California's Groundwater Update 2013

A Compilation of Enhanced Content for California Water Plan Update 2013

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State of California
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NORTH COAST HYDROLOGIC REGION

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Acronyms and Abbreviations Used in This Chapter

AB	Assembly Bill
ACWA	Association of California Water Agencies
af	acre-feet
af/yr.	acre-feet per year
AWMP	agricultural water management plan
bgs	below ground surface
BMO	basin management objective
CASGEM	California Statewide Groundwater Elevation Monitoring
CDPH	California Department of Public Health
CWP	California Water Plan
CWS	community water system
DAU	detailed analysis unit
DPR	California Department of Pesticide Regulation
DWR	California Department of Water Resources
DWSAP	Drinking Water Source Assessment and Protection Program
EPA	U.S. Environmental Protection Agency
GAMA	Groundwater Ambient Monitoring and Assessment
gpm	gallons per minute
GPS	global positioning system
GWMP	groundwater management plan
HAL	health advisory level
IRWM	integrated regional water management

KWAPA	Klamath Water and Power Agency
LLNL	Lawrence Livermore National Laboratory
maf	million acre-feet
MCL	maximum contaminant level
MTBE	methyl tertiary butyl ether
NL	notification level
North Coast region	North Coast Hydrologic Region
PA	planning area
PCE	perchloroethylene
RWMG	regional water management groups
RWQCB	regional water quality control board
SB	Senate Bill
SB X7-6	2009 Comprehensive Water Package legislation
SB X7-7	Water Conservation Bill of 2009
SCWA	Sonoma County Water Agency
SMCL	secondary maximum contaminant level
SWN	State Well Number
SWRCB	State Water Resources Control Board
taf	thousand acre-feet
TDS	total dissolved solids
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geological Survey
UWMP	urban water management plan

Chapter 3. North Coast Hydrologic Region Groundwater Update

Introduction

The primary goal of the North Coast Hydrologic Region (North Coast region) groundwater update is to expand information about region-specific groundwater conditions for *California Water Plan Update 2013*, and to guide more informed groundwater management actions and policies. A second goal is to steadily improve the quality of groundwater information in future California Water Plan (CWP) updates to a level that will enable regional water management groups (RWMGs) to accurately evaluate their groundwater resources and implement management strategies that can meet local and regional water resource objectives in the context of broader statewide objectives. The final goal is to identify data gaps and groundwater management challenges that will guide prioritizing of future data collection and funding opportunities relevant to the region.

This regional groundwater update is not intended to provide a comprehensive and detailed examination of local groundwater conditions, or be a substitute for local studies and analysis. Nonetheless, where information is readily available, this update does report some aspects of the regional groundwater conditions in greater detail.

The North Coast region, shown in Figure 3-1, is a diverse region covering 19,400 square miles and includes all or portions of 13 predominantly rural Northern California counties. The North Coast region covers all of Del Norte, Trinity, Humboldt, and Mendocino counties, major portions of Modoc, Siskiyou, and Sonoma counties, and minor portions of Glenn, Lake, and Marin counties. Also within the region's boundaries are small areas of Tehama, Colusa, and Shasta counties. Information from the 2010 census indicates a population of approximately 670,000, with more than half of the population (370,000) residing in Sonoma County.

The region includes the Pacific Ocean coastline from Tomales Bay to Oregon. Moving eastward, the North Coast region extends along the California-Oregon border to the Goose Lake Basin. The region includes the Klamath River Basin and the North Coastal Basin, as well as three of the state's 18 national forests. The Klamath River Basin has four major tributaries to the Klamath River: the Shasta, Scott, Salmon, and Trinity rivers. The North Coastal Basin includes the Eel River and its tributaries, which comprise the third largest river system in California. The region also includes the Smith, Russian, Trinity, Mad, and Mattole river systems.

The majority of the North Coast region is mountainous and rugged. Significant geographic features include the Coast Ranges, the Klamath Mountains, the Modoc Plateau, Mount Shasta, the Northern California coastline, and the Santa Rosa Plain. Mountain peaks average about 6,000 feet, with some peaks having elevations higher than 8,000 feet. The topography, geology, hydrology, and land-use practices are highly variable, as are the various associated approaches to water resource management.

Figure 3-1 North Coast Hydrologic Region

The North Coast region is characterized by distinct temperature zones. Along the coast, the climate is moderate and foggy with temperatures ranging in the mid-80s in the summer to mid-30s during the winter. Inland regions of Siskiyou and Modoc counties have a more Mediterranean climate, with summer highs reaching 100 degrees and winters often dropping below freezing.

Precipitation over the North Coast region is greater than for all other areas of California. The annual precipitation in the North Coast region is highly variable, ranging from 100 inches in the Smith River drainage to 29 inches in the Santa Rosa area and about 10 inches in the Klamath Drainage District.

The groundwater update for the North Coast region provides an overview and assessment of the region's groundwater supply and development, groundwater use, monitoring efforts, aquifer conditions, and various management activities. It also identifies challenges and opportunities associated with sustainable groundwater management. The regional update starts with a summary of findings, examines groundwater data gaps, and makes recommendations to further improve the overall sustainability of groundwater resources. This is followed by a comprehensive overview of the relevant groundwater topics.

Findings, Data Gaps, and Recommendations

The following information is specific to the North Coast region and summarizes the findings, data gaps, and recommendations.

Findings

The bulleted items presented in this section are adopted from more comprehensive information presented in this chapter and generally reflect information that was readily available through August 2012. Much of the groundwater information, including well infrastructure discussions, water supply analysis, and groundwater management plan (GWMP) reviews, is new to this update of the CWP. The groundwater data presented in this document will be used as the foundation for the next update of California Department of Water Resources (DWR) Bulletin 118 and the CWP, with the goal of generating information that can be used to make informed decisions to sustainably manage California's groundwater resources. The following information highlights the groundwater findings for the North Coast region.

Groundwater Supply and Development

- The North Coast region contains 63 alluvial groundwater basins and subbasins recognized by DWR Bulletin 118-2003. Those groundwater basins and subbasins underlie approximately 1,600 square miles, or 8 percent, of the hydrologic region (Figure 3-2 and Table 3-1).
- Based on DWR well-log records, the number of wells completed in the North Coast region between 1977 and 2010 is approximately 34,955 and ranges from a high of 15,833 wells for Sonoma County to a low of 1,270 wells for Del Norte County (Figure 3-3 and Table 3-2).
- Based on the California Statewide Groundwater Elevation Monitoring (CASGEM) Basin Prioritization completed in December 2013, no groundwater basins in the North Coast region are identified as high priority, eight groundwater basins are identified as medium priority, two groundwater basins are listed as low priority, and 53 groundwater basins are listed as very low priority. The eight groundwater basins designated as medium priority include 79 percent of the annual groundwater use, and 62 percent of the 2010 population living within the region's groundwater basin boundaries (Figure 3-6 and Table 3-3).

Groundwater Use and Aquifer Conditions

- The 2005-2010 average annual total water supply for the North Coast region, based on planning area boundaries, is estimated at 1.1 million acre-feet (maf). Water demands in the region are met through a combination of local surface water diversions, reservoir storage, groundwater, and reuse/recycled water supplies (Figure 3-7).
- Groundwater contributes about 32 percent (364 thousand acre-feet [taf]) of the 2005-2010 average annual total water supply for the North Coast region (Figure 3-7).
- Groundwater supplies, based on average annual estimates for 2005-2010, contribute 41 percent of the supply to meet the total agricultural water uses, 41 percent of the supply to meet total urban uses, and approximately 1 percent of the supply to meet the total managed wetlands uses in the North Coast region (Table 3-4).
- Between 2002 and 2010, annual groundwater use in the North Coast region ranged between 939 taf (in 2005) and 1.2 maf (in 2006) and contributed between 31 percent and 34 percent toward the annual water supply (Figure 3-8).
- Of the groundwater pumped on an annual basis between 2002 and 2010, between 78 percent and 85 percent of the groundwater was used for agricultural purposes (Figure 3-9).

Groundwater Monitoring Efforts

- One hundred ninety-four wells are actively monitored for groundwater-level information in the North Coast region (Figure 3-10 and Table 3-7).
- There are an estimated 260 community water systems (CWSs) in the North Coast region, with an estimated 416 active CWS wells. Twenty-one of the CWS wells (5 percent) are identified as being affected by one or more chemical contaminants that exceed a maximum contaminant level (MCL). The affected wells are used by 15 CWSs in the region, and 11 of the 15 affected CWSs serve small communities. The most prevalent groundwater contaminant affecting community drinking water wells in the region is arsenic (Tables 3-10, 3-11 and 3-12).
- Most groundwater basins along the coastal portion of the North Coast region have limited risk for land subsidence resulting from groundwater withdrawal. Consequently, no land subsidence monitoring efforts are known to exist along the coastal portion of the North Coast region. Recent increases in groundwater withdrawals for some inland groundwater basins have resulted in the installation of land subsidence monitoring programs. One of these programs is in the Tule Lake Groundwater Subbasin.

Groundwater Management and Conjunctive Management

- There are four GWMPs in the North Coast region that collectively cover less than 1 percent of the region, approximately 0.36 percent of the Bulletin 118-2003 alluvial groundwater basin area, and about 0.45 percent of the overall region.
- The DWR assessment of GWMPs in the North Coast region determined that all four of the GWMPs have been developed or updated to include the legislative requirements of Senate Bill (SB) 1938 and are considered "active" for the purposes of the GWMP assessment. None of the GWMPs in the region address all of the required components identified in California Water Code Section 10753.7 (Figure 3-12 and Table 3-14).
- There are no active conjunctive management or groundwater recharge programs in the North Coast region.

Data Gaps

Gaps in groundwater information are separated into the following three categories: data collection and analysis, groundwater basin assessments, and sustainable management. Where possible, the discussion of data gaps is specific to the North Coast region. Many of the identified gaps are applicable to several or all hydrologic regions in California. Addressing these data gaps, at both the local level and State-agency level, will help ensure that groundwater resources throughout California are better characterized and sustainably managed.

Data Collection and Analysis

Although the general characterization of some alluvial aquifer systems in the North Coast region is satisfactory, there is a need to further improve the characterization of many of the region's aquifers, especially those aquifers that serve disadvantaged communities. More data is always necessary to better understand basin-wide and region-wide groundwater levels, groundwater quality, groundwater use, and the interaction between surface water and groundwater.

Information related to groundwater extraction, groundwater use, managed and natural recharge, and groundwater basin budgets in the North Coast region is extremely limited. Much of the related information has been estimated primarily through water supply balance and land-use information derived from DWR's land-use surveys. Little or no information is known, or is publically available, about the fractured-bedrock aquifers in the North Coast region and how they interact with the region's alluvial aquifer systems.

Some local water agencies in the North Coast region are collecting appropriate groundwater data, conducting necessary analyses, and are sustainably managing their groundwater basins using their existing authorities. Much of the locally collected and analyzed data, which could be used by RWMGs and State agencies to better characterize the groundwater basins in the North Coast region, are generally not readily available.

Groundwater Basin Assessments

Region-wide depth-to-groundwater information and annual estimates of change in groundwater in storage are not well understood for most of the groundwater basins in the North Coast region. One exception is the Tule Lake Groundwater Subbasin where monthly groundwater levels have been measured and groundwater withdrawal has been estimated yearly since 2001.

Cleanup of shallow groundwater contamination is a high priority in the North Coast region. The region is predominately rural and, for that reason, many people rely on shallow wells for their drinking water. Some water quality investigations have occurred in the North Coast region, but no region-wide domestic well studies have been conducted.

Most groundwater basins along the coastal portion of the North Coast region have a limited risk for land subsidence resulting from groundwater withdrawal. Outside of the Tule Lake Groundwater Subbasin, monitoring and analysis of land subsidence is not conducted.

There were no groundwater recharge or conjunctive use projects identified in the North Coast region as part of the statewide conjunctive management survey, but some projects may be in the planning or feasibility stage. The survey, conducted as part of *California Water Plan Update 2013,* was unable to collect comprehensive information about many statewide programs. As a result, a general understanding of the effectiveness of the State's groundwater recharge and conjunctive management programs could not be determined. In addition, it is unknown whether local agencies have complied with the groundwater recharge mapping requirements of Assembly Bill (AB) 359, which went into effect on January 1, 2013.

Sustainable Management

The four active GWMPs in the North Coast region that meet some or all of the SB 1938 groundwater management requirements cover 0.36 percent of the alluvial groundwater basin area. A key gap to implementing sustainable groundwater management practices at the local level is the limited authority of some agencies to assess management fees, restrict groundwater extraction, and regulate land use in groundwater-short areas.

Recommendations

While much information is known about some of the groundwater basins in the North Coast region, comprehensive information that could provide a realistic water budget to determine groundwater sustainability in the region is largely unknown. To better characterize and sustainably manage the region's groundwater resources, the following recommendations are made for the North Coast region:

- Increase collection and analysis of groundwater level, groundwater quality, groundwater use, and groundwater extraction data, as well as information regarding the surface-water–groundwater interaction in alluvial aquifers, to a level allowing for development of groundwater budgets, groundwater supply forecasting, and assessment of sustainable groundwater management practices.
- Increase data collection in fractured-bedrock aquifers to determine the degree of interaction that the upland areas have with the region's alluvial aquifers.
- Establish land subsidence monitoring in areas of high groundwater use to quantify the potential permanent loss of groundwater storage throughout the region that has been caused by excessive local groundwater pumping.
- Continue to monitor groundwater quality throughout the region to better determine sources of natural and anthropogenic contamination, and comply with all groundwater quality protection strategies recommended by the North Coast Regional Water Quality Control Board.
- Update all existing GWMPs to meet the standards set forth in California Water Code Section 10750 et seq., and ensure that GWMPs are prepared for all medium-priority groundwater basins as identified by the CASGEM Basin Prioritization process.
- Determine the extent and effectiveness of the groundwater recharge and conjunctive management programs in the North Coast region by DWR working with local water managers to complete the conjunctive management survey information, and ensure that the groundwater recharge mapping requirements of AB 359 are met.
- Ensure local agency goals, actions, and plans for sustainable groundwater management are compatible with a minimum set of goals and actions established by the overlying integrated regional water management (IRWM) plan.

- Provide local and regional agencies the authority to assess fees, limit groundwater extraction, and restrict land use in groundwater-short areas as needed to better establish a path toward sustainable groundwater management.
- Develop annual groundwater management reports that summarize groundwater management goals, objectives, and performances measures; current and projected trends for groundwater extraction; groundwater levels; groundwater quality; land subsidence; and surface-water–groundwater interaction. Annual reports should evaluate how existing groundwater management practices contribute toward sustainable groundwater management. They should also identify proposed actions for improvements.

Groundwater Supply and Development

This section provides an overview of the key aquifer systems that contribute groundwater to the regional supply, the well infrastructure used to develop these supplies, and an introduction to groundwater basin prioritization for the region.

Groundwater resources in the North Coast region are supplied by both alluvial aquifers and by fractured-rock aquifers. Alluvial aquifers are comprised of sand and gravel or finer-grained sediments, with groundwater stored within the voids or pore space among the alluvial sediments. Fractured-rock aquifers consist of impermeable metamorphic, volcanic, and hard sedimentary rocks, with groundwater stored within cracks, fractures, or other void spaces. The distribution and extent of the alluvial and fractured-rock aquifers, and the location of well development, varies significantly in the North Coast region. A brief description of the alluvial and fractured-rock aquifers for the region is provided in the following paragraphs. Additional information regarding alluvial and fractured-rock aquifers is available online from DWR Bulletin 118-2003 (http://water.ca.gov/groundwater/bulletin118/index.cfm).

Alluvial Aquifers

The North Coast region contains 63 alluvial groundwater basins and subbasins recognized by DWR Bulletin 118-2003. Those groundwater basins and subbasins underlie approximately 1,600 square miles, or 8 percent, of the hydrologic region. The majority of the groundwater used in the North Coast region is stored in alluvial aquifers. A detailed description of aquifers in this region is beyond the scope of this chapter. This section includes a brief summary of the major groundwater basins and aquifers in the North Coast region. Additional information regarding groundwater basins in this hydrologic region may be obtained online from DWR Bulletin 118-2003 or DWR Bulletin 118 Groundwater Basin Maps and Descriptions. Figure 3-2 shows the locations of the alluvial groundwater basins and subbasins in the region, and Table 3-1 lists the name and number associated with the alluvial groundwater basins and subbasins.

Groundwater extracted by wells located outside of the alluvial groundwater basins is supplied largely from fractured-rock aquifers. In some cases, groundwater stored within a thin overlying layer of alluvial deposits or a thick soil horizon may also contribute to a well's groundwater supply.

