hill Canyon)-was part of Conejo Crk Reaches 2 & 3, and lower Conejo Crk/Arroyo Conejo N Fk on 1998 303d list)	River & Stream	Nutrients & Pathogens	Nutrients being addressed by USEPA approved TMDL TMDL required for pathogens
Calleguas Creek Reach 11 (Arroyo Santa Rosa, was part of Conejo Creek Reach 3 on 1998 303d list)	River & Stream	Nutrients & Pathogens	Nutrients being addressed by USEPA approved TMDL TMDL required for pathogens
Calleguas Creek Reach 12 (was Conejo Creek/Arroyo Conejo North Fork on 1998 303d list)	River & Stream	Nutrients	Being addressed by USEPA approved TMDL
Calleguas Creek Reach 13 (Conejo Creek South Fork, was Conejo Cr Reach 4 and part of Reach 3 on 1998 303d list)	River & Stream	Nutrients	Being addressed by USEPA approved TMDL
Canada Larga (Ventura River Watershed)	River & Stream	Nutrients & Pathogens	TMDL required
Carbon Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Castlerock Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Channel Islands Harbor Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Colorado Lagoon	Wetland, Tidal	Pathogens	TMDL required
Compton Creek	River & Stream	Pathogens	TMDL required
Coyote Creek	River & Stream	Nutrients & Pathogens	Nutrients being addressed with action other than TMDL TMDL required for pathogens
Coyote Creek, North Fork	River & Stream	Pathogens	TMDL required
Crystal Lake	Lake & Reservoir	Nutrients	TMDL required
Dan Blocker Memorial (Coral) Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients

Water Body Name	Water Body Type	Pollutant Category	TMDL Status
Dockweiler Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Dominguez Channel (lined portion above Vermont Ave)	River & Stream	Nutrients & Pathogens	TMDL required
Dominguez Channel Estuary (unlined portion below Vermont Ave)	Estuary	Nutrients & Pathogens	TMDL required
Dry Canyon Creek	River & Stream	Pathogens	TMDL required
Duck Pond Agricultural Drains/Mugu Drain/Oxnard Drain No 2	River & Stream	Nutrients	Being addressed by USEPA approved TMDL
Echo Park Lake	Lake & Reservoir	Nutrients	TMDL required
El Dorado Lakes	Lake & Reservoir	Nutrients	TMDL required
Elizabeth Lake	Lake & Reservoir	Nutrients	TMDL required
Escondido Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Flat Rock Point Beach Area	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Fox Barranca (tributary to Calleguas Creek Reach 6)	River & Stream	Nutrients	Being addressed by USEPA approved TMDL
Hermosa Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Hobie Beach (Channel Islands Harbor)	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Inspiration Point Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
La Costa Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Lake Calabasas	Lake & Reservoir	Nutrients	TMDL required
Lake Hughes	Lake & Reservoir	Nutrients	TMDL required
Lake Lindero	Lake & Reservoir	Nutrients	Being addressed by USEPA approved TMDL
Lake Sherwood	Lake & Reservoir	Nutrients	Being addressed by USEPA approved TMDL
Las Flores Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Las Tunas Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Las Virgenes Creek	River & Stream	Nutrients & Pathogens	Both being addressed by USEPA approved TMDL
Legg Lake	Lake & Reservoir	Nutrients	TMDL required
Leo Carillo Beach (South of County Line)	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Lincoln Park Lake	Lake & Reservoir	Nutrients	TMDL required

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients

Water Body Name	Water Body Type	Pollutant Category	TMDL Status
Lindero Creek Reach 1	River & Stream	Nutrients & Pathogens	Both being addressed by USEPA approved TMDL
Lindero Creek Reach 2 (Above Lake)	River & Stream	Nutrients & Pathogens	Both being addressed by USEPA approved TMDL
Long Beach City Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Long Point Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Los Angeles Harbor - Inner Cabrillo Beach Area	Bay & Harbor	Pathogens	Being addressed by USEPA approved TMDL
Los Angeles River Reach 1 (Estuary to Carson Street)	River & Stream	Nutrients & Pathogens	Nutrients being addressed by USEPA approved TMDL TMDL required for pathogens
Los Angeles River Reach 2 (Carson to Figueroa Street)	River & Stream	Nutrients & Pathogens	Nutrients being addressed by USEPA approved TMDL TMDL required for pathogens
Los Angeles River Reach 3 (Figueroa St. to Riverside Dr.)	River & Stream	Nutrients	Being addressed by USEPA approved TMDL
Los Angeles River Reach 4 (Sepulveda Dr. to Sepulveda Dam)	River & Stream	Nutrients & Pathogens	Nutrients being addressed by USEPA approved TMDL TMDL required for pathogens
Los Angeles River Reach 5 (within Sepulveda Basin)	River & Stream	Nutrients	Being addressed by USEPA approved TMDL
Los Angeles River Reach 6 (Above Sepulveda Flood Control Basin)	River & Stream	Pathogens	TMDL required
Los Angeles/Long Beach Inner Harbor	Bay & Harbor	Pathogens	TMDL required
Los Cerritos Channel	Wetland, Tidal	Nutrients & Pathogens	TMDL required
Lunada Bay Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Machado Lake (Harbor Park Lake)	Lake & Reservoir	Nutrients	Being addressed by USEPA approved TMDL
Malaga Cove Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Malibou Lake	Lake & Reservoir	Nutrients	Being addressed by USEPA approved TMDL
Malibu Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Malibu Creek	River & Stream	Nutrients & Pathogens	Both being addressed by USEPA approved TMDL
Malibu Lagoon	Estuary	Nutrients & Pathogens	Both being addressed by USEPA approved TMDL
Malibu Lagoon Beach (Surfrider)	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Manhattan Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Marina del Rey Harbor - Back Basins	Bay & Harbor	Pathogens	Being addressed by USEPA approved TMDL
Marina del Rey Harbor Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients

Water Body Name	Water Body Type	Pollutant Category	TMDL Status
McCoy Canyon Creek	River & Stream	Nutrients & Pathogens	TMDL required
McGrath Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
McGrath Lake	Lake & Reservoir	Pathogens	TMDL required
Medea Creek Reach 1 (Lake to Confl. with Lindero)	River & Stream	Nutrients & Pathogens	Both being addressed by USEPA approved TMDL
Medea Creek Reach 2 (Abv Confl. with Lindero)	River & Stream	Nutrients & Pathogens	Both being addressed by USEPA approved TMDL
Mint Canyon Creek Reach 1 (Confl to Rowler Cyn)	River & Stream	Nutrients	Being addressed by USEPA approved TMDL
Munz Lake	Lake & Reservoir	Nutrients	TMDL required
Nicholas Canyon Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Ormond Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Palo Comado Creek	River & Stream	Pathogens	Being addressed by USEPA approved TMDL
Palo Verde Shoreline Park Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Paradise Cove Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Peck Road Park Lake	Lake & Reservoir	Nutrients	TMDL required
Peninsula Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Point Dume Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Point Fermin Park Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Point Vicente Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Portuguese Bend Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Promenade Park Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Puddingstone Reservoir	Lake & Reservoir	Nutrients	TMDL required
Puente Creek	River & Stream	Pathogens	TMDL required
Puerco Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Redondo Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Resort Point Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Rincon Beach	Coastal & Bay Shoreline	Pathogens	TMDL required

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients

Water Body Name	Water Body Type	Pollutant Category	TMDL Status
Rio De Santa Clara/Oxnard Drain No. 3	River & Stream	Nutrients	Being addressed by USEPA approved TMDL
Rio Hondo Reach 1 (Confl. LA River to Snt Ana Fwy)	River & Stream	Pathogens	TMDL required
Rio Hondo Reach 2 (At Spreading Grounds)	River & Stream	Pathogens	TMDL required
Robert H. Meyer Memorial Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Royal Palms Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
San Antonio Creek (Tributary to Ventura River Reach 4)	River & Stream	Nutrients & Pathogens	TMDL required
San Buenaventura Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
San Gabriel River Estuary	River & Stream	Nutrients	TMDL required
San Gabriel River Reach 1 (Estuary to Firestone)	River & Stream	Pathogens	TMDL required
San Gabriel River Reach 2 (Firestone to Whittier Narrows Dam	River & Stream	Pathogens	TMDL required
San Gabriel River Reach 3 (Whittier Narrows to Ramona)	River & Stream	Pathogens	TMDL required
San Jose Creek Reach 1 (SG Confluence to Temple St.)	River & Stream	Nutrients & Pathogens	Being addressed by action other than TMDL
San Jose Creek Reach 2 (Temple to I-10 at White Ave.)	River & Stream	Pathogens	TMDL required
Santa Clara River Estuary	Estuary	Nutrients & Pathogens	TMDL required
Santa Clara River Reach 3 (Freeman Diversion to A Street)	River & Stream	Nutrients	Being addressed by USEPA approved TMDL
Santa Clara River Reach 5 (Blue Cut gaging station to West Pier Hwy 99 Bridge) (was named Santa Clara River Reach 7 on 2002 303(d) list)	River & Stream	Pathogens	TMDL required
Santa Clara River Reach 6 (W Pier Hwy 99 to Bouquet Cyn Rd) (was named Santa Clara River Reach 8 on 2002 303(d) list)	River & Stream	Pathogens	TMDL required
Santa Clara River Reach 7 (Bouquet Canyon Rd to above Lang Gaging Station) (was named Santa Clara River Reach 9 on 2002 303(d) list)	River & Stream	Pathogens	TMDL required
Santa Monica Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Santa Monica Canyon	River & Stream	Pathogens	Being addressed by USEPA approved TMDL
Sawpit Creek	River & Stream	Pathogens	TMDL required
Sea Level Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Sepulveda Canyon	River & Stream	Nutrients & Pathogens	TMDL required for nutrients Pathogens being addressed by USEPA approved TMDL

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients

Water Body Name	Water Body Type	Pollutant Category	TMDL Status
Stokes Creek	River & Stream	Pathogens	Being addressed by USEPA approved TMDL
Surfers Point at Seaside	Coastal & Bay Shoreline	Pathogens	TMDL required
Topanga Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Torrance Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Torrance Carson Channel	River & Stream	Pathogens	TMDL required
Torrey Canyon Creek	River & Stream	Nutrients	Being addressed by USEPA approved TMDL
Trancas Beach (Broad Beach)	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Tujunga Wash (LA River to Hansen Dam)	River & Stream	Nutrients & Pathogens	Nutrients being addressed by USEPA approved TMDL TMDL required for pathogens
Venice Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Ventura Harbor: Ventura Keys	Bay & Harbor	Pathogens	TMDL required
Ventura River Estuary	River & Stream	Nutrients & Pathogens	TMDL required
Ventura River Reach 1 and 2 (Estuary to Weldon Canyon)	River & Stream	Nutrients	TMDL required
Ventura River Reach 3 (Weldon Canyon to Confl. w/ Coyote Cr)	River & Stream	Pathogens	TMDL required
Verdugo Wash Reach 1 (LA River to Verdugo Rd.)	River & Stream	Pathogens	TMDL required
Verdugo Wash Reach 2 (Above Verdugo Road)	River & Stream	Pathogens	TMDL required
Walnut Creek Wash (Drains from Puddingstone Res)	River & Stream	Pathogens	TMDL required
Westlake Lake	Lake & Reservoir	Nutrients	Being addressed by USEPA approved TMDL
Wheeler Canyon/Todd Barranca	River & Stream	Nutrients	Being addressed by USEPA approved TMDL
Whites Point Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Will Rogers Beach	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Wilmington Drain	River & Stream	Pathogens	TMDL required
Zuma Beach (Westward Beach)	Coastal & Bay Shoreline	Pathogens	Being addressed by USEPA approved TMDL
Region 5			
Anderson Creek (Shasta County)	River & Stream	Pathogens	TMDL required
Ash Creek, Upper	River & Stream	Pathogens	TMDL required
Avena Drain	River & Stream	Nutrients & Pathogens	TMDL required
Bear Creek (from Bear Valley to San Joaquin River, Mariposa and Merced Counties)	River & Stream	Pathogens	TMDL required