Figure 3-2 Alluvial Groundwater Basins and Subbasins in the North Coast Hydrologic Region

Table 3-1 Alluvial Groundwater Basins and Subbasins in the North Coast Hydrologic Region

Basin/Subbasin		Basin Name	Basin/Subbasin		Basin Name
1-1	-	Smith River Plain	1-33	-	Larabee Valley
1-2	-	Klamath River Valley	1-34	-	Dinsmores Town Area
-	1-2.01	Tule Lake	1-35	-	Hyampom Valley
-	1-2.02	Lower Klamath	1-36	-	Hettenshaw Valley
1-3	-	Butte Valley	1-37	-	Cottoneva Creek
1-4	-	Shasta Valley	1-38	-	Lower Laytonville
1-5	-	Scott River Valley	1-39	-	Branscomb Town Area
1-6	-	Hayfork Valley	1-40	-	Ten Mile River Valley
1-7	-	Hoopa Valley	1-41	-	Little Valley
1-8	-	Mad River Valley	1-42	-	Sherwood Valley
-	1-8.01	Mad River Lowland	1-43	-	Williams Valley
-	1-8.02	Dows Prairie School Area	1-44	-	Eden Valley
1-9	-	Eureka Plain	1-45	-	Big River Valley
1-10	-	Eel River Valley	1-46	-	Navarro River Valley
1-11	-	Covelo Round Valley	1-48	-	Gravelly Valley
1-12	-	Laytonville Valley	1-49	-	Annapolis Ohlson Ranch Formation
1-13	-	Little Lake Valley	1-50	-	Knights Valley
1-14	-	Lower Klamath River Valley	1-51	-	Potter Valley
1-15	-	Happy Camp Town Area	1-52	-	Ukiah Valley
1-16	-	Seiad Valley	1-53	-	Sanel Valley
1-17	-	Bray Town Area	1-54	-	Alexander Valley
1-18	-	Red Rock Valley	-	1-54.01	Alexander Area
1-19	-	Anderson Valley	-	1-54.02	Cloverdale Area
1-20	-	Garcia River Valley	1-55	-	Santa Rosa Valley
1-21	-	Fort Bragg Terrace Area	-	1-55.01	Santa Rosa Plain
1-22	-	Fairchild Swamp Valley	-	1-55.02	Healdsburg Area
1-25	-	Prairie Creek Area	-	1-55.03	Rincon Valley
1-26	-	Redwood Creek Area	1-56	-	McDowell Valley
1-27	-	Big Lagoon Area	1-57	-	Bodega Bay Area
1-28	-	Mattole River Valley	1-59	-	Wilson Grove Formation Highlands
1-29	-	Honeydew Town Area	1-60	-	Lower Russian River
1-30	-	Pepperwood Town Area	1-61	-	Fort Ross Terrace
1-31	-	Weott Town Area	1-62		Wilson Point Area
1-32	-	Garberville Town Area	-		-

The most heavily used groundwater basin in the North Coast region is the Klamath River Valley Groundwater Basin, which is located in the northeastern portion of the region along the Oregon border in Modoc and Siskiyou counties. Other significant groundwater basins in the region are located in Siskiyou, Humboldt, Sonoma, and Marin counties. As a result of the heavy groundwater use and its impact on the Scott River, the Scott River Valley Groundwater Basin was adjudicated in 1980. The Scott and Shasta Valley Watermaster District is responsible for distributing and monitoring groundwater pumping and surface water diversions according to the court decree.

Klamath River Valley Groundwater Basin

The Klamath River Valley Groundwater Basin (1-2) is the largest groundwater basin in the North Coast region, encompassing approximately 159,260 acres. The groundwater basin is bordered on the west by the Mahogany Mountains, on the south by Pliocene-to-Pleistocene volcanics, on the east by the Big Crack fault, and is separated into two groundwater subbasins, the Tule Lake Groundwater Subbasin (1-2.01) and Lower Klamath Groundwater Subbasin (1-2.02), by Sheepy Ridge. The primary alluvial aquifers in the Klamath River Valley Groundwater Basin are the Pliocene-to-Holocene lake deposits. These alluvial deposits consist primarily of sand, silt, and clay sediment. Although these deposits are widespread and hundreds of feet thick, the permeability of the sediments and the associated well yields are generally low. Many domestic and small irrigation wells draw water from permeable zones within these deposits.

Santa Rosa Valley Groundwater Basin

The second largest groundwater basin in the North Coast region is the Santa Rosa Valley Groundwater Basin (1-55) in Sonoma County. The groundwater basin covers approximately 101,000 acres, and is divided into three groundwater subbasins: the Santa Rosa Plain (1-55.01), Healdsburg Area (1-55.02), and Rincon Valley (1-55.03). The groundwater basin extends to the northwest to the edge of the Russian River floodplain, west to the Mendocino Range, south to the hills dividing the Santa Rosa and Petaluma valleys, southeast to the Sonoma Mountains, and northeast to the Mayacamas Mountains.

The Santa Rosa Plain Groundwater Subbasin covers an area of approximately 80,000 acres and is home to approximately half of the population of Sonoma County. The four main geologic units, which form the primary aquifers in the Santa Rosa Plain Groundwater Subbasin, are sedimentary deposits of the Alluvium and Glen Ellen formations, the Wilson Grove Formation (previously described as the Merced Formation), and the Sonoma Volcanics. The groundwater subbasin's best water-producing units are stream channels filled with alluvial sands and gravels, groundwater basin-fill alluvium and alluvial fan deposits that connect the Santa Rosa Plain with its bordering hills, and massive sandstone units of the Wilson Grove Formation. The Sonoma Volcanics, a thick sequence of lava flows present along the eastern boundary of the groundwater basin, produce variable amounts of water. The Petaluma Formation also produces variable amounts of water, but underlies much of the groundwater basin at depth and is important in terms of its extensive distribution and the number of wells producing from it. Groundwater within the Santa Rosa Plain Groundwater Subbasin is generally present under confined conditions, except locally in the vicinity of clay or silt horizons where conditions may be semi-confined or confined.

The Glen Ellen Formation consists of continental deposits of partially cemented gravel, sand, silt, and clay, and also yields modest amounts of water to smaller groundwater wells. The thickness of the formation ranges from approximately 1,500 to 3,000 feet. Permeability of the formation varies greatly by location; data indicates that some wells can produce more than 500 gallons per minute (gpm), but most wells produce less and incur significant drawdowns. The Glen Ellen Formation produces groundwater primarily for domestic well use. This formation is notable because it is composed of continental sediments, rather than marine sediments, like many of the other water-bearing formations in the area.

Wilson Grove Formation Highlands Groundwater Basin

The Wilson Grove Formation Highlands Groundwater Basin (1-59) covers approximately 65,000 acres, and is located in southwestern Sonoma County and northwestern Marin County. The primary groundwater-bearing formation is the marine sedimentary deposits of the Wilson Grove Formation (U.S. Geological Survey 2004). This formation consists of fine-grained sandstone with lenses of conglomerate and shale. The formation underlies most of the groundwater basin and ranges from 300 to 2,000 feet in thickness. It is moderately permeable caused by its high porosity and moderate transmissivity. Well-production data for the area is very limited (U.S. Geological Survey 2004). Sonoma County Water Agency (SCWA), as part of its groundwater monitoring program, estimates that 2,370 water wells have been constructed in the groundwater basin in the last 30 years.

Alexander Valley Groundwater Basin

The Alexander Valley Groundwater Basin (1-54) occupies approximately 31,000 acres that are drained by the Russian River within a structural-controlled valley in northern Sonoma County. The Alexander Valley Groundwater Basin includes both the Cloverdale Area Groundwater Subbasin (1-54.02) in the north and the Alexander Area Groundwater Subbasin (1-54.01) in the south, which are hydraulically connected through thin deposits of alluvial materials beneath the Russian River (U.S. Geological Survey 2006). Primary water-bearing units include the Quaternary alluvial deposits, the Glen Ellen Formation, and the Sonoma Volcanics. Groundwater recharge within the groundwater basin primarily originates from the infiltration of precipitation and seepage from the Russian River and its tributaries.

Eel River Valley Groundwater Basin

The Eel River Valley Groundwater Basin (1-10) is in Humboldt County, approximately two-thirds of the way up the coast from Sonoma and Marin counties toward the Oregon border. The groundwater basin includes the lower 8 miles of the Van Duzen River Valley and the Eel River Valley, and is bound by the Little Salmon fault on the north, the Wildcat Formation geologic series on the east, and the Carlotta Formation on the south. The groundwater basin covers approximately 73,700 acres.

The primary groundwater-bearing geologic formation is the Holocene Alluvium, which consists of the gravel, sand, and clay that underlie the floodplain of the Eel River. The deposits in the delta region of the Eel River Valley tend to be thinner and finer, but extensive gravel layers are present farther up the valley. In the delta, the thickness of the alluvium is estimated to be approximately 75 feet, while in the valley portions of the region, the gravel layer can be as thick as 200 feet. Wells constructed to produce water from these gravels can attain specific capacities of 600 gpm per foot of drawdown (California Department of Water Resources 1965).

Butte Valley Groundwater Basin

The Butte Valley Groundwater Basin (1-3) is located in northeastern Siskiyou County near the Oregon border. The groundwater basin encompasses approximately 79,700 acres and is bound on the east by the Mahogany Mountains, on the southeast by Sheep Mountain and Red Rock Valley, and on the north, south, and west by the Cascade Mountains. Well-yield data from well-driller reports indicate that groundwater production in the Butte Valley Groundwater Basin varies between 200 gpm and 5,000 gpm, with an average yield of 2,350 gpm.

The primary alluvial groundwater-bearing formations in Butte Valley are the Pleistocene-to-Holocene alluvial-fan deposits and lake deposits. The alluvial fan deposits are composed of poorly sorted volcanic rock debris, cobbles, gravel, sand, and clay from the Cascade Range and are found on the west side of the valley. These deposits generally have low permeability, except where gravel lenses are encountered, and yield small quantities of water to wells. The thickness of these deposits can range as much as 350 feet. The Pleistocene-to-Holocene lake deposits consist of sand, silt, clay, lenses of diatomaceous clay, and local stringers of gravelly sand. In areas where the lake deposits are composed of fine-grained silts and clays, permeability is very low. Coarser layers in the western and northwestern part of the groundwater basin generally yield sufficient water for stock wells.

Shasta Valley Groundwater Basin

The Shasta Valley Groundwater Basin (1-4) is located in central Siskiyou County and encompasses approximately 52,640 acres. The groundwater basin is bound on the west by the Klamath Mountains and on the east by debris flow from ancestral Mount Shasta. Well-yield data from well-driller reports indicate that groundwater production in the Shasta Valley Groundwater Basin varies between 2 gpm and 1,200 gpm, with an average yield of 275 gpm.

The primary groundwater-bearing formation in the Shasta Valley Groundwater Basin is Quaternary alluvium. The alluvium consists of beds of gravel, sand, silt, and clay and underlies most of the valley. The thickness of the alluvium ranges as much as 140 feet. Groundwater data indicates that the entire groundwater basin, including surrounding formations such as the Pluto’s Cave Basalt, volcanic rocks of the western Cascade Mountains, and ancestral Mount Shasta debris flow, are hydrologically connected. The productivity of the alluvial deposits varies greatly within the groundwater basin, with well yields ranging from 150 gpm to 1,000 gpm. Most wells producing groundwater from the alluvium throughout the valley are used for domestic and stock water. The majority of the irrigation wells utilizing this formation are on the western margin of the valley.

Scott River Groundwater Basin

The Scott River Valley Groundwater Basin (1-5) is located in southwestern Siskiyou County and covers approximately 63,900 acres. The groundwater basin is bound on the north and northwest by the Scott Bar Mountains, on the south and southeast by the Scott Mountains, and on the east by a northern extension of the Trinity Mountains. Well-yield data from well-driller reports indicate that groundwater production in the Scott River Valley Groundwater Basin varies between 30 gpm and 3,000 gpm, with an average yield of 800 gpm.

The primary groundwater-bearing formations in the Scott River Valley are the stream channel deposits, floodplain deposits, and alluvial fan deposits. The stream channel and floodplain deposits consist of layered gravel, sand, and clay deposited by the Scott River and its tributaries. The productivity of these deposits varies greatly within the groundwater basin. Data indicates that the greatest production is most often found along the east side of the valley between Etna and Fort Jones. Wells in other areas may only produce sufficient quantities for domestic uses. The formations range in thickness as much as 260 feet or more. Larger irrigation wells is this area often produce 1,200 gpm to 2,500 gpm. The alluvial fan deposits consist of sandy clay with some intermixed boulders that were deposited by the Scott River tributaries on the west side of the valley. The most productive areas within this formation are large gravelly fans deposited by West Patterson, Kidder, Etna, and Shackleford creeks. Little production data is available for wells constructed specifically in these deposits. The highly recognized interconnection between surface water and groundwater resources in Scott River Valley resulted from the 1980 adjudication for both surface water and groundwater.

Fractured-Rock Aquifers

Groundwater supply in the North Coast region is also found in the fractured-rock aquifers in the foothill and mountain regions adjacent to the many alluvial groundwater basins. Groundwater from fractured-rock aquifers tends to supply individual domestic and stock wells, or small CWSs. Fractured-rock aquifers, and the wells they supply, tend to have less capacity and reliability than the alluvial aquifers wells. Nonetheless, localized fractured-volcanic deposits of basalt and pyroclastic rocks within the Klamath, Butte, and Shasta Valley groundwater basins tend to form some of the most highly productive fractured-rock aquifers in California.

Klamath River Valley Groundwater Basin

The two major fractured-rock aquifers in the Klamath River Valley are the Pleistocene Intermediate Basalt and the Miocene-to-Pliocene Lower Basalt. The Pleistocene Intermediate Basalt aquifer is comprised of a series of thin-bedded basalt flows, which originated south of the groundwater basin and flowed northward. As a result, basalt outcrops form the southern boundary of the groundwater basin in many locations, and the layers of the basalt tend to be interfingered with the lakebed deposits to the north. Fracturing of the basalt appears to be extensive, resulting in high permeability and high well yield in most locations. It is common for properly constructed wells to produce between 2,000 gpm and 4,000 gpm.

Fractured and jointed lower basalt deposits of Miocene-to-Pliocene age underlie the lake deposits in most locations throughout the groundwater basin. The depth of the lower-basalt deposits in the Tule Lake Groundwater Subbasin area varies as a result of faulting. It ranges from several hundred feet near the edges of the groundwater basin, to more than 1,200 feet in the center of the groundwater basin. Wells constructed as part of the 2001 Emergency Well Drilling Program in the Tule Lake Groundwater Subbasin produce groundwater primarily from the fractured-rock aquifer within the lower basalt at rates from 6,000 gpm to 12,000 gpm. Regardless, groundwater elevation data collected from these wells indicate that recharge rates within the groundwater basin are slow. Spring groundwater elevations do not necessarily indicate significant recharge has taken place even after years of limited pumping and normal precipitation.

Butte Valley Groundwater Basin

The primary groundwater-bearing formations in the Butte Valley Groundwater Basin are the Butte Valley Basalt, the Holocene and Pleistocene Pyroclastic Rocks, and the High Cascade Volcanics. The Butte Valley Basalt is highly permeable, fractured, and vesicular basalt located primarily in the southern and southeastern portions of the Butte Valley Groundwater Basin. The basalt occurs at depths of generally less than 150 feet below ground surface (bgs) in the valley. It averages about 40 feet thick, and can be as much as 80 feet thick in places. The Butte Valley Basalt yields large amounts of groundwater to wells, but a study completed in the early 1980s determined that this aquifer was already developed to it maximum productivity (U.S. Bureau of Reclamation 1980).

The Holocene and Pleistocene Pyroclastic Rocks consist of generally well-consolidated tuffs and tuff breccias with great variability in permeability and porosity. The deposits are as much as 400 feet thick and are found east and southeast of Macdoel. Well yields vary greatly because of the variable nature of the formation, but it is developed extensively for stock supply wells. The High Cascades Volcanics consist of successive layers of basalt, tuff, tuff breccia, and cinder-cone deposits. This highly fractured and permeable formation forms the boundaries on the western, northern, and eastern extents of the groundwater basin. The units generally range in thickness between 10 and 50 feet, but can be as thick as 100 feet in some locations. Well yields vary within the groundwater basin because of the variable nature of the formation. Wells constructed to produce water from highly productive aquifer zones within this formation commonly produce more than 3,000 gpm.

Shasta Valley Groundwater Basin

In Shasta Valley, the Pluto's Cave Basalt is a highly productive and locally valuable fractured-rock aquifer. The Holocene-age Pluto's Cave Basalt is a highly vesicular and fractured-basalt complex that covers about 32,000 acres in the southeastern part of the valley (California Department of Water Resources 2003). Williams (1949) describes the formation as a series of overlapping flow units ranging in thickness from about 10 to 30 feet. During flow events, clinkery surfaces, which are rough rubbly surfaces composed of broken lava blocks formed at the contact between successive flows, produce what drillers refer to as "cinders." These surfaces, together with cooling fractures and lava tubes, serve as conduits for transmitting large volumes of groundwater. The total thickness of the flow ranges from more than 500 feet in the south to 50 feet or less in the north (Goosenest Ranger District 1997; Peninsula Geological Society 2001).

Groundwater from fractures and local lava tubes provides a significant source of water to wells and springs for irrigation and domestic uses. Big Springs, Hole in the Ground Spring, and several unnamed springs arise from the contact between Pluto's Cave Basalt and deposits of the debris avalanche. Groundwater discharge to the Shasta River from the Pluto's Cave Basalt aquifer is the primary source of cold water inflow to the river during summer months and relatively warmer water in winter months (California Department of Water Resources 2011).

DWR Bulletin 118-2003 identified the average well yield in the Pluto's Cave Basalt aquifer at 1,300 gpm, with yields up to 4,000 gpm being recorded. A more recent review of 142 well-driller logs indicated an average well yield of about 350 gpm and a maximum yield of about 1,400 gpm (California Department of Water Resources 2011).

Well Infrastructure

A key aspect to understanding the region's groundwater supply and development is identifying the age, distribution, and type of wells that have been drilled in a region. A valuable source of well information is the well completion reports, or well logs, submitted by licensed well drillers to the landowner, the local county Department of Environmental Health, and DWR. Among other things, well logs commonly identify well location, construction details, borehole geology data, installation date, and type of well use.

Well drillers have been required by law to submit well logs to the State since 1949. California Water Code Section 13751 requires drillers that construct, alter, abandon, or destroy a well, to submit a well log to DWR within 60 days of the completed work. Well logs submitted to DWR for wells completed from 1977 to 2010 were used to evaluate the distribution and the uses of groundwater wells in the region. DWR does not have well logs for all the wells completed in the region. For some well logs, information regarding well location or use is inaccurate, incomplete, ambiguous, or missing. Consequently, some well logs could not be used in the evaluation. Even so, for a regional scale evaluation of well installation and distribution, the quality of the data is considered adequate and informative. Additional information regarding assumptions and methods of reporting well-log information to DWR is in Appendix A.

The number and distribution of wells in the North Coast region are grouped according to their location by county and according to the six most common well-use types: domestic, irrigation, public supply, industrial, monitoring, and other. Public supply wells include all wells identified on the well completion report as municipal or public. Wells identified as "other" include a combination of the less common well types, such as, stock wells, test wells, or unidentified wells (no information listed on the well log).

Six counties were included in the analysis of well infrastructure for the North Coast region. Del Norte, Humboldt, Trinity, and Mendocino counties are fully contained with the North Coast region, while Siskiyou and Sonoma counties are partially in the region. Well-log data for counties that fall in multiple hydrologic regions were assigned to the region containing the majority of alluvial groundwater basins within the county. Well information for Modoc, Lake, and Glenn counties are included in the statistics for the Sacramento River Hydrologic Region, and well information for Marin County is included in the statistics for the San Francisco Bay Hydrologic Region.

Table 3-2 lists the number of well logs received by DWR for wells drilled in the North Coast region from 1977 to 2010. Figures 3-3 and 3-4 provide an illustration of these data according to well use for each county and for the region as a whole.

The total number of wells installed in the North Coast region between 1977 and 2010 is approximately 34,955, and ranges from a high of 15,833 wells for Sonoma County to a low of 1,270 wells for Del Norte County. The three counties having the highest number of domestic wells on file are Sonoma, Mendocino, and Siskiyou counties, with well counts of 10,750 domestic wells, 5,771 wells, and 5,120 wells, respectively. Counties with the most irrigation wells on file include Sonoma, Siskiyou, and Mendocino counties, with well counts of 1,215 irrigation wells, 445 wells, and 157 wells, respectively.

Table 3-2 Number of Well Logs, According to Well Use and County, for the North Coast Hydrologic Region (1977-2010)

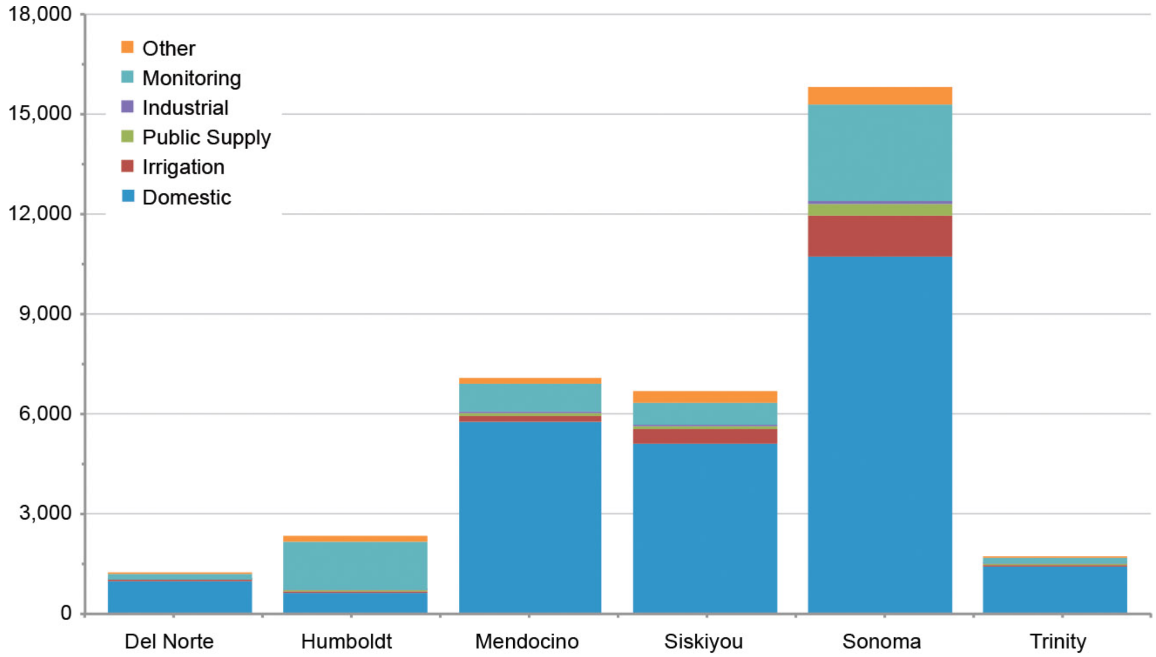
County	Total Number of Well Logs According to Well Use						Total Well Records
	Domestic	Irrigation	Public Supply	Industrial	Monitoring	Other	
Del Norte	980	30	20	5	178	57	1,270
Humboldt	647	29	51	7	1,421	189	2,344
Mendocino	5,771	157	119	20	852	163	7,082
Siskiyou	5,120	445	86	20	663	358	6,692
Sonoma	10,750	1,215	366	95	2,878	529	15,833
Trinity	1,442	23	47	3	163	56	1,734
Total Well Records	**24,710**	**1,899**	**689**	**150**	**6,155**	**1,352**	**34,955**

In most counties in the North Coast region, domestic wells make up the majority of well logs on file at DWR. The exception for the North Coast region is Humboldt County, which has a higher percentage of monitoring wells — almost 61 percent of the wells in Humboldt County are identified as monitoring wells. Statewide, monitoring wells comprise about 24 percent of the total number of wells in California. High percentages of monitoring wells, compared with other well types, could indicate increased groundwater quality monitoring for characterization of areas with affected groundwater quality.

Figure 3-4 displays the percentages of wells, by well use, for the overall North Coast region between 1977 and 2010. Figure 3-4 shows that domestic wells in the North Coast region is about 71 percent of the total number of wells, while the number of irrigation wells comprises about 5 percent. Comparatively, the statewide distribution of domestic and irrigation wells is 54 percent and 10 percent, respectively. A higher percentage of domestic wells and lower percentage of irrigation wells reinforces that the North Coast region is a more rural domestic setting and has a reduced use of groundwater for irrigation. Nonetheless, irrigation wells typically have a higher capacity than domestic wells. In Sonoma County, for example, agricultural irrigation is the largest use of groundwater in many groundwater basins, although there are more individual domestic wells than irrigation wells. Region-wide, monitoring wells make up about 18 percent of the wells, public supply wells account for about 2 percent of the wells, and industrial wells comprise less than 0.05 percent.

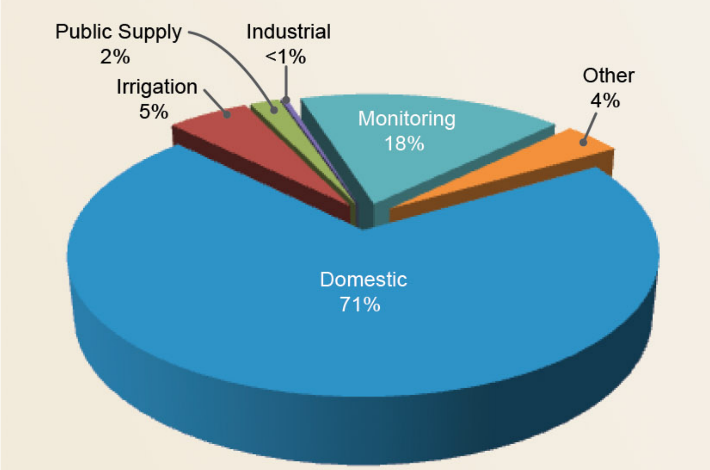
In addition to analyzing the number of wells by location and use, well logs were analyzed by well installation date (Figure 3-5). Evaluating the number and types of wells completed over time can help offer a perspective on the average age of the existing infrastructure and the general pattern of wells installed during various water years and economic cycles. Well-log records for the 2007 through 2010 period are known to be less complete because of constraints associated with processing and incorporating the data.

Figure 3-3 Number of Well Logs, According to Well Use and County, for the North Coast Hydrologic Region (1977-2010)



Prepared by California Department of Water Resources for California's Groundwater Update 2013

Figure 3-4 Percentage of Well Logs by Type of Use for the North Coast Hydrologic Region (1977-2010)



North Coast Well Logs Summary by Well Type

Well Type	Number of Well Logs
Domestic	24,710
Irrigation	1,899
Public Supply	689
Industrial	150
Monitoring	6,155
Other	1,352
Total	**34,955**

Prepared by California Department of Water Resources for California's Groundwater Update 2013

Figure 3-5 Number of Well Logs per Year, by Well Use, for the North Coast Hydrologic Region (1977-2010)

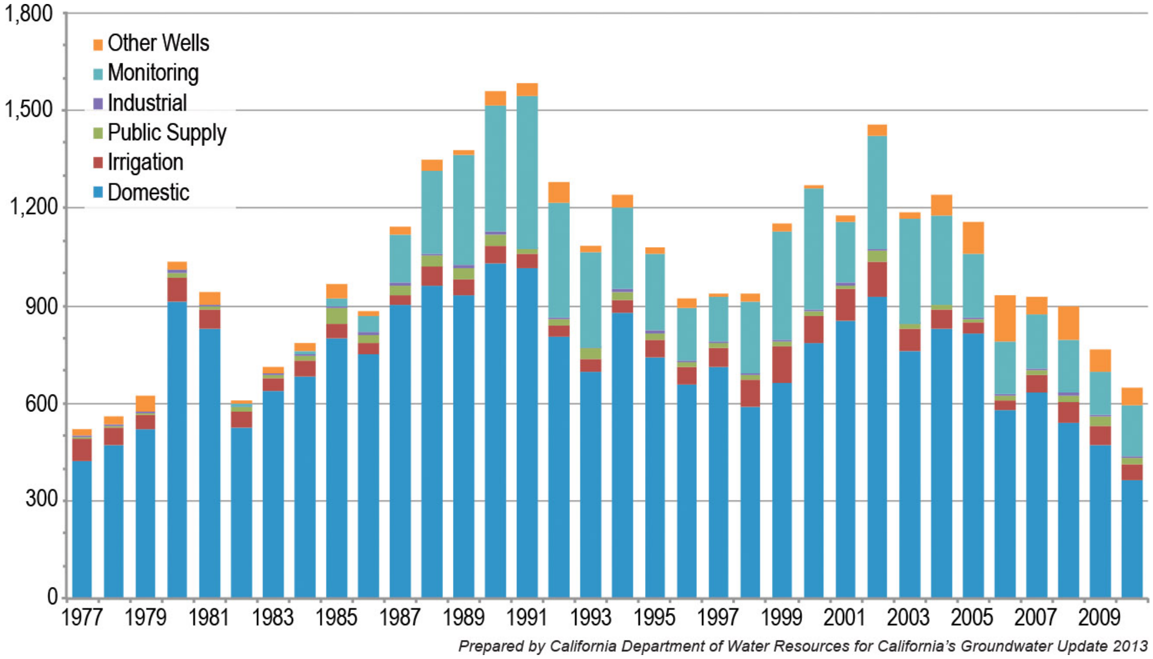


Figure 3-5 shows a cyclic pattern of well installations for the North Coast region, with new well construction ranging from 523 wells per year in 1977 to 1,586 wells per year in 1991, with an average of 1,028 wells per year during the period of record. Multiple factors are known to affect the annual number and type of wells drilled. Some of these factors include the annual variations in climate, economy, agricultural cropping trends, or alternative water supply availability.

Large fluctuations in domestic well drilling are likely associated with fluctuations in population growth and residential housing construction trends. Figure 3-5 shows an increase in domestic well drilling in the North Coast region during the late 1980s and late 1990s, which is likely attributed to noted increases in housing construction during this time. Similarly, the decline in domestic well drilling in the early 1990s, and from 2007 to 2010, is likely the result of declining economic conditions and the related drop in housing construction.

Irrigation well installation is more closely related to climate conditions, cropping trends, and surface water supply cutbacks. Figure 3-5 shows that the installation of irrigation wells averaged about 50 wells per year up until the late 1990s, and an average of approximately 90 irrigation wells per year were installed from 1998 to 2003. During this time of increased irrigation well installation, the Klamath River Valley Groundwater Basin experienced an extended drought. In the years following this drought, installation of irrigation wells dropped back down to an average rate of about 50 wells per year.

The onset of monitoring well installation in the mid- to late-1980s is likely associated with federal underground storage tank programs signed into law in the mid-1980s. Starting in 1984, the Underground Storage Tank Cleanup Program took effect. The program provided partial reimbursement of expenses associated with the cleanup of leaking underground storage tanks and quickly resulted in an increase in the installation of groundwater quality monitoring wells. Beginning in 1987, changes in regulations also required well drillers to begin submitting well logs for monitoring well installation. Well logs typically do not distinguish between monitoring wells that are installed as part of a groundwater cleanup project, compared with those wells that are installed primarily to collect changes in groundwater levels. Nevertheless, DWR estimates that the majority of monitoring wells were completed for use in environmental assessments relating to leaking underground storage tanks, waste disposal sites, and hazardous chemical spills.

In the North Coast region, the installation of monitoring wells peaked in 1991 at 468 wells, with an average of 323 monitoring wells installed per year from 1988 to 1995. Another period of increased monitoring well installation occurred from 1998 to 2004, averaging 294 wells per year. Since 2004, monitoring well installation in the North Coast region has averaged 162 wells per year.

CASGEM Basin Prioritization

As part of the California's 2009 Comprehensive Water Package legislation (SB X7-6), DWR implemented the CASGEM Program. The SB X7-6 Groundwater Monitoring legislation added Part 2.11 to Division 6 of the California Water Code (Section 10920 et seq.) that established provisions and requirements for local agencies to develop and conduct groundwater-level monitoring programs. The legislation requires DWR to identify the current extent of groundwater elevation monitoring within each of the alluvial groundwater basins defined under Bulletin 118-2003 and to prioritize those basins to help identify, evaluate, and determine the need for additional groundwater-level monitoring. The basin prioritization process (California Water Code Section 10933[b]) directs DWR to consider, to the extent available, the following eight components:

1. The population overlying the basin.
2. The rate of current and projected growth of the population overlying the basin.
3. The number of public supply wells that draw from the basin.
4. The total number of wells that draw from the basin.
5. The irrigated acreage overlying the basin.
6. The degree to which persons overlying the basin rely on groundwater as their primary source of water.
7. Any documented impacts on the groundwater within the basin, including overdraft, subsidence, saline intrusion, and other water quality degradation.
8. Any other information determined to be relevant by the department.

Using groundwater reliance as the leading indicator of basin priority, DWR evaluated California's 515 groundwater basins and categorized them into four prioritization groups: high, medium, low, and very low.

Table 3-3 lists the medium priority CASGEM groundwater basins for the North Coast region and Figure 3-6 identifies these groundwater basins on a map. The final full listing of the CASGEM Groundwater Basin Prioritization is provided in Appendix B. Of the 63 groundwater basins in the North Coast region, none of the groundwater basins were in the high priority ranking. Eight groundwater basins were ranked as medium priority, two were ranked as low priority, and 53 were ranked as very low priority.