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients

Water Body Name	Water Body Type	Pollutant Category	TMDL Status
Bear Creek (San Joaquin and Calaveras Counties; partly in Delta Waterways, eastern portion)	River & Stream	Nutrients & Pathogens	TMDL required
Beaver Creek	River & Stream	Pathogens	TMDL required
Butte Slough	River & Stream	Nutrients	TMDL required
Calaveras River, Lower (from Stockton Diverting Canal to the San Joaquin River; partly in Delta Waterways, eastern portion)	River & Stream	Nutrients & Pathogens	TMDL required for nutrients Pathogens being addressed by USEPA approved TMDL
Canyon Creek (Modoc County)	River & Stream	Pathogens	TMDL required
Clear Lake	Lake & Reservoir	Nutrients	Being addressed by USEPA approved TMDL
Clover Creek	River & Stream	Pathogens	TMDL required
Colusa Basin Drain	River & Stream	Nutrients & Pathogens	TMDL required
Coon Creek, Lower (from Pacific Avenue to Main Canal, Sutter County)	River & Stream	Pathogens	TMDL required
Cosumnes River, Lower (below Michigan Bar; partly in Delta Waterways, eastern portion)	River & Stream	Pathogens	TMDL required
Cottonwood Creek (S Madera County)	River & Stream	Pathogens	TMDL required
Curtis Creek (Tuolumne County)	River & Stream	Pathogens	TMDL required
Deadman Creek (Merced County)	River & Stream	Pathogens	TMDL required
Del Puerto Creek	River & Stream	Pathogens	TMDL required
Delta Waterways (Stockton Ship Channel)	Estuary	Nutrients & Pathogens	Both being addressed by USEPA approved TMDL
Dry Creek (tributary to Tuolumne River at Modesto, E Stanislaus County)	River & Stream	Pathogens	TMDL required
Duck Creek (San Joaquin County)	River & Stream	Pathogens	TMDL required
Duck Slough (Merced County)	River & Stream	Pathogens	TMDL required
Five Mile Slough (Alexandria Place to Fourteen Mile Slough; in Delta Waterways, eastern portion)	River & Stream	Nutrients & Pathogens	TMDL required for nutrients Pathogens being addressed by USEPA approved TMDL
French Camp Slough (confluence of Littlejohns and Lone Tree Creeks to San Joaquin River, San Joaquin Co.; partly in Delta Waterways, eastern portion)	River & Stream	Nutrients & Pathogens	TMDL required
French Ravine	River & Stream	Pathogens	TMDL required
Fresno River (Above Hensley Reservoir to confl w Nelder Creek and Lewis Fork)	River & Stream	Nutrients	TMDL required
Gordon Slough (from headwaters and Goodnow Slough to Adams Canal, Yolo County)	River & Stream	Nutrients	TMDL required
Grayson Drain (at outfall)	River & Stream	Pathogens	TMDL required
Harding Drain	River & Stream	Pathogens	TMDL required
Hensley Lake	Lake & Reservoir	Nutrients	TMDL required
Honcut Creek (Butte and Yuba Counties)	River & Stream	Nutrients	TMDL required
Hospital Creek (San Joaquin and Stanislaus Counties)	River & Stream	Pathogens	TMDL required

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients

Water Body Name	Water Body Type	Pollutant Category	TMDL Status
Hume Lake	Lake & Reservoir	Nutrients	TMDL required
Ingram Creek (from confluence with San Joaquin River to confluence with Hospital Creek)	River & Stream	Pathogens	TMDL required
Isabella Lake	Lake & Reservoir	Nutrients	TMDL required
Kellogg Creek (Los Vaqueros Reservoir to Discovery Bay; partly in Delta Waterways, western portion)	River & Stream	Nutrients & Pathogens	TMDL required
Knights Landing Ridge Cut (Yolo County)	River & Stream	Nutrients	TMDL required
Littlejohns Creek	River & Stream	Pathogens	TMDL required
Live Oak Slough	River & Stream	Nutrients	TMDL required
Lone Tree Creek	River & Stream	Nutrients & Pathogens	TMDL required
Los Banos Creek (below Los Banos Reservoir, Merced County)	River & Stream	Nutrients & Pathogens	TMDL required
Main Drainage Canal	River & Stream	Nutrients	TMDL required
Marsh Creek (Marsh Creek Reservoir to San Joaquin River; partly in Delta Waterways, western portion)	River & Stream	Pathogens	TMDL required
Merced River, Lower (McSwain Reservoir to San Joaquin River)	River & Stream	Pathogens	TMDL required
Middle River (in Delta Waterways, southern portion)	River & Stream	Nutrients	TMDL required
Miners Ravine (Placer County)	River & Stream	Nutrients	TMDL required
Mokelumne River, Lower (in Delta Waterways, eastern portion)	River & Stream	Nutrients	TMDL required
Mormon Slough (Commerce Street to Stockton Deep Water Channel; partly in Delta Waterways, eastern portion)	River & Stream	Nutrients & Pathogens	TMDL required
Mormon Slough (Stockton Diverting Canal to Commerce Street)	River & Stream	Pathogens	TMDL required
Mosher Slough (downstream of I-5; in Delta Waterways, eastern portion)	River & Stream	Nutrients & Pathogens	TMDL required
Mosher Slough (upstream of I-5; partly in Delta Waterways, eastern portion)	River & Stream	Pathogens	TMDL required
Mud Slough, North (upstream of San Luis Drain)	River & Stream	Pathogens	TMDL required
Newman Wasteway	River & Stream	Nutrients & Pathogens	TMDL required
Oak Run Creek	River & Stream	Pathogens	TMDL required
Old River (San Joaquin River to Delta-Mendota Canal; in Delta Waterways, southern portion)	River & Stream	Nutrients	TMDL required
Orestimba Creek (above Kilburn Road)	River & Stream	Pathogens	TMDL required
Orestimba Creek (below Kilburn Road)	River & Stream	Pathogens	TMDL required
Pit River (from confluence of N and S forks to Shasta Lake)	River & Stream	Nutrients	TMDL required