Table 3-3 CASGEM Basin Prioritization for Groundwater Basins in the North Coast Hydrologic Region

Basin Prioritization	Count	Basin/Subbasin Number	Basin Name	Subbasin Name	2010 Census Population
High	0	None			
Medium	1	1-4	Shasta Valley	-	5,333
Medium	2	1-55.01	Santa Rosa Valley	Santa Rosa Plain	250,375
Medium	3	1-1	Smith River Plain	-	24,588
Medium	4	1-2.01	Klamath River Valley	Tule Lake	2,261
Medium	5	1-52	Ukiah Valley	-	32,761
Medium	6	1-10	Eel River Valley	-	21,558
Medium	7	1-5	Scott River Valley	-	3,520
Medium	8	1-3	Butte Valley	-	1,464
Low	2	See Appendix B			
Very Low	53	See Appendix B			
Total	**63**	**Population of Groundwater Basin Area:**			**550,630**[a]

Notes:

CASGEM = California Statewide Groundwater Elevation Monitoring Ranking as of December, 2013

Senate Bill X7-6 (SB X7-6; Part 2.11 to Division 6 of the California Water Code Section 10920 et seq.) requires, as part of the CASGEM Program, DWR to prioritize groundwater basins to help identify, evaluate, and determine the need for additional groundwater-level monitoring by considering available data that include the population overlying the basin, the rate of current and projected growth of the population overlying the basin, the number of public supply wells that draw from the basin, the total number of wells that draw from the basin, the irrigated acreage overlying the basin, the degree to which persons overlying the basin rely on groundwater as their primary source of water, any documented impacts on the groundwater within the basin, including overdraft, subsidence, saline intrusion, and other water quality degradation, and any other information determined to be relevant by the DWR."

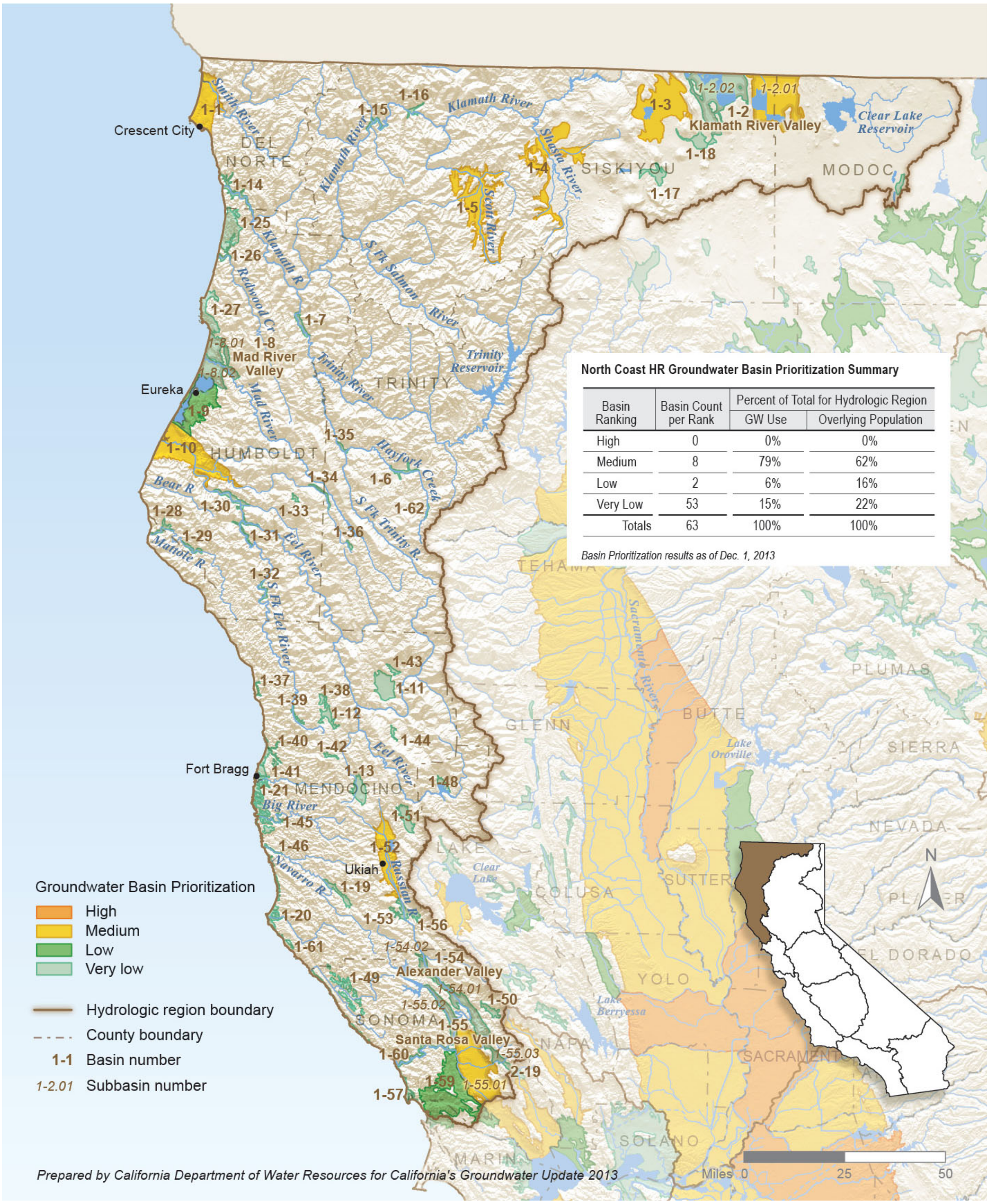
Using groundwater reliance as the leading indicator of basin priority, DWR evaluated California's 515 alluvial groundwater basins and categorized them into four groups: high, medium, low, and very low.

[a]Population of groundwater basin area includes the population of all basins win North Coast Hydrologic Region.

Although the primary intent of basin prioritization is to assist DWR in implementing the CASGEM Basin Prioritization program, which is based on the comprehensive set of data included in the analysis, basin prioritization is also a valuable statewide tool to help evaluate, focus, and align limited resources. Basin prioritization is also an important tool to implement effective groundwater management practices by improving the statewide reliability and sustainability of groundwater resources.

In the North Coast region, implementing sustainable groundwater resource management should focus initially on the eight groundwater basins listed in Table 3-3 as medium priority. The eight groundwater basins designated as medium priority comprise 79 percent of the annual groundwater use for the North Coast region and 62 percent of the 2010 population that overlies the groundwater basin area in the North Coast region.

Figure 3-6 CASGEM Groundwater Basin Prioritization for the North Coast Hydrologic Region



North Coast HR Groundwater Basin Prioritization Summary

Basin Ranking	Basin Count per Rank	Percent of Total for Hydrologic Region: GW Use	Percent of Total for Hydrologic Region: Overlying Population
High	0	0%	0%
Medium	8	79%	62%
Low	2	6%	16%
Very Low	53	15%	22%
Totals	63	100%	100%

Basin Prioritization results as of Dec. 1, 2013

Groundwater Use

The amount and timing of groundwater extraction, along with the location and type of groundwater use, are fundamental components for building a groundwater basin budget and identifying effective options for groundwater management. While some types of groundwater uses are reported for some California groundwater basins, the majority of groundwater users are not required to monitor, meter, or publically record their annual groundwater extraction amount. Groundwater-use estimates for this chapter are based on water supply and balance information derived from DWR land-use surveys, and from groundwater-use information voluntarily provided to DWR by water purveyors or other State agencies.

Groundwater extraction estimates derived from land- and water-use methods typically assume that local surface water supplies are the first to be used to meet local water demands. Once surface water supplies have been fully allocated, if crop demand and water balance information indicates that additional water supplies are needed, groundwater supplies are then applied until the full water use is met and the overall supply and use for the area is balanced. For agricultural areas employing conjunctive management practices, which may involve frequent exchanges between surface water and groundwater supplies, making accurate estimates of annual groundwater extraction by using the land- and water-use method can be challenging.

DWR water supply and balance data are collected and analyzed by hydrologic regions, which largely correspond to watershed boundaries. The land- and water-use data are first compiled and analyzed by detailed analysis units (DAUs). Water supply and balance data for DAUs are then compiled into larger planning areas, hydrologic regions, and then into a statewide water supply and balance estimate. To assist local resource planning, DWR also generates water supply and balance information by county. Although some local groundwater management groups independently develop groundwater extraction estimates for their local groundwater basins, DWR does not currently generate groundwater use information by groundwater basin area.

Water use is reported by water year (October 1 through September 30), and categorized according to urban, agriculture, and managed wetland uses. Reference to *total water supply* for a region represents the sum of surface water supplies, groundwater supplies, and reuse/recycled water supplies. Reuse/recycled water supplies also include desalinated water supplies. Groundwater-use information is presented by planning area, county, and type of use. Additional information regarding water use analysis is provided in Appendix A, "Methods and Assumptions," and in Appendix C, "Groundwater Use Data."

2005-2010 Average Annual Groundwater Supply

Water demands in the North Coast region are highly variable and are met through a combination of local surface water diversions, reservoir storage, groundwater extraction, and reuse or recycled water supplies, with many rural areas relying exclusively on private wells for residential water. Groundwater extraction in the North Coast region accounts for approximately 2 percent of California's 2005-2010 average annual groundwater use, which is estimated at 16,461 taf, although groundwater supplies account for 100 percent of the domestic supply for many rural communities, and is heavily relied upon to meet local agricultural demands.

Groundwater Use by Planning Area Boundaries

The North Coast region includes four planning areas: the Upper Klamath, Lower Klamath, Coastal, and Russian River Planning Areas (PAs). The 2005-2010 average annual total water supply for the North Coast region, assuming planning area boundaries, is estimated at 1,143 taf, with 364 taf (32 percent) of that total supply met by groundwater. Table 3-4 lists the 2005-2010 average annual total water supply met by groundwater, by planning area and by type of use, and by the percentage that groundwater contributes to the total water supply for the region. Table 3-5 identifies the percentage of groundwater use in the North Coast region, according to planning area and type of use. Figure 3-7 shows the planning areas for the region and summarizes the groundwater-use information presented in Table 3-4 and Table 3-5.

Table 3-4 Average Annual Groundwater Supply and Percentage of Total Water Supply, According to Planning Area and Type of Use, for the North Coast Hydrologic Region (2005-2010)

North Coast Hydrologic Region		Agriculture Use Met by Groundwater		Urban Use Met by Groundwater		Managed Wetlands Use Met by Groundwater		Total Water Use Met by Groundwater Use	
PA Number	PA Name	taf	%[a]	taf	%[a]	taf	%[a]	taf	%[a]
101	Upper Klamath	182.6	33%	7.2	65%	2.5	1%	192.3	24%
102	Lower Klamath	8.2	30%	5.9	51%	0.0	0%	14.1	36%
103	Coastal	63.9	77%	18.1	37%	0.0	0%	81.9	62%
104	Russian River	46.7	62%	29.1	38%	0.0	0%	75.8	50%
2005-2010 annual average HR total:		**301.3**	**41%**	**60.3**	**41%**	**2.5**	**1%**	**364.0**	**32%**

Notes:
HR = hydrologic region, PA = planning area, taf = thousand acre-feet
[a]Percentage of use is the percent of the total water supply (groundwater + surface water + reuse) that is met by groundwater.
2005-10 precipitation equals 99% of the 30-yr. average for the North Coast region.
Total water use = groundwater + surface water + reuse

Assuming the planning area boundaries for the North Coast region and the 2005-2010 average annual total water supply estimates, groundwater contributes to 32 percent (364 taf) of the average annual total water supply. Of the 364 taf of groundwater used in the North Coast region, 60 taf is used for urban needs, 301 taf is used for agricultural purposes, and 2.5 taf is used for managed wetlands. Individual planning area information provided in Table 3-4 shows that 62 percent of the overall water needs for the Coastal PA and 50 percent of the overall water needs for the Russian River PA are met by groundwater. Although the Upper Klamath PA relies on groundwater supplies for 24 percent of their overall demand, 65 percent of the urban water supply in the Upper Klamath PA is met by groundwater.

Table 3-5 provides a percentage breakdown of how the 364 taf of North Coast region groundwater supply is used in each planning area. Table 3-5 shows the Upper Klamath PA accounts for 53 percent of the total groundwater use for the region, with 95 percent of that groundwater meeting agricultural demands. The Coastal and Russian River PAs utilize 23 and

21 percent, respectively, of the North Coast region's average annual groundwater supply, with 78 and 62 percent, respectively, of that groundwater meeting agricultural demands. The Lower Klamath PA uses the least amount of groundwater in the North Coast region, with 14 taf accounting for 4 percent of the groundwater used in the region.

Table 3-5 Percentage[a] of Average Annual Groundwater Supply, According to Planning Area and Type of Use, for the North Coast Hydrologic Region (2005-2010)

North Coast Hydrologic Region		Groundwater for Agricultural Use	Groundwater for Urban Use	Groundwater for Managed Wetlands Use	Groundwater Use by PA
PA Number	**PA Name**	**%[a,b]**	**%[a,b]**	**%[a,b]**	**%[b]**
101	Upper Klamath	95%	4%	1%	53%
102	Lower Klamath	58%	42%	0%	4%
103	Coastal	78%	22%	0%	23%
104	Russian River	62%	38%	0%	21%
2005-2010 Annual Average Hydrologic Region Total:		**83%**	**17%**	**1%**	**100%**

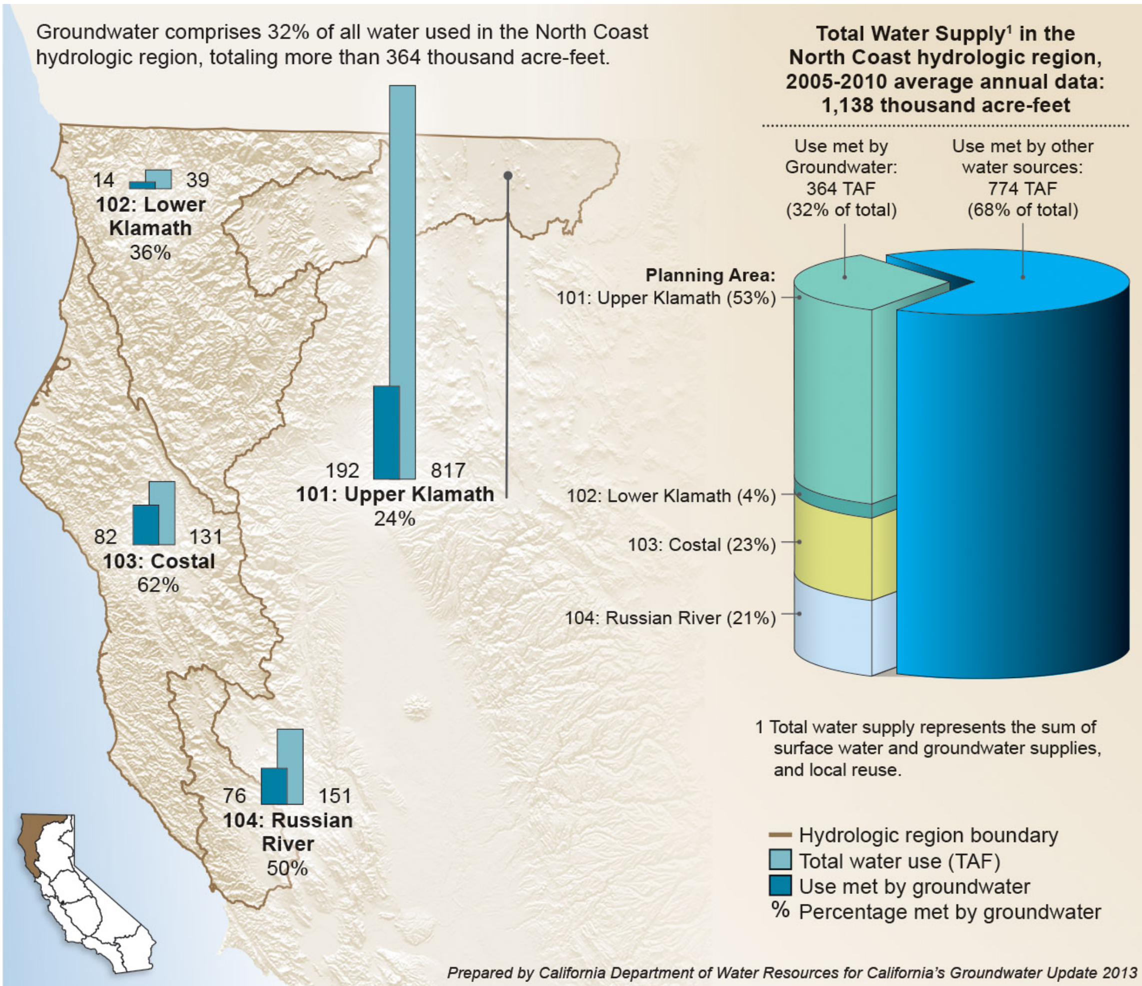
Notes:
PA = planning area
[a]Percentage of use is average annual groundwater use by planning area and type of use, compared with the total groundwater use for the North Coast region.
[b]Percentages are rounded to the nearest whole number.

Groundwater Use by County Boundaries

Groundwater supply and use was also calculated by county. County boundaries do not align with planning area or hydrologic region boundaries, so regional totals for groundwater based on county area vary from the estimates based on planning area boundaries shown in Table 3-4. The North Coast region covers all of Del Norte, Trinity, Humboldt, and Mendocino counties, major portions of Modoc, Siskiyou, and Sonoma counties, and minor portions of Glenn, Lake, and Marin counties. Also within the region's boundaries are small areas of Tehama, Colusa, and Shasta counties. For the purposes of this section, groundwater-use data for the North Coast region is reported only for Del Norte, Siskiyou, Trinity, Humboldt, Mendocino, and Sonoma counties. Groundwater-supply and -use information for Modoc, Lake, Glenn, Tehama, Colusa, and Shasta counties are provided in the Sacramento River Hydrologic Region chapter, while this information for Marin County is included in the statistics for the San Francisco Bay Hydrologic Region chapter. Tables showing groundwater use for all 58 California counties are included in Appendix C.

Table 3-6 lists the 2005-2010 average annual groundwater use by county, by type of use, and by the percentage that groundwater contributes to the total water supply of the North Coast region. Overall, based on county boundaries for the North Coast region, groundwater contributes 382 taf (39 percent) of the average annual total water supply, which is estimated to be 987 taf. Table 3-6 indicates that groundwater contributes from 30 to 72 percent of the total water supply for the six counties included in the North Coast region. Groundwater supplies in the six-county area meet approximately 48 percent of the agricultural demand and 40 percent of the urban demand.

Figure 3-7 Groundwater Use and Total Water Supply Met by Groundwater, According to Planning Area, in the North Coast Hydrologic Region (2005-2010)



As previously stated and listed on Table 3-3, the eight groundwater basins designated as medium priority CASGEM basins comprise 79 percent of the annual groundwater use for the North Coast region and 62 percent of the 2010 population that overlies the groundwater basin area in for the North Coast region.

Change in Annual Groundwater Use

Changes in annual amount and type of groundwater use may be related to a number of factors, such as changes in surface water availability, urban and agricultural growth, economic fluctuations, and water-use efficiency practices.

Table 3-6 Groundwater Use and Percentage of Total Water Supply Met by Groundwater, According to County and Type of Use, for the North Coast Hydrologic Region (2005-2010)

North Coast Hydrologic Region	Agriculture Use Met by Groundwater		Urban Use Met by Groundwater		Managed Wetlands Use Met by Groundwater		Total Water Use Met by Groundwater	
County	**taf**	**%[a]**	**taf**	**%[a]**	**taf**	**%[a]**	**taf**	**%[a]**
Del Norte	4.6	49%	1.7	40%	0.0	0%	6.3	46%
Humboldt	58.5	92%	17.9	42%	0.0	0%	76.4	72%
Mendocino	24.3	47%	7.4	43%	0.0	0%	31.7	46%
Siskiyou	175.0	39%	11.4	56%	2.5	1%	188.9	30%
Sonoma	43.7	74%	29.6	35%	0.0	0%	73.3	51%
Trinity	3.2	35%	1.8	42%	0.0	0%	5.0	37%
2005-2010 annual average total:	**309.3**	**48%**	**69.8**	**40%**	**2.5**	**1%**	**381.6**	**39%**

Notes:
taf = thousand acre-feet
[a]Percentage of use is the percent of the total water supply that is met by groundwater, by type of use.
2005-10 Precipitation equals 99 percent of the 30-yr. average for the North Coast region

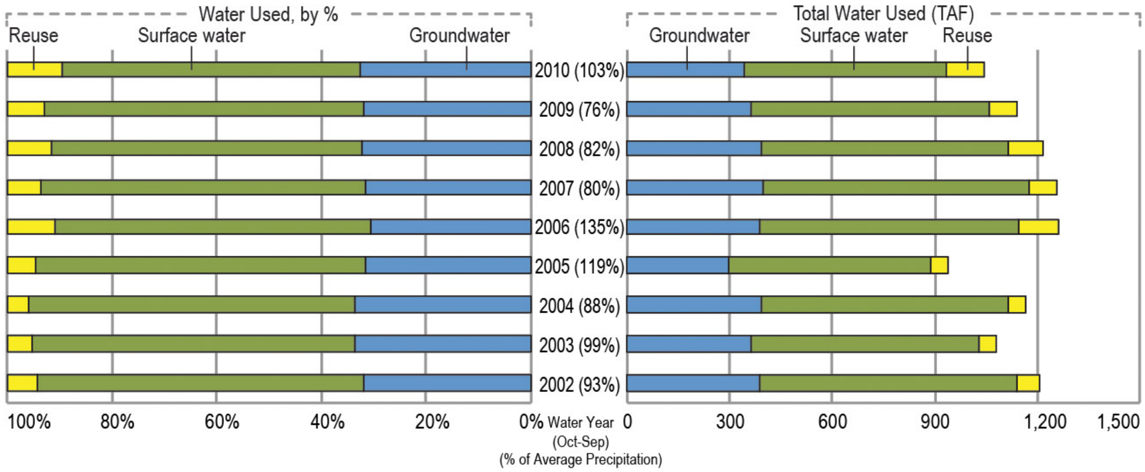
Figure 3-8 illustrates the 2002-2010 water supply trend for the North Coast region. The right side of Figure 3-8 illustrates the total water supply volume by supply type (groundwater, surface water, and reuse/recycled water), while the left side shows the percentage of the overall water supply that is met by those sources of water. The center column identifies the water year along with the corresponding amount of precipitation, as a percentage of the previous 30-year average for the hydrologic region.

As shown on the right side of Figure 3-8, the annual total water supply for the North Coast region fluctuated between a low of 939 taf in 2005 and a high of 1,262 taf in 2006. During each of the water years shown on Figure 3-8, annual groundwater supply ranged between a low of 298 taf in 2005 and a high of 396 taf in 2007 and met between 31 percent and 34 percent of the total water supply for the region.

Figure 3-9 shows the 2002-2010 groundwater supply trend by urban, agricultural, and managed wetland uses in the North Coast region. The right side of Figure 3-9 illustrates the annual volume of groundwater extraction by type of use, while the left side shows the percentage of groundwater extraction by type of use. The center column identifies the water year along with the corresponding amount of precipitation, as a percentage of the previous 30-year average for the hydrologic region.

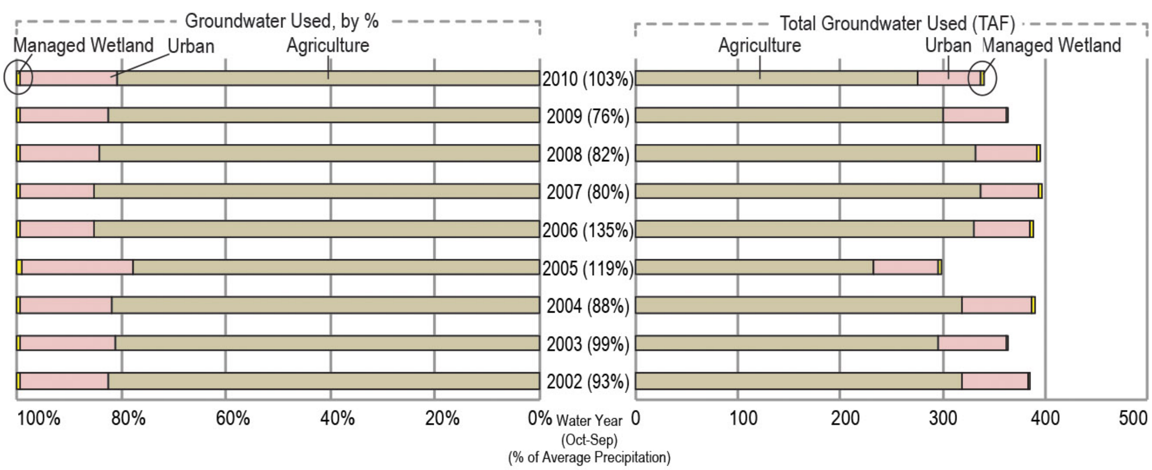
For each of the water years represented in Figure 3-9, groundwater used for agricultural purposes was far greater than the amount of groundwater used for urban purposes. Groundwater for agricultural activities ranged from 78 to 85 percent of the total groundwater used in the North Coast region, while urban uses accounted for 14 to 21 percent of the total groundwater used in the region. Groundwater supply for managed wetland use, for each of the water years represented in Figure 3-9, was generally less than 1 percent of the total amount of groundwater used in the region.

Figure 3-8 Annual Surface Water and Groundwater Supply Trend for the North Coast Hydrologic Region (2002-2010)



Prepared by California Department of Water Resources for California's Groundwater Update 2013

Figure 3-9 Annual Groundwater Supply Trend by Type of Use for the North Coast Hydrologic Region (2002-2010)



Prepared by California Department of Water Resources for California's Groundwater Update 2013

Groundwater Monitoring Efforts

Groundwater resource monitoring and evaluation is a key aspect to understanding groundwater conditions, identifying effective resource management strategies, and implementing sustainable resource management practices. California Water Code Section 10753.7 requires local agencies seeking State funds administered by DWR to prepare and implement GWMPs that include monitoring of groundwater levels, groundwater quality degradation, inelastic land subsidence, and changes in surface water flow and quality that directly affect groundwater levels or quality. The protocols associated with groundwater monitoring can vary greatly depending on the local conditions; but overall, monitoring protocols should be designed to generate information that promotes efficient and effective groundwater management.

This section summarizes some of the groundwater-level monitoring, groundwater-quality monitoring, and land-subsidence monitoring activities in the North Coast region. The summary includes publically available groundwater data compiled by DWR, State Water Resources Control Board (SWRCB), California Department of Public Health (CDPH), and the U.S. Geological Survey (USGS). Information regarding the groundwater monitoring methods, assumptions, and data availability is provided in Appendix A.

Groundwater-Level Monitoring

State and federal agencies with groundwater-level monitoring programs in the North Coast region include DWR and USGS. Groundwater-level monitoring is also performed by CASGEM-designated monitoring entities, as well as local cooperators who measure, or contract others to measure, groundwater levels. Groundwater-level information presented in this section represents data that is publically available through DWR or USGS online information systems. Privately collected and locally maintained groundwater-level information is not discussed in this section. The groundwater-level information in this section only includes active monitoring wells or those wells that have been measured since January 1, 2010, and monitoring groups that have entered data into the CASGEM or USGS online databases as of July 2012. Because monitoring programs are frequently adjusted to meet changing demands and management actions, groundwater-level information presented for the North Coast region may not represent the most current information available. Updated groundwater-level information may be obtained online from the DWR CASGEM Program Web site (http://www.water.ca.gov/groundwater/casgem/) and the USGS National Water Information System (http://waterdata.usgs.gov/nwis).

A list of the number of monitoring wells in the North Coast region by monitoring agencies, cooperators, and CASGEM-designated monitoring entities is in Table 3-7. The locations of these monitoring wells, by monitoring entity and monitoring well type, are shown in Figure 3-10.

Table 3-7 shows that 194 wells in the North Coast region are actively monitored for groundwater-level information. DWR monitors 123 wells; 90 wells are in 15 groundwater basins and 33 wells are outside Bulletin 118-2003 alluvial groundwater basins. The USGS monitoring network consists of 37 wells in 10 groundwater basins. Three CASGEM monitoring entities monitor a combined 34 wells in six groundwater basins, and nine wells outside Bulletin 118-2003 alluvial groundwater basins. Comparison of Figures 3-6 and 3-10 indicate that several medium-priority groundwater basins were not being monitored for groundwater levels as of July 2012.

Most of the groundwater-level monitoring networks include a variety of well-use types. The groundwater-level monitoring wells are categorized by the type of well use and include irrigation, domestic, observation, public supply, and other. Groundwater-level monitoring wells identified as "other" include a combination of the less common well types, such as stock wells, test wells, industrial wells, or unidentified wells (no information listed on the well log). Wells listed as "observation" also include those wells described by drillers in the well logs as "monitoring" wells. Some of the domestic and irrigations wells used for groundwater-level monitoring include actively operated wells and some consist of older inactive or unused wells.

Table 3-7 Groundwater-Level Monitoring Wells, According to Monitoring Entity, for the North Coast Hydrologic Region

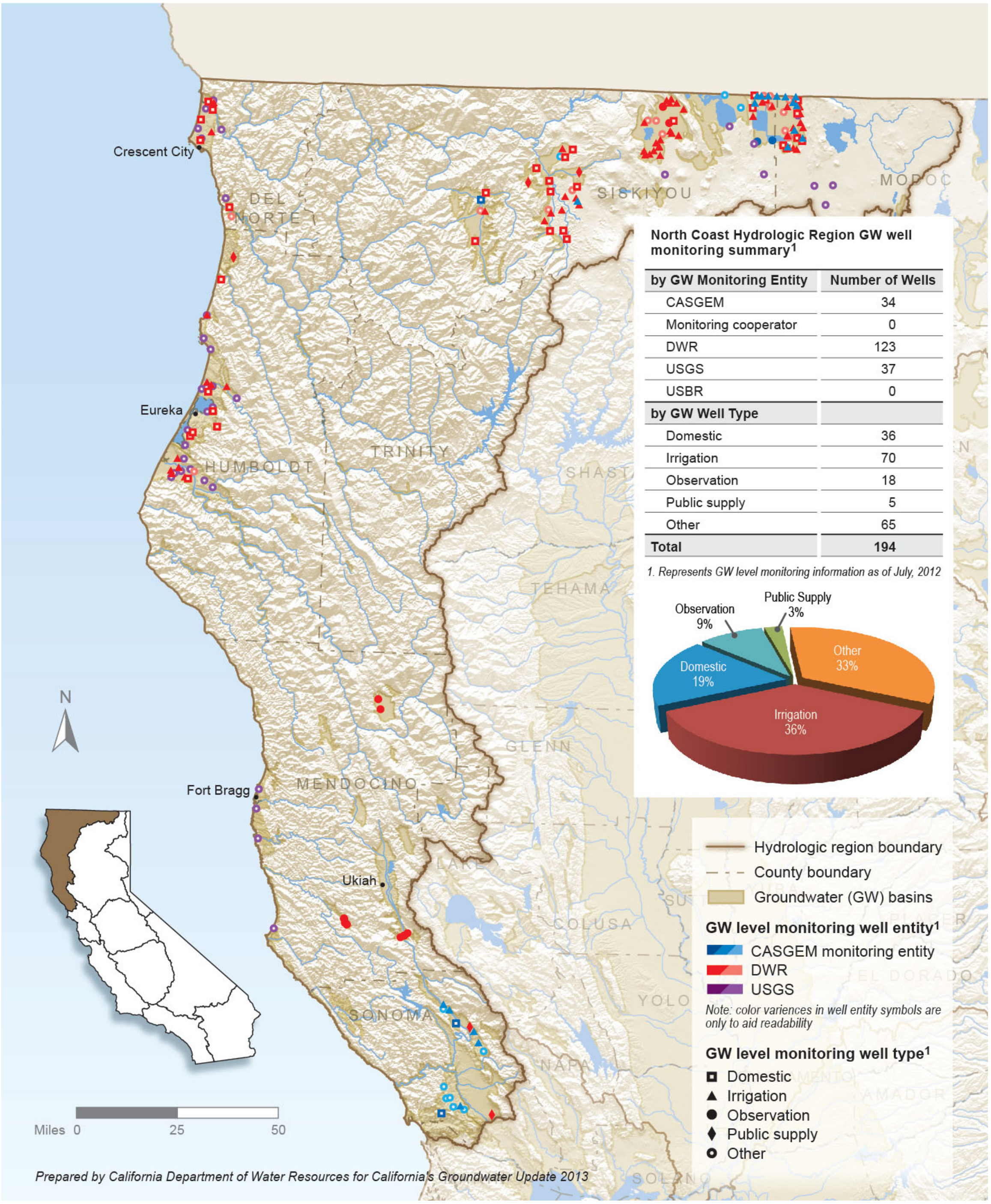
State and Federal Agencies	Number of Wells
California Department of Water Resources	123
U.S. Geological Survey	37
U.S. Bureau of Reclamation	0
Total State and federal wells:	**160**
Monitoring Cooperators	**Number of Wells**
None	0
Total cooperator wells:	**0**
CASGEM Monitoring Entities	**Number of Wells**
Siskiyou County Public Health and Community Development	5
Sonoma County Permit and Resource Management Department	14
Tulelake Irrigation District	15
Total CASGEM entity wells:	**34**
Total hydrologic region monitoring wells:	**194**

Notes:
CASGEM = California Statewide Groundwater Elevation Monitoring
Table represents monitoring information as of July 2012.
Table includes groundwater-level monitoring wells having publically available online data.