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients

Water Body Name	Water Body Type	Pollutant Category	TMDL Status
Pixley Slough (San Joaquin County; partly in Delta Waterways, eastern portion)	River & Stream	Nutrients & Pathogens	TMDL required
Pleasant Grove Creek	River & Stream	Nutrients	TMDL required
Pleasant Grove Creek, South Branch	River & Stream	Nutrients	TMDL required
Ramona Lake (Fresno County)	Lake & Reservoir	Pathogens	TMDL required
Rattlesnake Creek (at confluence w Mokelumne River, N Fork)	River & Stream	Pathogens	TMDL required
Sacramento Slough	River & Stream	Nutrients	TMDL required
Salado Creek (Stanislaus County)	River & Stream	Pathogens	TMDL required
Salt Slough (upstream from confluence with San Joaquin River)	River & Stream	Pathogens	TMDL required
San Joaquin River (Bear Creek to Mud Slough)	River & Stream	Pathogens	TMDL required
San Joaquin River (Mud Slough to Merced River)	River & Stream	Pathogens	TMDL required
San Joaquin River (Stanislaus River to Delta Boundary)	River & Stream	Pathogens	TMDL required
Sand Creek (Colusa County)	River & Stream	Nutrients	TMDL required
Sand Creek (tributary to Marsh Creek, Contra Costa County; partly in Delta Waterways, western portion)	River & Stream	Pathogens	TMDL required
Smith Canal (in Delta Waterways, eastern portion)	River & Stream	Nutrients & Pathogens	TMDL required
South Cow Creek	River & Stream	Pathogens	TMDL required
Spring Creek (Colusa County)	River & Stream	Nutrients	TMDL required
Stone Corral Creek	River & Stream	Nutrients	TMDL required
Sullivan Creek (from Phoenix Reservoir to Don Pedro Lake, Tuolumne County)	River & Stream	Pathogens	TMDL required
Sycamore Slough (Yolo County)	River & Stream	Nutrients	TMDL required
Temple Creek	River & Stream	Nutrients	TMDL required
Tom Paine Slough (in Delta Waterways, southern portion)	River & Stream	Nutrients	TMDL required
Tule Canal (Yolo County)	River & Stream	Pathogens	TMDL required
Turner Slough (Merced County)	River & Stream	Pathogens	TMDL required
Walker Slough (partly in Delta Waterways, eastern portion)	River & Stream	Pathogens	Being addressed by USEPA approved TMDL
Westley Wasteway (Stanislaus County)	Lake & Reservoir	Pathogens	TMDL required
Willow Creek (Lassen County, Central Valley)	River & Stream	Pathogens	TMDL required
Willow Slough Bypass (Yolo County)	River & Stream	Pathogens	TMDL required
Wolf Creek (Nevada County)	River & Stream	Pathogens	TMDL required
Woods Creek (Tuolumne County)	River & Stream	Pathogens	TMDL required
Region 6			
Blackwood Creek	River & Stream	Nutrients	TMDL required
Bridgeport Reservoir	Lake & Reservoir	Nutrients	TMDL required

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients

Water Body Name	Water Body Type	Pollutant Category	TMDL Status
Buckeye Creek	River & Stream	Pathogens	Being addressed by action other than TMDL
Carson River, West Fork (Headwaters to Woodfords)	River & Stream	Nutrients	TMDL required
Carson River, West Fork (Paynesville to State Line)	River & Stream	Pathogens	TMDL required
Carson River, West Fork (Woodfords to Paynesville)	River & Stream	Nutrients & Pathogens	TMDL required
Cold Creek	River & Stream	Nutrients	Being addressed by action other than TMDL
Crowley Lake	Lake & Reservoir	Nutrients	TMDL required
Eagle Lake (Lassen County)	Lake & Reservoir	Nutrients	TMDL required
East Walker River, above Bridgeport Reservoir	River & Stream	Pathogens	Being addressed by action other than TMDL
General Creek	River & Stream	Nutrients	TMDL required
Heavenly Valley Creek (source to USFS boundary)	River & Stream	Nutrients	TMDL required
Hilton Creek	River & Stream	Nutrients	TMDL required
Indian Creek (Alpine County)	River & Stream	Pathogens	TMDL required
Indian Creek Reservoir	Lake & Reservoir	Nutrients	Being addressed by USEPA approved TMDL
Pleasant Valley Reservoir	Lake & Reservoir	Nutrients	TMDL required
Robinson Creek (Hwy 395 to Bridgeport Res)	River & Stream	Pathogens	Being addressed by action other than TMDL
Robinson Creek (Twin Lakes to Hwy 395)	River & Stream	Pathogens	Being addressed by action other than TMDL
Sheep Creek	River & Stream	Nutrients	TMDL required
Susan River (Headwaters to Susanville)	River & Stream	Nutrients	TMDL required
Swauger Creek	River & Stream	Nutrients & Pathogens	TMDL required
Tahoe, Lake	Lake & Reservoir	Nutrients	TMDL required
Tallac Creek (below Hwy 89)	River & Stream	Pathogens	TMDL required
Trout Creek (above Hwy 50)	River & Stream	Nutrients & Pathogens	TMDL required
Trout Creek (below Hwy 50)	River & Stream	Nutrients & Pathogens	TMDL required
Truckee River, Upper (above Christmas Valley)	River & Stream	Nutrients	TMDL required
Truckee River, Upper (below Christmas Valley)	River & Stream	Nutrients	TMDL required
Ward Creek	River & Stream	Nutrients	TMDL required
Region 7			
Alamo River	River & Stream	Pathogens	TMDL required
Coachella Valley Storm Water Channel	River & Stream	Pathogens	TMDL required

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients			
Water Body Name	**Water Body Type**	**Pollutant Category**	**TMDL Status**
New River (Imperial County)	River & Stream	Nutrients & Pathogens	TMDL required for nutrients Pathogens being addressed by USEPA approved TMDL
Palo Verde Outfall Drain and Lagoon	River & Stream	Pathogens	TMDL required
Salton Sea	Saline Lake	Nutrients & Pathogens	TMDL required
Region 8			
Big Bear Lake	Lake & Reservoir	Nutrients	Being addressed by USEPA approved TMDL
Bolsa Chica Channel	River & Stream	Nutrients & Pathogens	TMDL required (Pathogens added by USEPA)
Borrego Creek (from Irvine Blvd to San Diego Creek Reach 2)	River & Stream	Nutrients & Pathogens	TMDL required (Pathogens added by USEPA)
Buck Gully Creek	River & Stream	Pathogens	TMDL required
Canyon Lake (Railroad Canyon Reservoir)	Lake & Reservoir	Nutrients & Pathogens	Nutrients being addressed by USEPA approved TMDL TMDL required for pathogens
Chino Creek Reach 1A (Santa Ana River R5 confl to just downstream of confl with Mill Creek)	River & Stream	Nutrients & Pathogens	TMDL required for nutrients Pathogens being addressed by USEPA approved TMDL
Chino Creek Reach 1B (Mill Creek confl to start of concrete lined channel)	River & Stream	Nutrients & Pathogens	TMDL required for nutrients Pathogens being addressed by USEPA approved TMDL
Chino Creek Reach 2 (Beginning of concrete channel to confl w San Antonio Creek)	River & Stream	Pathogens	Being addressed by USEPA approved TMDL
Cucamonga Creek Reach 1 (Valley Reach)	River & Stream	Pathogens	Being addressed by USEPA approved TMDL
East Garden Grove Wintersburg Channel	River & Stream	Nutrients	TMDL required
Elsinore, Lake	Lake & Reservoir	Nutrients	Being addressed by USEPA approved TMDL
Fulmor, Lake	Lake & Reservoir	Pathogens	TMDL required
Goldenstar Creek	River & Stream	Pathogens	TMDL required (added by USEPA)
Grout Creek	River & Stream	Nutrients	TMDL required
Huntington Harbour	Bay & Harbor	Pathogens	TMDL required
Knickerbocker Creek	River & Stream	Pathogens	TMDL required
Los Trancos Creek (Crystal Cove Creek)	River & Stream	Pathogens	TMDL required
Lytle Creek	River & Stream	Pathogens	TMDL required
Mill Creek (Prado Area)	River & Stream	Nutrients & Pathogens	TMDL required for nutrients Pathogens being addressed by USEPA approved TMDL
Mill Creek Reach 1	River & Stream	Pathogens	TMDL required
Mill Creek Reach 2	River & Stream	Pathogens	TMDL required
Morning Canyon Creek	River & Stream	Pathogens	TMDL required (added by USEPA)
Mountain Home Creek	River & Stream	Pathogens	TMDL required
Mountain Home Creek, East Fork	River & Stream	Pathogens	TMDL required

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients			
Water Body Name	**Water Body Type**	**Pollutant Category**	**TMDL Status**
Newport Bay, Lower (entire lower bay, including Rhine Channel, Turning Basin and South Lido Channel to east end of H-J Moorings)	Bay & Harbor	Nutrients & Pathogens	Both being addressed by USEPA approved TMDL
Newport Bay, Upper (Ecological Reserve)	Estuary	Nutrients & Pathogens	Both being addressed by USEPA approved TMDL
Newport Slough	River & Stream	Pathogens	TMDL required
Peters Canyon Channel	River & Stream	Pathogens	TMDL required (added by USEPA)
Prado Park Lake	Lake & Reservoir	Nutrients & Pathogens	TMDL required for nutrients Pathogens being addressed by USEPA approved TMDL
Rathbone (Rathbun) Creek	River & Stream	Nutrients	TMDL required
San Diego Creek Reach 1	River & Stream	Nutrients & Pathogens	Nutrients being addressed by USEPA approved TMDL TMDL required for pathogens
San Diego Creek Reach 2	River & Stream	Nutrients & Pathogens	Nutrients being addressed by USEPA approved TMDL TMDL required for pathogens (Pathogens added by USEPA)
Santa Ana Delhi Channel	River & Stream	Pathogens	TMDL required (added by USEPA)
Santa Ana River, Reach 2	River & Stream	Pathogens	TMDL required (added by USEPA)
Santa Ana River, Reach 3	River & Stream	Pathogens	Being addressed by USEPA approved TMDL
Santa Ana River, Reach 4	River & Stream	Pathogens	TMDL required
Seal Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Serrano Creek	River & Stream	Nutrients & Pathogens	TMDL required (Pathogens added by USEPA)
Silverado Creek	River & Stream	Pathogens	TMDL required
Summit Creek	River & Stream	Nutrients	TMDL required
Temescal Creek, Reach 6 (Elsinore Groundwater sub-basin boundary to Lake Elsinore Outlet)	River & Stream	Pathogens	TMDL required (added by USEPA)
Region 9			
Agua Hedionda Creek	River & Stream	Nutrients & Pathogens	TMDL required
Aliso Creek	River & Stream	Nutrients & Pathogens	TMDL required
Aliso Creek (mouth)	Estuary	Pathogens	TMDL required
Arroyo Trabuco Creek	River & Stream	Nutrients	TMDL required
Barrett Lake	Lake & Reservoir	Nutrients	TMDL required
Buena Creek	River & Stream	Nutrients	TMDL required
Buena Vista Lagoon	Estuary	Nutrients & Pathogens	TMDL required
Chollas Creek	River & Stream	Nutrients & Pathogens	TMDL required
Cloverdale Creek	River & Stream	Nutrients	TMDL required
De Luz Creek	River & Stream	Nutrients	TMDL required

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients

Water Body Name	Water Body Type	Pollutant Category	TMDL Status
El Capitan Lake	Lake & Reservoir	Nutrients	TMDL required
Escondido Creek	River & Stream	Nutrients & Pathogens	TMDL required
Famosa Slough and Channel	Estuary	Nutrients	TMDL required
Forester Creek	River & Stream	Pathogens	TMDL required
Guajome Lake	Lake & Reservoir	Nutrients	TMDL required
Hodges, Lake	Lake & Reservoir	Nutrients	TMDL required
Loma Alta Slough	Estuary	Nutrients & Pathogens	TMDL required
Long Canyon Creek (tributary to Murrieta Creek)	River & Stream	Pathogens	TMDL required
Los Penasquitos Creek	River & Stream	Nutrients & Pathogens	TMDL required
Loveland Reservoir	Lake & Reservoir	Nutrients	TMDL required
Miramar Reservoir	Lake & Reservoir	Nutrients	TMDL required
Mission Bay (area at mouth of Rose Creek only)	Bay & Harbor	Nutrients	TMDL required
Mission Bay (area at mouth of Tecolote Creek only)	Bay & Harbor	Nutrients	TMDL required
Mission Bay Shoreline, at Bahia Point	Coastal & Bay Shoreline	Pathogens	TMDL required
Mission Bay Shoreline, at Bonita Cove	Coastal & Bay Shoreline	Pathogens	TMDL required
Mission Bay Shoreline, at Campland	Coastal & Bay Shoreline	Pathogens	TMDL required
Mission Bay Shoreline, at De Anza Cove	Coastal & Bay Shoreline	Pathogens	TMDL required
Mission Bay Shoreline, at Fanual Park	Coastal & Bay Shoreline	Pathogens	TMDL required
Mission Bay Shoreline, at Leisure Lagoon	Coastal & Bay Shoreline	Pathogens	TMDL required
Mission Bay Shoreline, at North Crown Point	Coastal & Bay Shoreline	Pathogens	TMDL required
Mission Bay Shoreline, at Tecolote Shores	Coastal & Bay Shoreline	Pathogens	TMDL required
Mission Bay Shoreline, at Visitors Center	Coastal & Bay Shoreline	Pathogens	TMDL required
Morena Reservoir	Lake & Reservoir	Nutrients	TMDL required
Murray Reservoir	Lake & Reservoir	Nutrients	TMDL required
Murrieta Creek	River & Stream	Nutrients	TMDL required
Otay Reservoir, Lower	Lake & Reservoir	Nutrients	TMDL required