Domestic wells are typically relatively shallow and screened in the upper portion of the aquifer system, while irrigation wells tend to be constructed deeper within the aquifer system. Consequently, groundwater-level data collected from domestic wells typically represent shallow aquifer conditions, while groundwater-level data from irrigation wells represent middle-to-deep aquifer conditions. Some observation wells are constructed as a nested or clustered set of dedicated monitoring wells. These wells are designed to characterize groundwater conditions at very specific and discrete production intervals throughout the aquifer system.

Figure 3-10 indicates what agency collects the groundwater elevation data and graphically displays groundwater-level monitoring wells by use. A percentage breakdown of the groundwater-level monitoring wells, by use, illustrated by the pie chart, indicates that wells identified for irrigation and "other" uses make up the majority of the region's monitoring wells, comprising 36 percent and 33 percent, respectively, of the total percentage of groundwater monitoring wells. Wells listed as domestic and observation monitoring wells consist of 19 percent and 9 percent, respectively, of the total percentage of groundwater monitoring wells, while public supply wells comprise less than 3 percent of the total percentage of groundwater monitoring wells.

Figure 3-10 Monitoring Well Location by Agency, Monitoring Cooperator, and CASGEM Monitoring Entity for the North Coast Hydrologic Region



Groundwater Quality Monitoring

Groundwater quality monitoring is an important aspect to effective groundwater basin management and is one of the required groundwater management planning components under

California Water Code Section 10753.7. Groundwater quality monitoring and assessment evaluates current conditions, can be used to establish groundwater quality thresholds, and can help guide management decisions. Without sufficient groundwater quality monitoring, it is almost impossible to determine if groundwater problems exist or to forecast the potential for future problems that may warrant management actions. Many local, regional, and State agencies have statutory responsibility or authority to collect water quality and water-use/level data and information. Nonetheless, monitoring is inconsistent throughout the state, with significant regional variation in parameters monitored, monitoring frequency, and data availability. In spite of these inconsistencies, there are excellent examples of groundwater monitoring programs being implemented at the local, regional, and State levels.

Regional and statewide groundwater quality monitoring information and data are available to the public on the SWRCB Groundwater Ambient Monitoring and Assessment (GAMA) Web site (http://www.waterboards.ca.gov/gama/geotracker_gama.shtml), DWR's Water Data Library (http://www.water.ca.gov/waterdatalibrary/), and the GeoTracker GAMA Web site (http://geotracker.waterboards.ca.gov/). The GAMA Program was created in 2000 by the SWRCB to better understand California's groundwater quality issues. The GAMA Program was later expanded, as part of the Groundwater Quality Monitoring Act of 2001, resulting in a publicly accepted plan to monitor and assess groundwater quality in groundwater basins that account for more than 95 percent of the state's groundwater use. The GAMA Web site includes a description of the GAMA program and also provides links to published GAMA documents and related reports.

GeoTracker GAMA is an online groundwater information system that provides the public with access to groundwater quality data. The data is geographically displayed and includes analytical tools and reporting features to assess groundwater quality conditions. GeoTracker GAMA allows users to search for more than 60 million standardized analytical test results from more than 200,000 wells and contains more than 125 million data records. These data records were obtained from different sources, such as the SWRCB, regional water quality control boards (RWQCBs), CDPH, Department of Pesticide Regulation (DPR), USGS, and Lawrence Livermore National Laboratory (LLNL). In addition to groundwater quality data, GeoTracker GAMA contains more than 2.5 million depth-to-groundwater measurements from DWR and the RWQCBs. GeoTracker GAMA also contains hydraulically fractured oil and gas well information from the California Division of Oil, Gas, and Geothermal Resources. Groundwater quality data in the DWR Water Data Library primarily includes baseline minerals, metals, and nutrient data associated with regional monitoring.

Table 3-8 provides agency-specific groundwater quality information. Additional information regarding assessment and reporting of groundwater quality information is listed under the "Aquifer Conditions" section of this chapter.

Land Subsidence Monitoring

Land subsidence has been shown to occur in areas having a significant decline in groundwater levels. When groundwater is extracted from aquifers in sufficient quantity, the groundwater level

Table 3-8 Sources of Groundwater Quality Information for the North Coast Hydrologic Region

Agency	Links to Information
State Water Resources Control Board http://www.waterboards.ca.gov/	Groundwater http://www.waterboards.ca.gov/water_issues/programs/#groundwater • Communities that Rely on a Contaminated Groundwater Source for Drinking Water http://www.waterboards.ca.gov/water_issues/programs/gama/ab2222/index.shtml • Hydrogeologically Vulnerable Areas http://www.waterboards.ca.gov/gama/docs/hva_map_table.pdf • Aquifer Storage and Recovery http://www.waterboards.ca.gov/water_issues/programs/asr/index.shtml Groundwater Ambient Monitoring and Assessment (GAMA) http://www.waterboards.ca.gov/gama/index.shtml • GeoTracker GAMA (Monitoring Data) http://geotracker.waterboards.ca.gov • Domestic Well Project http://www.waterboards.ca.gov/gama/domestic_well.shtml • Priority Basin Project http://www.waterboards.ca.gov/water_issues/programs/gama/sw_basin_assesmt.shtml • Special Studies Project http://www.waterboards.ca.gov/water_issues/programs/gama/special_studies.shtml California Aquifer Susceptibility Project http://www.waterboards.ca.gov/water_issues/programs/gama/cas.shtml **Contaminant Sites** • Land Disposal Program http://www.waterboards.ca.gov/water_issues/programs/land_disposal/ • Department of Defense Program http://www.waterboards.ca.gov/water_issues/programs/dept_of_defense/ • Underground Storage Tank Program http://www.waterboards.ca.gov/ust/index.shtml • Brownfields http://www.waterboards.ca.gov/water_issues/programs/brownfields/
California Department of Public Health http://www.cdph.ca.gov/Pages/DEFAULT.aspx	**Division of Drinking Water and Environmental Management** http://www.cdph.ca.gov/programs/Pages/DDWEM.aspx • Drinking Water Source Assessment and Protection (DWSAP) Program http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/DWSAP.shtml • Chemicals and Contaminants in Drinking Water http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/Chemicalcontaminants.shtml • Chromium-VI http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/Chromium6.shtml • Groundwater Replenishment with Recycled Water http://www.cdph.ca.gov/services/DPOPP/regs/Pages/DPH14-003EGroundwaterReplenishmentUsingRecycledWater.aspx

Agency	Links to Information
California Department of Water Resources http://www.water.ca.gov/	**Groundwater Information Center** http://www.water.ca.gov/groundwater/index.cfm • Bulletin 118 Groundwater Basins http://www.water.ca.gov/groundwater/bulletin118/gwbasins.cfm • California Statewide Groundwater Elevation Monitoring (CASGEM) http://www.water.ca.gov/groundwater/casgem/ • Groundwater-Level Monitoring http://www.water.ca.gov/groundwater/data_and_monitoring/levels.cfm • Groundwater Quality Monitoring http://www.water.ca.gov/groundwater/data_and_monitoring/gw_quality_monitoring.cfm • Well Construction Standards http://www.water.ca.gov/groundwater/wells/standards.cfm • Well Completion Reports http://www.water.ca.gov/groundwater/wells/well_completion_reports.cfm
California Department of Toxic Substance Control http://www.dtsc.ca.gov/	**EnviroStor** http://www.envirostor.dtsc.ca.gov/public/
California Department of Pesticide Regulation http://www.cdpr.ca.gov/	**Groundwater Protection Program** http://www.cdpr.ca.gov/docs/emon/grndwtr/index.htm • Well Sampling Database http://www.cdpr.ca.gov/docs/emon/grndwtr/wellinv/data_policy.htm • Groundwater Protection Area Maps http://www.cdpr.ca.gov/docs/emon/grndwtr/gwpa_locations.htm
U.S. Environmental Protection Agency http://www.epa.gov/safewater/	**Storage and Retrieval (STORET) Environmental Data System** http://www.epa.gov/storet/
U.S. Geological Survey http://ca.water.usgs.gov/	**Water Data for the Nation** http://waterdata.usgs.gov/nwis

is lowered and the water pressure that supports the skeletal structure of the sediment grains decreases. A decrease in water pressure causes more weight from the overlying sediments to be supported by the sediment grains within the aquifer. In unconsolidated deposits, the increased weight from overlying sediments may compact the fine-grained sediments and permanently decrease both the porosity of the aquifer and the ability of the aquifer to store water. The partial collapse of the aquifer's skeletal structure results in the subsidence of the land surface that overlies the aquifer. *Elastic land subsidence* is the reversible and temporary fluctuation of the earth's surface in response to seasonal periods of groundwater extraction and recharge. *Inelastic land subsidence* is the irreversible and permanent decline in the earth's surface caused by the collapse or compaction of the pore structure within the fine-grained portions of an aquifer system (U.S. Geological Survey 1999).

Most groundwater basins along the coastal portion of the North Coast region have limited risk for land subsidence resulting from groundwater withdrawal. Consequently, no land subsidence monitoring efforts are known to exist along the coastal portion of the North Coast region. Even so, recent increases in groundwater withdrawals for some inland groundwater basins have resulted in the installation of land subsidence monitoring in the Tule Lake Groundwater Subbasin.

There is a global positioning system (GPS) land subsidence network, consisting of 23 monitoring stations in the North Coast region. Sixteen stations are within the Tule Lake Groundwater Subbasin and seven stations are located within hard rock along the outside edge of the groundwater basin. More information about this GPS land subsidence network is in the "Land Subsidence" section.

Aquifer Conditions

Aquifer conditions and groundwater levels change in response to varying supply, demand, and weather conditions. During years of normal or above-normal precipitation, or during periods of low groundwater use, aquifer systems tend to recharge and respond with rising groundwater levels. As a result, if groundwater levels rise sufficiently, water table aquifers can reconnect to surface water systems, contributing to the overall base flow, or directly discharging onto the ground surface via wetlands, seeps, and springs.

During dry years or periods of increased groundwater use, seasonal groundwater levels tend to fluctuate more widely and, depending on annual recharge conditions, may respond with a long-term decline in local and regional groundwater levels. Depending on the amount, timing, and duration of groundwater-level decline, affected well owners may need to deepen wells or lower pumps to regain access to groundwater.

Lowering of groundwater levels can also affect the surface-water–groundwater interaction by inducing additional infiltration and recharge from nearby surface water systems, reducing the groundwater contribution to the water base flow of surface water systems, and reducing groundwater discharge to wetlands areas. Extensive lowering of groundwater levels can also result in land subsidence resulting from the dewatering, compaction, and loss of storage within finer grained aquifer systems.

Groundwater Occurrence and Movement

Groundwater comes from infiltration of precipitation and of water from streams, canals, and other surface water systems and moves from higher to lower elevations. Under predevelopment conditions, the occurrence and movement of groundwater was largely controlled by the surface and the subsurface geology, the size and distribution of the natural surface water systems, the average annual hydrology, and the regional topography. But many decades of high-volume groundwater extraction can considerably affect the natural occurrence and movement of groundwater. Areas of high groundwater extraction tend to redirect and capture groundwater underflow that may otherwise have contributed to nearby surface water systems, leading to varying degrees of surface water depletion. High-capacity wells screened over multiple aquifer zones also lend themselves to vertical aquifer mixing, which can additionally alter natural groundwater flow conditions. Moreover, infiltration along unlined water conveyance canals, percolation of applied irrigation water, and direct recharge programs create significant groundwater recharge areas where none previously existed.

Depth to Groundwater

Understanding the local depth to groundwater provides a better awareness of these factors:

- Potential interaction between groundwater and surface water systems.
- Relationship between land use and groundwater levels.
- Potential for land subsidence.
- Groundwater contributions to the local ecosystems.
- Costs associated with well installation and groundwater extraction.

Under predevelopment aquifer conditions, changes in the depth to groundwater will generally correlate with ground surface elevation. For example, with increasing ground surface elevation, there is a corresponding increase in the depth to groundwater. In high-use groundwater basins or in conjunctively managed groundwater basins, the correlation between depth to water and ground surface elevation will eventually start to break down and show significant variability. This can occur even in areas where there is little change in ground surface elevation.

Groundwater levels in the North Coast region are highly variable from groundwater basin to groundwater basin. Depth-to-groundwater data for some of the groundwater basins in the North Coast region are at DWR's Water Data Library (http://www.water.ca.gov/waterdatalibrary/), DWR's CASGEM system (http://www.water.ca.gov/groundwater/casgem/), and the USGS National Water Information System (http://waterdata.usgs.gov/nwis/gw). In addition, basin-specific groundwater information may be obtained from the following sources. Although a reference for Sonoma Valley is provided in this section, the groundwater basins comprising the southeastern portion of Sonoma County are covered in the San Francisco Bay Hydrologic Region chapter of this report.

- Ground-Water Hydrology of the Upper Klamath Basin (http://pubs.usgs.gov/sir/2007/5050/) (U.S. Geological Survey 2010).
- Santa Rosa Valley (http://pubs.usgs.gov/sir/2013/5118/) (U.S. Geological Survey 2013).
- Alexander Valley (http://pubs.usgs.gov/sir/2006/5115/pdf/sir2006-5115.pdf) (U.S. Geological Survey 2006).
- Scott Valley Groundwater (http://groundwater.ucdavis.edu/Research/ScottValley/) (University of California, Davis 2015).
- Sonoma Valley (http://pubs.usgs.gov/sir/2006/5092/pdf/sir2006-5092.pdf) (U.S. Geological Survey 2006).

No detailed depth-to-groundwater information was generated for the North Coast region as part of *California Water Plan Update 2013*.

Groundwater Elevations

Depth-to-groundwater measurements can be converted to groundwater elevations if the elevation of the ground surface is known. Groundwater elevation contours provide a good regional estimate of the occurrence and movement of groundwater. Similar to topographic contours, the pattern and spacing of groundwater elevation contours can be used to help estimate the direction of groundwater movement and the gradient, or rate, of groundwater flow. DWR monitors the depth to groundwater in some groundwater basins in the North Coast region, though groundwater elevation contours were not developed as part of this chapter. Some references and links to local agencies that independently or cooperatively monitor the groundwater levels in the groundwater basins and develop groundwater elevation maps are provided in the previous section.

Groundwater-Level Trends

Depth-to-water measurements collected from a particular well over time can be plotted to create a hydrograph. Hydrographs assist in the presentation and analysis of seasonal and long-term groundwater-level variability and trends over a time. Because of the highly variable nature of the aquifer systems within each groundwater basin, and because of the variable nature of annual groundwater extraction, recharge, and surrounding land-use practices, the hydrographs selected for discussion do not attempt to illustrate or depict average aquifer conditions over a broader region. Rather, the hydrographs were selected to help tell a story of how the local aquifer systems respond to changing groundwater extractions and implementation of resource management practices.

The following hydrographs are identified by the State Well Number (SWN) system. The SWN identifies a well by its location using the U.S. Public Lands Survey System of township, range, and section. Details about the SWN system are in DWR's information brochure, *water facts* No. 7 (http://www.water.ca.gov/pubs/conservation/waterfacts/numbering_water_wells_in_california__water_facts_7_/water_facts_7.pdf).

Figure 3-11 shows hydrograph examples for four selected groundwater elevation monitoring wells in the North Coast region and provides a brief explanation of the hydrograph. Detailed information about each hydrograph can be found in the following paragraphs.

Hydrograph 48N04E31N002M

Figure 3-11a is a hydrograph for Well 48N04E31N002M, which is located along the western edge of the Tule Lake Groundwater Subbasin (1-2.01). The hydrograph depicts the aquifers response to a rapid increase in groundwater demand resulting from surface water cutbacks, and the ongoing increased reliance on a previously seldom-used portion of the aquifer system. The well is a deep domestic well that draws water from a fractured-basalt portion of the aquifer underlying the Tule Lake Groundwater Subbasin. The surrounding well area is dominated by agricultural land use. Groundwater-level monitoring in this well was conducted on a semi-annual basis from 1995 to 2000, and on a monthly basis from 2001 to present. The Tule Lake Groundwater Subbasin is designated as a CASGEM medium-priority groundwater basin.

In 2001, in response to one of the driest years on record for the Klamath Basin watershed, the U.S. Bureau of Reclamation (USBR) stopped surface water deliveries from the Klamath Project to the Tule Lake Groundwater Subbasin area. In response, a drought emergency was declared and a number of new high-capacity wells were installed in the fractured-basalt portion of the Tule Lake Groundwater Subbasin aquifer. In subsequent years, ongoing environmental water shortages for the Klamath Project resulted in additional surface water cutbacks and the implementation groundwater-substitution water transfers for 9 of the next 10 years. Because of Oregon regulations that limit groundwater pumping, the majority of groundwater-substitution pumping came from the California portion of the Klamath Basin. Almost two-thirds of the 210,000 irrigated acres in the Klamath Project service area are in Oregon.