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients

Water Body Name	Water Body Type	Pollutant Category	TMDL Status
Pacific Ocean Shoreline, Aliso HSA, at Aliso Beach - middle	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Aliso HSA, at Aliso Creek mouth	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Batiquitos HSA, at Moonlight State Beach (Cottonwood Creek outlet)	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Coronado HA, at Silver Strand (north end, Oceanside)	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Dana Point HSA, at Aliso Beach at West Street	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Dana Point HSA, at Dana Point Harbor at Baby Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Dana Point HSA, at Salt Creek outlet at Monarch Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Imperial Beach Pier	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Laguna Beach HSA, at Main Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Loma Alta HSA, at Loma Alta Creek mouth	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Lower San Juan HSA, at North Beach Creek	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Lower San Juan HSA, at North Doheny State Park Campground	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Lower San Juan HSA, at San Juan Creek	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Lower San Juan HSA, at South Doheny State Park Campground	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Miramar Reservoir HA, at Los Penasquitos River mouth	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Otay Valley HA, at Carnation Ave and Camp Surf Jetty	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Point Loma HA, at Bermuda Ave	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, San Clemente HA, at Poche Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, San Clemente HA, at San Clemente City Beach at Pier	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, San Clemente HA, at San Clemente City Beach, North Beach	Coastal & Bay Shoreline	Pathogens	TMDL required

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients

Water Body Name	Water Body Type	Pollutant Category	TMDL Status
Pacific Ocean Shoreline, San Clemente HA, at South Capistrano Beach at Beach Road	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, San Clemente HA, at South Capistrano County Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, San Diego HU, at the San Diego River outlet, at Dog Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, San Dieguito HU, at San Dieguito Lagoon Mouth at San Dieguito River Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, San Elijo HSA, at Cardiff State Beach at San Elijo Lagoon	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, San Luis Rey HU, at San Luis Rey River mouth	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, San Mateo Canyon HA, at San Mateo Creek outlet	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Scripps HA, at Avenida de la Playa at La Jolla Shores Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Scripps HA, at Childrens Pool	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Scripps HA, at La Jolla Cove	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Scripps HA, at Pacific Beach Point , Pacific Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Scripps HA, at Ravina	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Scripps HA, at Vallecitos Court at La Jolla Shores Beach	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Tijuana HU, at 3/4 mile North of Tijuana River	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Tijuana HU, at end of Seacoast Drive	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Tijuana HU, at Monument Road	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Tijuana HU, at the US Border	Coastal & Bay Shoreline	Pathogens	TMDL required
Pacific Ocean Shoreline, Tijuana HU, at Tijuana River mouth	Coastal & Bay Shoreline	Pathogens	TMDL required
Prima Deshecha Creek	River & Stream	Nutrients	TMDL required
Rainbow Creek	River & Stream	Nutrients	Being addressed with USEPA approved TMDL
Redhawk Channel	River & Stream	Nutrients & Pathogens	TMDL required
San Diego Bay Shoreline, at Bayside Park (J Street)	Bay & Harbor	Pathogens	TMDL required
San Diego Bay Shoreline, at Spanish Landing	Bay & Harbor	Pathogens	TMDL required

Table 4-10: 2010 303(d) Water Bodies Listed for Pathogens and/or Nutrients

Water Body Name	Water Body Type	Pollutant Category	TMDL Status
San Diego Bay Shoreline, G Street Pier	Coastal & Bay Shoreline	Pathogens	TMDL required
San Diego Bay Shoreline, Shelter Island Shoreline Park	Coastal & Bay Shoreline	Pathogens	TMDL required
San Diego Bay Shoreline, Tidelands Park	Coastal & Bay Shoreline	Pathogens	TMDL required
San Diego Bay Shoreline, Vicinity of B St and Broadway Piers	Bay & Harbor	Pathogens	TMDL required
San Diego River (Lower)	River & Stream	Nutrients & Pathogens	TMDL required
San Dieguito River	River & Stream	Nutrients & Pathogens	TMDL required
San Elijo Lagoon	Estuary	Nutrients & Pathogens	TMDL required
San Juan Creek	River & Stream	Nutrients & Pathogens	TMDL required
San Juan Creek (mouth)	Estuary	Pathogens	TMDL required
San Luis Rey River, Lower (west of Interstate 15)	River & Stream	Nutrients & Pathogens	TMDL required
San Luis Rey River, Upper (east of Interstate 15)	River & Stream	Nutrients	TMDL required
San Marcos Creek	River & Stream	Nutrients	TMDL required
San Marcos Lake	Lake & Reservoir	Nutrients	TMDL required
San Vicente Creek (San Diego County)	River & Stream	Nutrients	TMDL required
San Vicente Reservoir	Lake & Reservoir	Nutrients	TMDL required
Santa Gertrudis Creek	River & Stream	Nutrients & Pathogens	TMDL required
Santa Margarita Lagoon	Estuary	Nutrients	TMDL required
Santa Margarita River (Lower)	River & Stream	Nutrients & Pathogens	TMDL required
Santa Margarita River (Upper)	River & Stream	Nutrients	TMDL required
Segunda Deshecha Creek	River & Stream	Nutrients	TMDL required
Sutherland Reservoir	Lake & Reservoir	Nutrients	TMDL required
Sweetwater Reservoir	Lake & Reservoir	Nutrients	TMDL required
Sweetwater River, Lower (below Sweetwater Reservoir)	River & Stream	Nutrients & Pathogens	TMDL required
Tecolote Creek	River & Stream	Nutrients & Pathogens	TMDL required
Temecula Creek	River & Stream	Nutrients	TMDL required
Tijuana River	River & Stream	Nutrients & Pathogens	TMDL required
Tijuana River Estuary	Estuary	Nutrients & Pathogens	TMDL required
Warm Springs Creek (Riverside County)	River & Stream	Nutrients & Pathogens	TMDL required

Table 4-11: Water Bodies from 2010 303(d) List Subject to Tier 3 Requirements

REGION NO.	REGION NAME	WATERBODY NAME	COUNTIES	Pollutant Type
1	North Coast	Clam Beach	Humboldt	Pathogen
1	North Coast	Hare Creek Beach	Mendocino	Pathogen
1	North Coast	Luffenholtz Beach	Humboldt	Pathogen
1	North Coast	Moonstone County Park	Humboldt	Pathogen
1	North Coast	Pudding Creek Beach	Mendocino	Pathogen
1	North Coast	Russian River HU, Lower Russian River HA, Guerneville HSA	Sonoma	Pathogen
1	North Coast	Russian River HU, Lower Russian River HA, Guerneville HSA, Green Valley Creek watershed	Sonoma	Pathogen
1	North Coast	Russian River HU, Middle Russian River HA, Geyserville HSA	Mendocino, Sonoma	Pathogen
1	North Coast	Russian River HU, Middle Russian River HA, Laguna de Santa Rosa	Sonoma	Nitrogen & Pathogen
1	North Coast	Russian River HU, Middle Russian River HA, Santa Rosa Creek	Sonoma	Pathogen
1	North Coast	Trinidad State Beach	Humboldt	Pathogen
2	San Francisco Bay	Chicken Ranch Beach	Marin	Pathogen
2	San Francisco Bay	China Camp Beach	Marin	Pathogen
2	San Francisco Bay	Golden Hinde Beach	Marin	Pathogen
2	San Francisco Bay	Hearts Desire Beach	Marin	Pathogen
2	San Francisco Bay	Lagunitas Creek	Marin	Nitrogen & Pathogen
2	San Francisco Bay	Lawsons Landing	Marin	Pathogen
2	San Francisco Bay	Napa River	Napa, Solano	Nitrogen
2	San Francisco Bay	Olema Creek	Marin	Pathogen
2	San Francisco Bay	Pacific Ocean at Fitzgerald Marine Reserve	San Mateo	Pathogen
2	San Francisco Bay	Pacific Ocean at Muir Beach	Marin	Pathogen
2	San Francisco Bay	Pacific Ocean at Pillar Point Beach	San Mateo	Pathogen

Table 4-11: Water Bodies from 2010 303(d) List Subject to Tier 3 Requirements

REGION NO.	REGION NAME	WATERBODY NAME	COUNTIES	Pollutant Type
2	San Francisco Bay	Petaluma River	Marin, Sonoma	Nitrogen & Pathogen
2	San Francisco Bay	Petaluma River (tidal portion)	Marin, Sonoma	Nitrogen & Pathogen
2	San Francisco Bay	San Gregorio Creek	San Mateo	Pathogen
2	San Francisco Bay	Sonoma Creek	Sonoma	Nitrogen
2	San Francisco Bay	Tomales Bay	Marin	Nitrogen
2	San Francisco Bay	Walker Creek	Marin	Nitrogen & Pathogen
3	Central Coast	Atascadero Creek (San Luis Obispo County)	San Luis Obispo	Pathogen
3	Central Coast	Pacific Ocean at Capitola Beach (Santa Cruz County)	Santa Cruz	Pathogen
3	Central Coast	Pacific Ocean at Olde Port Beach (at restrooms)	San Luis Obispo	Pathogen
3	Central Coast	Pacific Ocean at Pismo State Beach (San Luis Obispo County), south of Pismo Pier	San Luis Obispo	Pathogen
3	Central Coast	Pacific Ocean at Point Rincon (mouth of Rincon Cr, Santa Barbara County)	Santa Barbara	Pathogen
3	Central Coast	Pismo Creek	San Luis Obispo	Pathogen
3	Central Coast	Rincon Creek	Santa Barbara, Ventura	Pathogen
3	Central Coast	San Pedro Creek (Santa Barbara County)	Santa Barbara	Pathogen
3	Central Coast	Santa Rita Creek (Monterey County)	Monterey	Nitrogen
3	Central Coast	Valencia Creek	Santa Cruz	Pathogen
4	Los Angeles	Burbank Western Channel	Los Angeles	Pathogen
4	Los Angeles	Canada Larga (Ventura River Watershed)	Ventura	Pathogen
4	Los Angeles	Castlerock Beach	Los Angeles	Pathogen
4	Los Angeles	Coyote Creek	Los Angeles, Orange	Pathogen
4	Los Angeles	Hermosa Beach	Los Angeles	Pathogen
4	Los Angeles	Lake Calabasas	Los Angeles	Nitrogen
4	Los Angeles	Legg Lake	Los Angeles	Nitrogen
4	Los Angeles	McCoy Canyon Creek	Los Angeles	Nitrogen
4	Los Angeles	Point Dume Beach	Los Angeles	Pathogen

Table 4-11: Water Bodies from 2010 303(d) List Subject to Tier 3 Requirements

REGION NO.	REGION NAME	WATERBODY NAME	COUNTIES	Pollutant Type
4	Los Angeles	Rincon Beach	Ventura	Pathogen
4	Los Angeles	San Antonio Creek (Tributary to Ventura River Reach 4)	Ventura	Nitrogen & Pathogen
4	Los Angeles	San Gabriel River Reach 1 (Estuary to Firestone)	Los Angeles	Pathogen
4	Los Angeles	San Gabriel River Reach 2 (Firestone to Whittier Narrows Dam	Los Angeles	Pathogen
4	Los Angeles	San Gabriel River Reach 3 (Whittier Narrows to Ramona)	Los Angeles	Pathogen
4	Los Angeles	San Jose Creek Reach 1 (SG Confluence to Temple St.)	Los Angeles	Pathogen
4	Los Angeles	San Jose Creek Reach 2 (Temple to I-10 at White Ave.)	Los Angeles	Pathogen
4	Los Angeles	Sawpit Creek	Los Angeles	Pathogen
4	Los Angeles	Ventura River Reach 3 (Weldon Canyon to Confl. w/ Coyote Cr)	Ventura	Pathogen
4	Los Angeles	Walnut Creek Wash (Drains from Puddingstone Res)	Los Angeles	Pathogen
4	Los Angeles	Zuma Beach (Westward Beach)	Los Angeles	Pathogen
5	Central Valley	Rattlesnake Creek (at confluence w Mokelumne River, N Fork)	Amador	Pathogen
5	Central Valley	Sullivan Creek (from Phoenix Reservoir to Don Pedro Lake, Tuolumne County)	Tuolumne	Pathogen
5	Central Valley	Wolf Creek (Nevada County)	Nevada, Placer	Pathogen
5	Central Valley	Woods Creek (Tuolumne County)	Tuolumne	Pathogen
6	Lahontan	Eagle Lake (Lassen County)	Lassen	Nitrogen
7	Colorado River	Alamo River	Imperial	Pathogen
7	Colorado River	Coachella Valley Storm Water Channel	Riverside	Pathogen
7	Colorado River	New River (Imperial County)	Imperial	Nitrogen
7	Colorado River	Palo Verde Outfall Drain and Lagoon	Imperial, Riverside	Pathogen
7	Colorado River	Salton Sea	Imperial, Riverside	Nitrogen & Pathogen
8	Santa Ana	Canyon Lake (Railroad Canyon Reservoir)	Riverside	Pathogen
8	Santa Ana	Fulmor, Lake	Riverside	Pathogen
8	Santa Ana	Goldenstar Creek	Riverside	Pathogen
8	Santa Ana	Los Trancos Creek (Crystal Cove Creek)	Orange	Pathogen
8	Santa Ana	Lytle Creek	San Bernardino	Pathogen