In 2000, prior to the groundwater-substitution pumping, groundwater demand from the Tule Lake Groundwater Subbasin was estimated at 8,500 acre-feet (af). Over the next few years, transfer operations resulted in groundwater extraction of 70,000 af in 2001 to about 22,000 acre-feet per year (af/yr.) for 2002 and 2003 (California Department of Water Resources 2004). Groundwater pumping increased to 32,000 af in 2004, and then declined to an average of about 14,000 af/yr. for 2005 and 2006. No pumping amounts were recorded for 2007 and 2008, but in 2010, groundwater extraction volume increased to 51,000 af. No groundwater-substitution transfers took place in 2009. It was estimated that nontransfer groundwater pumping was 8,500 af.

Although there is considerable annual variation in groundwater levels between 2001 and 2010, the hydrograph shows that the overall rate of groundwater-basin recharge has not been able to keep pace with the post-2001 increases in groundwater extraction. After the initial drop of 7 feet between 2001 and 2002, the hydrograph shows a slow, but steady, trend of declining groundwater levels until 2006, a period of relatively stable levels from 2006 to 2009, and then another groundwater level drop from 2009 to 2012.

The period of somewhat stable groundwater levels from 2006 to 2009 indicates that the annual rate of aquifer recharge was likely sufficient to offset the average annual groundwater pumping volume of about 14,000 af. Conversely, the post-2009 decline in groundwater levels associated with the increase in groundwater extraction to 51,000 af in 2010 indicates that annual extraction rates of 50,000 af/yr. are not sustainable for this portion of the groundwater basin aquifer.

The hydrograph for Well 48N04E31N002M also highlights the importance of implementing appropriate data collection and adaptive management practices when implementing conjunctive management via groundwater substitution, especially in areas where aquifer response to increased pumping is largely unknown. From a statewide perspective, a groundwater level decline of 17 feet during 12 years in response to groundwater substitution may not seem significant when compared with the economic advantages of maintaining existing land-use practices. At the local level, these declines have resulted in impacts to shallow wells, increased the risk for future subsidence within the fine-grained lakebed deposits above the fractured-basalt aquifer, and are bringing into question the sustainability of land-use practices that require greater than about 40,000 af of groundwater extraction.

Uncertainties associated with the operation of the Klamath Project Water have led to the development of the Klamath Water and Power Agency (KWAPA) to help align water supply and demand. The On-Project Water Plan is being implemented by KWAPA to help align long-term water supply and demand for the local service area. In addition, conservation and management practices are currently being implemented by the Tule Lake Irrigation District to help increase water supply reliability (Tule Lake Irrigation District 2011).

Hydrograph 44N06W10F001M

Figure 3-11b is a hydrograph for Well 44N06W10F001M, located near Grenada in the Shasta Valley Groundwater Basin (1-4), about 50 feet down-gradient from a Montague Water District conveyance ditch. The hydrograph for this well highlights dramatic seasonal effects of conveyance-ditch losses to the underlying shallow aquifer. Well 44N06W10F001M is a 113-feet deep domestic well that produces from the shallow aquifer, which consists of sand, gravel, clay,

Figure 3-11 Groundwater Hydrographs for the North Coast Hydrologic Region, Page 1

Aquifer response to changing demand and management practices

Hydrographs were selected to help tell a story of how local aquifer systems respond to changing groundwater demand and resource management practices. Additional detail is provided within the main text of the report.

Regional locator map

A Hydrograph 48N04E31N002M: shows the impact of deep high capacity pumps, fluctuating surface water deliveries, and long-term drought conditions.

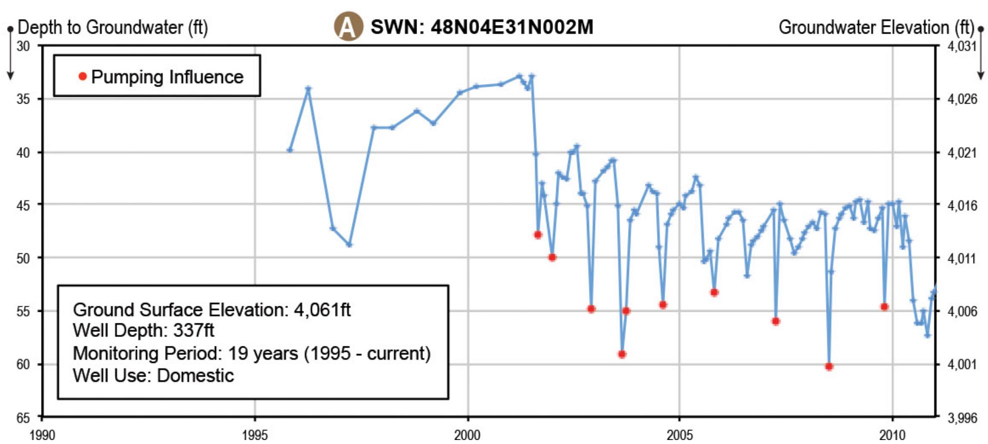
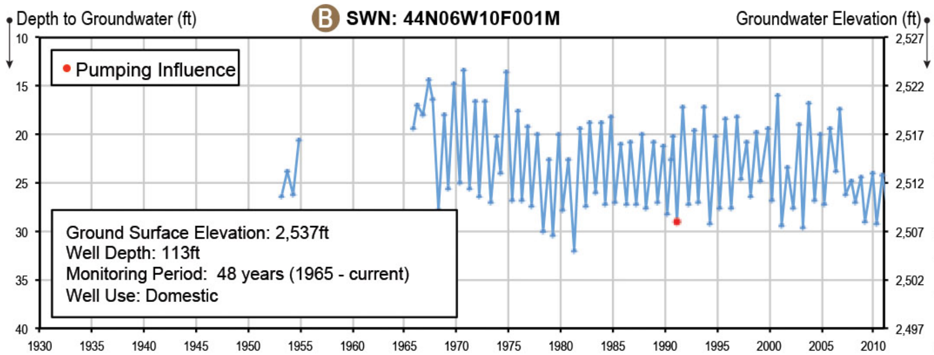
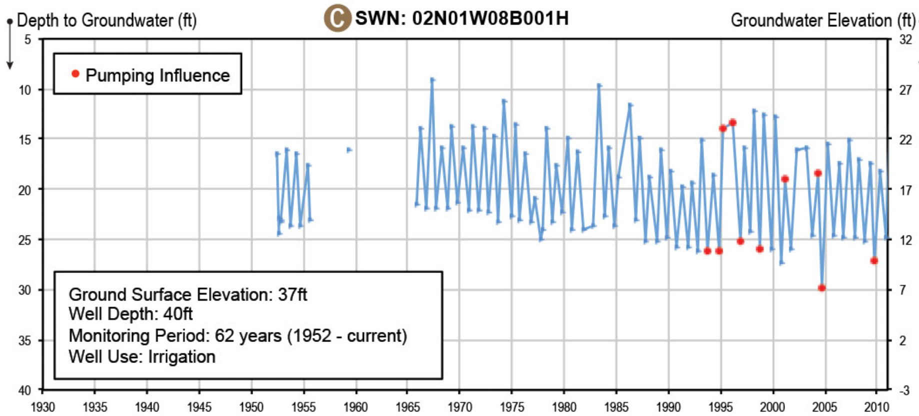


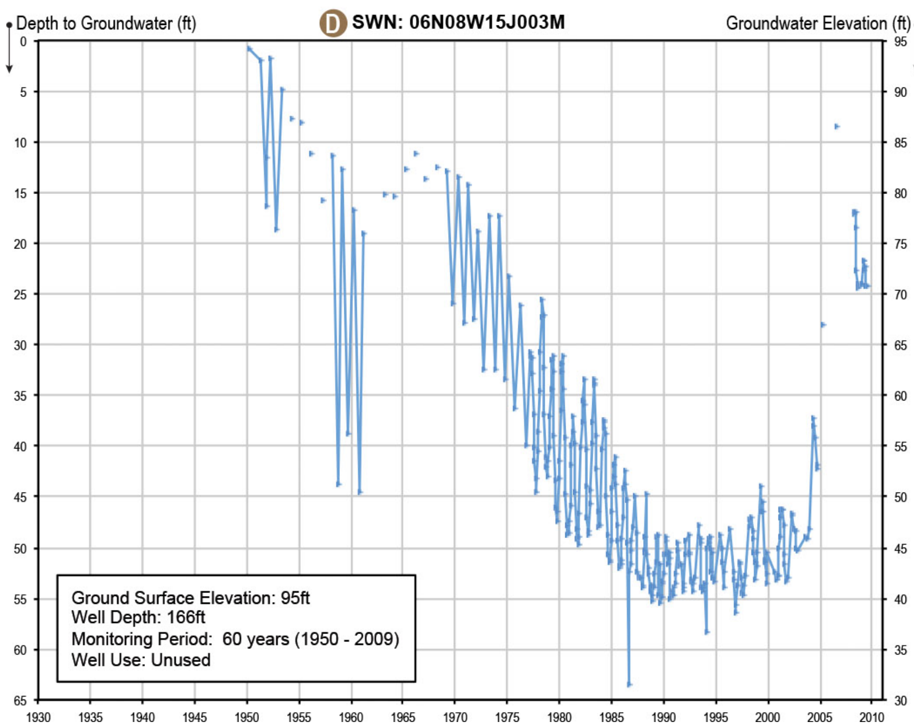
Figure 3-11 Groundwater Hydrographs for the North Coast Hydrologic Region, Page 2



B Hydrograph 44N06W10F001M: illustrates the interplay between the groundwater aquifer and the nearby surface water conveyance. The unconfined aquifer is replenished in summer and fall when the canal runs full and vice-versa in winter and spring. Sudden drop in the seasonal variation corresponds with the lining of canal in 2007.



C Hydrograph 02N01W08B001H: highlights the close interaction between perennial surface water systems and the shallow groundwater wells in aquifers along the California coast where the groundwater levels have more interaction with the surface water system in wet rather than dry years.



D Hydrograph 06N08W15J003M: Illustrates stabilization of and recovery in the groundwater levels as a result of increased surface water delivery, use of recycled water supplied in lieu of pumping groundwater and water conservation.

and volcanic deposits. Groundwater-level monitoring in this well has been conducted on a semi-annual basis from 1953 to present. The Shasta Valley Groundwater Basin is designated as a CASGEM medium-priority groundwater basin.

Throughout most of California, precipitation associated with Mediterranean-climate conditions typically result in seasonal groundwater levels being the highest during the late-winter-to-early-spring months, and the lowest during summer or early fall months. Yet, groundwater levels are consistently 5 to 10 feet higher during the fall contrasted with spring months. This reversed groundwater-level trend is likely caused by summer recharge from conveyance-ditch losses and the percolation of applied surface water for nearby agricultural demand. Once the irrigation season is over, the conveyance system is dewatered and nearby groundwater levels decline.

Prior to 2007, in the vicinity of this well, there were two parallel conveyance canals. In 2007, one of the two canals was replaced with an underground pipe system to reduce conveyance losses. The results of the conveyance piping project are evident in the hydrograph depicted in Figure 3-11b, where the overall groundwater levels declined by more than 5 feet. The reversed trend of seasonal fluctuation continued, but at a lower elevation, indicating that the remaining conveyance ditch is still leaking water.

Hydrograph 02N01W08B001H

Figure 3-11c is a hydrograph for Well 02N01W08B001H, located in the Eel River Valley Groundwater Basin (1-10). The hydrograph highlights the close interaction between surface water systems and the numerous shallow groundwater wells that produce water from thin alluvial river plain aquifers along the California coast. The well is a very shallow irrigation well that is constructed in the unconfined sand and gravel deposits of the Eel River Valley aquifer. Groundwater-level monitoring of this well dates back to 1952 and is comprised of mostly semi-annual measurements. Land use surrounding this well is predominantly a rural pasture and dairy cattle.

The hydrograph for Well 02N01W08B001H in the Eel River Valley shows seasonal fluctuations in groundwater levels of about 6 to 8 feet during normal and drought years, and approximately 12 to 13 feet during wet years. A long-term comparison of spring-to-spring groundwater levels shows a very slight decline and recovery of groundwater levels associated with the 1976-1977 and the 1986-1994 droughts. Groundwater levels in wells that are closely connected to nearby perennial surface water systems are typically more affected by wet rather than drought years. Perennial surface water systems tend to provide a consistent source of recharge, which helps to govern the maximum seasonal decline in groundwater levels. Spring-to-spring groundwater levels during years of normal precipitation show a trend of slightly declining groundwater levels since the late 1960s. The Eel River Valley Groundwater Basin is designated as a CASGEM medium-priority groundwater basin.

Hydrograph 06N08W15J003M

Figure 3-11d is a hydrograph for Well 06N08W15J003M and depicts changes in groundwater use and conjunctive management practices in southern Sonoma County in the Santa Rosa Plain Groundwater Subbasin (1-55.01). The hydrograph for Well 06N08W15J003M shows the relationship between groundwater elevations and the availability of increased surface water supplies. The hydrograph is from an inactive well that is constructed in the upper 160 feet of the aquifer, within the alluvial deposits and the Glen Ellen Formation. The area surrounding the well is a combination of suburban residential and commercial land use. Groundwater-level monitoring in the well was conducted on a roughly semi-annual basis from 1950 to 1976, and then monthly from 1977 to present. Santa Rosa Plain Groundwater Subbasin is designated as a CASGEM medium-priority groundwater basin.

The hydrograph shows that from 1950 to 1986, the groundwater elevation declined approximately 50 feet resulting from groundwater extraction. During this time, municipal groundwater pumping in the Southern Santa Rosa Plain increased from less than 1,000 af in 1969 to more than 5,000 af in 1986, while surface water deliveries during this time averaged less than 500 af/yr., with some years having no surface water supply to the area.

SCWA began increasing its municipal surface water deliveries in 1986. Surface water deliveries increased from about 1,000 af/yr. in 1986 to about 4,000 af/yr. in 2003, and then to 6,000 af/yr. in 2005. Between 1986 and 2000, groundwater continued to be pumped at a volume between 5,000 and 6,000 af/yr. As shown on the hydrograph in Figure 3-11d, groundwater elevations did not start to recover until groundwater pumping was reduced to less than 2,000 af in 2003, and then to about 500 af in 2005. The 40-feet of groundwater-level recovery between 2003 and 2005 was also the result of additional increases in surface water deliveries during that same time.

The conjunctive management efforts in the Santa Rosa Plain Groundwater Subbasin not only reflects the important balance between groundwater extraction and surface water availability, but also illustrates the positive effects of water conservation and the use of recycled water supplies for irrigation.

Change in Groundwater in Storage

Change in groundwater in storage is the difference in groundwater volume between two different time periods. Change in groundwater in storage is calculated by multiplying the difference in groundwater elevation between two monitoring periods, by the overlying groundwater basin area, and by the estimated specific yield or volume of pore space from which water may be extracted.

Examining the annual change in groundwater in storage over a series of years helps identify aquifer response to changes in hydrology, land use, and groundwater management. If the volumetric change in storage is negligible over a period represented by average hydrologic and land-use conditions, the groundwater basin is considered to be in equilibrium. Declining groundwater levels and reduction of groundwater in storage during years of average hydrology and land use do not always indicate groundwater basin overdraft or unsustainable management; typically, some additional investigation is required. Use of groundwater in storage during years of diminishing surface water supply, followed by active recharge of the aquifer when surface water or other alternative supplies become available, is a recognized and acceptable approach to conjunctively managing a groundwater basin. Additional information regarding risks and benefits of conjunctive management in California can be found in *California Water Plan Update 2013,* Volume 3, Chapter 9, “Conjunctive Management and Groundwater Storage.”

Changes-in-groundwater-in-storage estimates for the North Coast region were not developed for *California Water Plan Update 2013*. SCWA is in the process of developing a GWMP for the Santa Rosa Plain Watershed and will be developing modeling-based information that can be used to determine changes of groundwater in storage in the Santa Rosa Valley aquifers. It is unknown if any of the other local groundwater management agencies in the North Coast region are developing changes-in-groundwater-in-storage estimates.

Groundwater Quality

Groundwater quality problems in the North Coast region include contamination from seawater intrusion and nitrates in shallow coastal groundwater aquifers; high total dissolved solids (TDS) and alkalinity in groundwater associated with the lake sediments of the Modoc Plateau groundwater basins; and iron, boron, and manganese in the inland groundwater basins of Mendocino, Sonoma, and Siskiyou counties.

Cleanup of shallow groundwater contamination remains a high priority in the North Coast region. The region is predominately rural and, for that reason, many people rely on shallow (sometimes hand-dug) wells for their drinking water. Various activities (e.g., wood treatment facilities, unlined landfills, leaking underground storage tanks, and dry cleaning facilities) have contributed to contamination of the shallow groundwater and, in some areas, this resource is not used because of contamination. Several State and federal GAMA-related groundwater quality reports that help assess and outline the groundwater quality conditions for the North Coast region are listed in Table 3-9.