Table 4-11: Water Bodies from 2010 303(d) List Subject to Tier 3 Requirements				
REGION NO.	REGION NAME	WATERBODY NAME	COUNTIES	Pollutant Type
8	Santa Ana	Mill Creek Reach 1	San Bernardino	Pathogen
8	Santa Ana	Mill Creek Reach 2	San Bernardino	Pathogen
8	Santa Ana	Morning Canyon Creek	Orange	Pathogen
8	Santa Ana	Mountain Home Creek	San Bernardino	Pathogen
8	Santa Ana	Mountain Home Creek, East Fork	San Bernardino	Pathogen
8	Santa Ana	Silverado Creek	Orange	Pathogen
9	San Diego	Agua Hedionda Creek	San Diego	Nitrogen & Pathogen
9	San Diego	Aliso Creek	Orange	Nitrogen
9	San Diego	Buena Creek	San Diego	Nitrogen
9	San Diego	Escondido Creek	San Diego	Nitrogen & Pathogen
9	San Diego	Hodges, Lake	San Diego	Nitrogen
9	San Diego	Long Canyon Creek (tributary to Murrieta Creek)	Riverside	Pathogen
9	San Diego	Morena Reservoir	San Diego	Nitrogen
9	San Diego	Murray Reservoir	San Diego	Nitrogen
9	San Diego	Otay Reservoir, Lower	San Diego	Nitrogen
9	San Diego	Rainbow Creek	San Diego	Nitrogen
9	San Diego	Redhawk Channel	Riverside	Pathogen
9	San Diego	San Diego River (Lower)	San Diego	Nitrogen
9	San Diego	San Dieguito River	San Diego	Nitrogen & Pathogen
9	San Diego	San Luis Rey River	San Diego	Nitrogen & Pathogen
9	San Diego	San Luis Rey River, Upper (east of Interstate 15)	San Diego	Nitrogen
9	San Diego	Santa Gertrudis Creek	Riverside	Pathogen
9	San Diego	Santa Margarita River (Lower)	San Diego	Nitrogen
9	San Diego	Sweetwater River, Lower (below Sweetwater Reservoir)	San Diego	Pathogen
9	San Diego	Tecolote Creek	San Diego	Nitrogen
9	San Diego	Warm Springs Creek (Riverside County)	Riverside	Nitrogen & Pathogen

Table 4-12: OWTS Discharge Prohibition Areas

	County
Region 1	
The Larkfield Area	Sonoma
Willside Estates Area	Sonoma
Region 2	

Table 4-12: OWTS Discharge Prohibition Areas

	County
Stinson Beach Area	Marin
Glen Ellen Area	Sonoma
Emerald Lake Hills	San Mateo
Oak Knoll Manor	San Mateo
Region 3	
Portions of the City of Nipomo	San Luis Obispo
Portions of the San Lorenzo River Valley	Santa Cruz
Los Osos/Baywood Park Area	San Luis Obispo
Region 4	
Oxnard Forebay	Ventura
Region 5	
Amador City	Amador
Martell Area	Amador
Shasta Dam Area Public Utilities District	Shasta
Vallecito Area	Calaveras
West Point Area	Calaveras
Celeste Subdivision Area	Merced
North San Juan	Nevada
Arnold Area	Calaveras
Contra Costa County Sanitation District No. 15	Contra Costa
Madera County Service Area No. 3, Bass Lake	Madera
Madera County Service Area No. 1, Parksdale	Madera
Coulterville County Service Area No. 1	Mariposa
Midway Community Services District	Merced
Adin Community Services District	Modoc
Fall River Mills, Community Services District	Shasta
Bell Road Community, including Panorama and Pearl	Placer
Nice and Lucerne	Lake
Courtland Sanitation District	Sacramento
Six-Mile Village	Calaveras
Communities of South Lakeshore Assessment District	Lake
Anderson-Cottonwood Irrigation District, Community of Cottonwood	Shasta
Daphnedale Area	Modoc
Chico Urban Area	Butte
Corcoran Fringe Area	Kings
East Porterville Area	Tulare
Home Garden Community Services District	Kings
Kettleman City County Service Area No. 1	Kings
Region 6	
Cady Springs Area	Lassen
Spaulding Tract and Stone-Bengard Subdivisions	Lassen
Truckee River Hydrologic Unit above Boca River confluence	Placer
Glenshire and Devonshire Subdivisions	Placer
Rush Creek above Grant Lake	Mono
Mammoth Creek watershed	Mono
Assessment District No. 1	Inyo
Assessment District No. 2	Inyo
Rocking K Subdivision	Inyo
City of Bishop	Inyo
Hilton Creek/Crowley Lake Communities	Mono
Silverwood Lake	San Bernardino
Deep Creek and Grass Valley Creek watersheds above 3,200 feet	San Bernardino
Desert Knolls Community	San Bernardino
Region 7	

Table 4-12: OWTS Discharge Prohibition Areas

	County
Cathedral City	
Mission Creek or Desert Hot Springs Aquifers	
Region 8	
Grand Terrace (CSD 70, Improvement Zone H)	
Yucaipa – Calimesa (Yucaipa Valley County Water District)	
Lytle Creek (above 2,00 foot elevation)	
Mill Creek (above 2,600 foot elevation)	
Bear Valley (includes the Baldwin Lake drainage area)	
Homeland-Green Acres	Riverside
Romoland	Riverside
Quail Valley	Riverside