Groundwater Quality at Community Drinking Water Wells

In 2013, the SWRCB recently completed a report to the Legislature, titled *Communities that Rely on a Contaminated Groundwater Source for Drinking Water* (State Water Resources Control Board 2013). The report focused on chemical contaminants found in active groundwater wells used by CWSs. A CWS is defined under the California Health and Safety Code Section 116275 as a "public water system that serves at least 15 service connections used by yearlong residents or regularly serve at least 25 yearlong residents of the area served by the system." CWSs serve the same group of people, year-round, from the same group of water sources. The findings of this report reflect raw untreated groundwater and do not necessarily reflect the final quality of groundwater delivered to these communities.

In the North Coast region, there are an estimated 260 CWSs, with an estimated 416 active CWS wells. Table 3-10 shows that 21 of the 416 CWS wells (5 percent) are identified as being affected by one or more chemical contaminants that exceed an MCL. These 21 affected wells are used by the 15 CWSs in the region, with 11 of the 15 affected CWS serving small communities that commonly require financial assistance to construct water treatment facilities or alternate solutions to meet drinking water standards (Table 3-11). The most prevalent groundwater contaminant affecting the region is arsenic, which affects 16 of the 21 CWSs (Table 3-12).

While most large CWSs are able to construct, operate, and maintain a water treatment system to remove or reduce groundwater contaminants below drinking water standards, small CWSs often cannot afford the high cost to operate and maintain a treatment system and, consequently, some are unable to provide drinking water that meets primary drinking water standards. As of February 2013, there were eight small CWSs in the North Coast region that violate a primary drinking water standard, primarily caused by groundwater contaminants. Seven of the eight small CWSs are affected by arsenic (California Department of Public Health 2013).

Table 3-9 GAMA Groundwater Quality Reports for the North Coast Hydrologic Region

Data Summary Reports:
Cascade Range and Modoc Plateau http://pubs.usgs.gov/ds/688/pdf/ds688.pdf.
Northern Coast Ranges http://www.waterboards.ca.gov/gama/docs/northern_coast_ranges_dsr.pdf
North San Francisco Bay http://www.waterboards.ca.gov/gama/docs/nsfb_dsr_final.pdf.
Klamath Mountains http://dx.doi.org/10.3133/fs20143031.
Assessment Report:
Status and Understanding of Groundwater Quality in the North San Francisco Bay Groundwater Basins http://www.waterboards.ca.gov/gama/docs/nsfbay_sir.pdf.
Fact Sheet:
Groundwater Quality in the North San Francisco Bay Groundwater Basins http://www.waterboards.ca.gov/gama/docs/nsfb_facts.pdf.
Domestic Well Project:
No counties in this region have been sampled by this program
Other Relevant Report:
Communities that Rely on a Contaminated Groundwater Source for Drinking Water http://www.waterboards.ca.gov/water_issues/programs/gama/ab2222/index.shtml.

Groundwater Quality Analysis of Domestic Wells

Private domestic wells are typically used by either single-family homeowners or other groundwater-reliant systems that are not regulated by the State. Domestic wells generally tap shallower groundwater, making them more susceptible to contamination. Many domestic well owners are unaware of the quality of the well water because the State does not require well owners to test their water quality. Although private domestic well water quality is not regulated by the State, it is a concern to local health and planning agencies and to State agencies in charge of maintaining water quality.

In an effort to assess domestic well water quality, the SWRCB's GAMA Domestic Well Project samples domestic wells for commonly detected chemicals at no cost to well owners who voluntarily participate in the program. Results are shared with the well owners and used by the GAMA Program to evaluate the quality of groundwater used by private well owners. As of 2011, the GAMA Domestic Well Project had sampled 1,146 wells in six county focus areas (Monterey, San Diego, Tulare, Tehama, El Dorado and Yuba counties).

Table 3-10 Community Drinking Water Wells that Exceed a Primary Maximum Contaminant Level Prior to Treatment in the North Coast Hydrologic Region

Well Information	Community Water System[a] Wells
Number of Affected Wells[b]	21
Total Wells in the Region	416
Percentage of Affected Wells[b]	5%

Source: State Water Resources Control Board's Report to the Legislature, *Communities that Rely on a Contaminated Groundwater Source for Drinking Water* (2013)

Notes:
[a]Community water system means a public water system that serves at least 15 service connections used by year-long residents or regularly serves at least 25 year-long residents of the areas served by the system (Health & Safety Code Section 116275).
[b]Affected wells exceeded a primary maximum contaminant level prior to treatment at least twice from 2002 to 2010. Gross alpha levels were used as a screening assessment only and did not consider uranium correction.)

Table 3-11 Community Drinking Water Systems that Rely on Contaminated Groundwater Wells in the North Coast Hydrologic Region

System Information	Community Water Systems[a]		
	Number of Affected Water Systems[b]	Total Water Systems in the Region	Percentage of Affected Water Systems[b]
Small Systems Population ≤ 3,300	11	233	5%
Medium Systems Population 3,301-10,000	2	16	13%
Large Systems Population > 10,000	2	11	18%
TOTAL	**15**	**260**	**6%**

Source: State Water Resources Control Board's Report to the Legislature, *Communities that Rely on Contaminated Groundwater Source for Drinking Water* (2013)

Notes:
[a]A community water system is a public water system that serves at least 15 service connections used by year-long residents, or regularly serves at least 25 year-long residents of the areas served by the system (Health & Safety Code Section 116275).
[b]Affected water systems are those with one or more wells that exceed a primary maximum contaminant level prior to treatment at least twice from 2002 to 2010. Gross alpha levels were used as a screening assessment only and did not consider uranium correction.
State small water systems are not included in this table. These systems serve five to 14 service connections and do not regularly serve water to more than 25 people. In general, state small water systems are regulated by county environmental health departments.

Table 3-12 Contaminants Affecting Community Drinking Water Systems[a] in the North Coast Hydrologic Region

Principal Contaminant	Number of Affected Water Systems[b] (PC Exceeds the Primary MCL)	Number of Affected Wells[c,d] (PC Exceeds the Primary MCL)
Arsenic	12	16
Nitrate	1	3
Trichloroethylene (TCE)	2	2
1,1-Dichloroethylene (1,1-DCE)	1	1

Source: State Water Resources Control Board's Report to the Legislature, *Communities that Rely on Contaminated Groundwater Source for Drinking Water* (2013)

Notes:
MCL = maximum contaminant level (State and/or federal), PC = principal contaminant
[a]A community water system is a public water system that serves at least 15 service connections used by year-long residents, or regularly serves at least 25 year-long residents of the areas served by the system (Health & Safety Code Section 116275).
[b]Affected water systems are those with one or more wells that exceed a primary maximum contaminant level prior to treatment at least twice from 2002 to 2010.
[c]Affected wells exceeded a primary maximum contaminant level prior to treatment at least twice from 2002 to 2010. Gross alpha levels were used as a screening assessment only and did not consider uranium correction.
[d]One well is affected by two contaminants.

The GAMA Domestic Well Project tests for chemicals that are most commonly a concern in domestic well water. These constituents include:

- Bacteria (total and fecal coliform).
- General minerals (sodium, bicarbonate, calcium, others).
- General chemistry parameters (pH, TDS, others).
- Inorganics (lead, arsenic, and other metals) and nutrients (nitrate, others).
- Organics (benzene, toluene, perchloroethylene [PCE], methyl tertiary butyl ether [MTBE], and others).

In addition to the above constituents, the GAMA Domestic Well Project may analyze for locally known chemicals of concern. Some of these chemicals include radionuclides, perchlorate, pesticides, and chromium VI.

The GAMA Domestic Well Project has not sampled private domestic wells in the counties in the North Coast region.

Groundwater Quality — GAMA Priority Basin Project

The GAMA Priority Basin Project was initiated to provide a comprehensive baseline of groundwater quality in the state and to assess deeper groundwater basins that account for more than 95 percent of all groundwater used for public drinking water supply. The GAMA Priority Basin Project is grouped into 35 groundwater basin groups statewide called “study units” and is being implemented by the SWRCB, the USGS, and the LLNL.

The GAMA Priority Basin Project tests for constituents that are a concern in public supply wells. The list of constituents includes:

- Field parameters.
- Organic.

- Pesticides.
- Constituents of special interest.
- Inorganic.
- Radioactive.
- Microbial.

For the North Coast region, the USGS has completed data summary reports for the following study units:

- Cascade Range and Modoc Plateau.
- Northern Coast Ranges.
- North San Francisco Bay.

These study units all cover multiple hydrologic regions. The Cascade Range and Modoc Plateau Study Unit includes wells in the North Coast, Sacramento River, and North Lahontan hydrologic regions. The Northern Coast Ranges Study Unit includes wells in the North Coast and Sacramento River hydrologic regions. The North San Francisco Bay Study Unit includes wells in the North Coast and San Francisco Bay hydrologic regions.

For comparison purposes only, groundwater quality results from these data summary reports were compared against the following public drinking water standards established by CDPH and/or the U.S. Environmental Protection Agency (EPA). These standards included MCLs, secondary maximum contaminant levels (SMCLs), notification levels (NLs), and lifetime health advisory levels (HALs). A summary of untreated groundwater quality results for these study units is listed in Table 3-13. In addition to these data summary reports, USGS has completed some assessment reports and fact sheets for the North Coast region listed in Table 3-13.

Land Subsidence

In 2001-2002, a Tule Lake GPS land subsidence monitoring network was installed in response to the 2001 Klamath Basin drought emergency and the ongoing potential for increased groundwater extraction. The existing GPS land subsidence network consists of 23 stations. Partial reoccupation of the GPS subsidence network was conducted in 2011.

The 2011 reoccupation of the Tule Lake Groundwater Subbasin subsidence network included 6 of the 23 GPS monuments along the east and southeast portion of the groundwater subbasin. The six monuments were surveyed using equipment similar to that used in 2001. Reoccupation results indicate that there has been no noticeable subsidence on the east side of the Tule Lake Groundwater Subbasin. Full reoccupation of all 23 stations has not been performed because of limited funding.

Further monitoring and analysis of land subsidence in the North Coast region is unknown. Additional information regarding land subsidence in California is provided in Appendix F.

Table 3-13 Groundwater Quality Results from GAMA Data Summary Reports for the North Coast Hydrologic Region

Constituent	Health-Based Threshold	Number of Detections Greater Than Health Based Threshold					
		Cascade Range and Modoc Plateau[a]			North Coast Ranges[b]		North San Francisco Bay Study Unit[c]
		Shasta Valley and Mt. Shasta Volcanic Area	Quaternary and Tertiary Volcanic Areas	Cascade Range and Modoc Plateau Low Use Basins	Coastal Basins	Interior Basins	
Number of Wells		15	5	5	30	19	44
Inorganic Constituents							
Arsenic	MCL	1	-	-	-	1	1
Beryllium	MCL	-	-	-	-	-	-
Boron	NL	-	2	-	-	3	1
Chromium (Total)	MCL	-	-	-	-	-	-
Fluoride	MCL	-	-	-	-	-	-
Molybdenum	MCL	-	1	-	-	-	-
Nitrate	MCL	-	-	-	-	-	-
Nitrite	MCL	-	-	-	-	-	-
Selenium	MCL	-	-	-	-	-	-
Thallium	MCL	-	-	-	-	-	-
Uranium	MCL	-	-	-	-	-	-
Vanadium	NL	1	-	-	-	-	-
Organic Constituents							
VOCs	MCL	0	0	0	0	0	0
Pesticides	MCL	0	0	0	0	0	0
Constituents of Special Interest							
Perchlorate	MCL	0	0	0	0	0	0
NDMA	NL	-	-	-	-	-	0
1,2,3 TCP	NL	-	-	-	-	-	0
Radioactive Constituents							
Gross Alpha	MCL	0	0	0	0	0	0

Constituent	Health-Based Threshold	Number of Detections Greater Than Health Based Threshold					
		Cascade Range and Modoc Plateau[a]			North Coast Ranges[b]		North San Francisco Bay Study Unit[c]
Secondary Standards							
Chloride[d]	SMCL	-	1	-	-	-	-
Iron	SMCL	-	-	1	8	4	-
Manganese	SMCL	1	1	1	-	-	5
Sulfate[d]	SMCL	-	-	-	-	-	-
Total Dissolved Solids[d]	SMCL	2	2	1	-	-	-

Sources:
U.S. Geological Survey (2006, 20110, 2011, 2014)

Notes:
GAMA = Groundwater Ambient Monitoring and Assessment, HAL = lifetime health advisory level (EPA), MCL = maximum contaminant level (State and/or federal), NL = notification level (State), SMCL = secondary maximum contaminant level (State), TDS = total dissolved solids, VOC = volatile organic compound, USGS = U.S. Geological Survey

[a]The Cascade Range and Modoc Plateau Study Unit includes 90 wells in the North Coast, Sacramento River and North Lahontan hydrologic regions. Forty-eight wells are in the Sacramento River Hydrologic Region and are shown in figures 4A and 4B, well ID numbers SH-01 through 15, QV-013, 02, 04, TV-01, 15, and LU-01, 02, 07, 08, 10 (USGS 2010).

[b]The North Coast Ranges Study Unit includes 58 wells in the North Coast and Sacramento River hydrologic regions. Forty-nine wells are in the North Coast Hydrologic Region and are shown in figures 2A, 2B, 3A, 3B, and 3C, well ID numbers NOCO-IN 01 through 16, 19, 23, 28, and NOCO-CO 01 through 309 (USGS 2011).

[c]The North San Francisco Bay Study Unit includes 89 wells in the North Coast and San Francisco Bay hydrologic regions. Forty-four wells are in the North Coast Hydrologic Region and are shown in figures 3, 4, and 5, well ID numbers NSFVP 1 through 20, 23, 24, 25, 26, 29, 30, 31, 42, NSFVPFP 1, 2, 4, NSFVOL 1, 2, 9, NSFWG 1, 3, 4, 5, 8, 9, 12, 13, 14, and NSFWGFP 1 (USGS 2006).

[d]Wells that exceed SMCLs for chloride, sulfate, and TDS are greater than recommended levels.

Groundwater Management

In 1992, the California Legislature provided an opportunity for formal groundwater management with the passage of AB 3030, the Groundwater Management Act (California Water Code Section 10750 et seq.). Groundwater management, as defined in DWR Bulletin 118-2003, is "the planned and coordinated monitoring, operation, and administration of a groundwater basin, or portion of a basin, with the goal of long-term groundwater resource sustainability." Groundwater management needs are generally identified and addressed at the local level in the form of GWMPs. If disputes over how groundwater should be managed cannot be resolved at the local level, additional actions, such as enactment of ordinances by local entities with jurisdiction over groundwater, passage of laws by the Legislature, or decisions made by the courts (groundwater basin adjudications), may be necessary to resolve the conflict. Under current practice, DWR's role in groundwater management is to provide technical and financial assistance to support local agencies in their groundwater management efforts.

In addition to AB 3030, enacted legislation includes SB 1938, AB 359, and provisions of SB X7-6 and AB 1152. These significant pieces of legislation establish specific procedures on how GWMPs are to be developed and adopted by local agencies. They define the required and voluntary technical components that must be part of a GWMP and a CASGEM Groundwater

Elevation Monitoring Plan. AB 359, introduced in 2011, made changes to the California Water Code that require local agencies to provide a copy of their GWMP to DWR and require DWR to provide public access to those plans. Prior to the passage of AB 359, which went into effect on January 1, 2013, local groundwater management planning agencies were not required to submit their GWMPs to DWR. As such, the groundwater management information included in this report is based on documents that were readily available or submitted to DWR as of August 2012 and may not be all-inclusive, especially for those plans that were in the process of being finalized and adopted in 2012.

Groundwater management in California also occurs through other resource planning efforts. Urban water management plans (UWMPs) incorporate long-term resource planning to meet existing and future water demands. Agricultural water management plans (AWMPs) advance irrigation efficiency that benefits both farms and the environment. IRWM planning is a collaborative effort to regionally identify and align all aspects of water resource management and planning. Given California's reliance on groundwater to meet municipal, agricultural, and environmental needs, developing a thorough understanding of the planning, implementation, and effectiveness of existing groundwater management in California is an important first step toward sustainable management of this valuable resource.

DWR's Groundwater Web site (http://water.ca.gov/groundwater/) has the latest information on California's groundwater management planning efforts and includes a summary of the Sustainable Groundwater Management Act, enacted in September 2014. The Sustainable Groundwater Management Act, a three-bill legislative package, includes the provisions of SB 1168 (Pavley), AB 1739 (Dickinson), and SB 1319 (Pavley). The act mandates the formation of locally controlled groundwater sustainability agencies in high- and medium-priority groundwater basins with the goal of sustainably managing local groundwater resources. Many of the newly established components of the act are based on the required, voluntary, and recommended groundwater management components described in the following sections.

The following sections provide an inventory and assessment of GWMPs, groundwater basin adjudications, county ordinances, and other groundwater planning activities in the North Coast region.

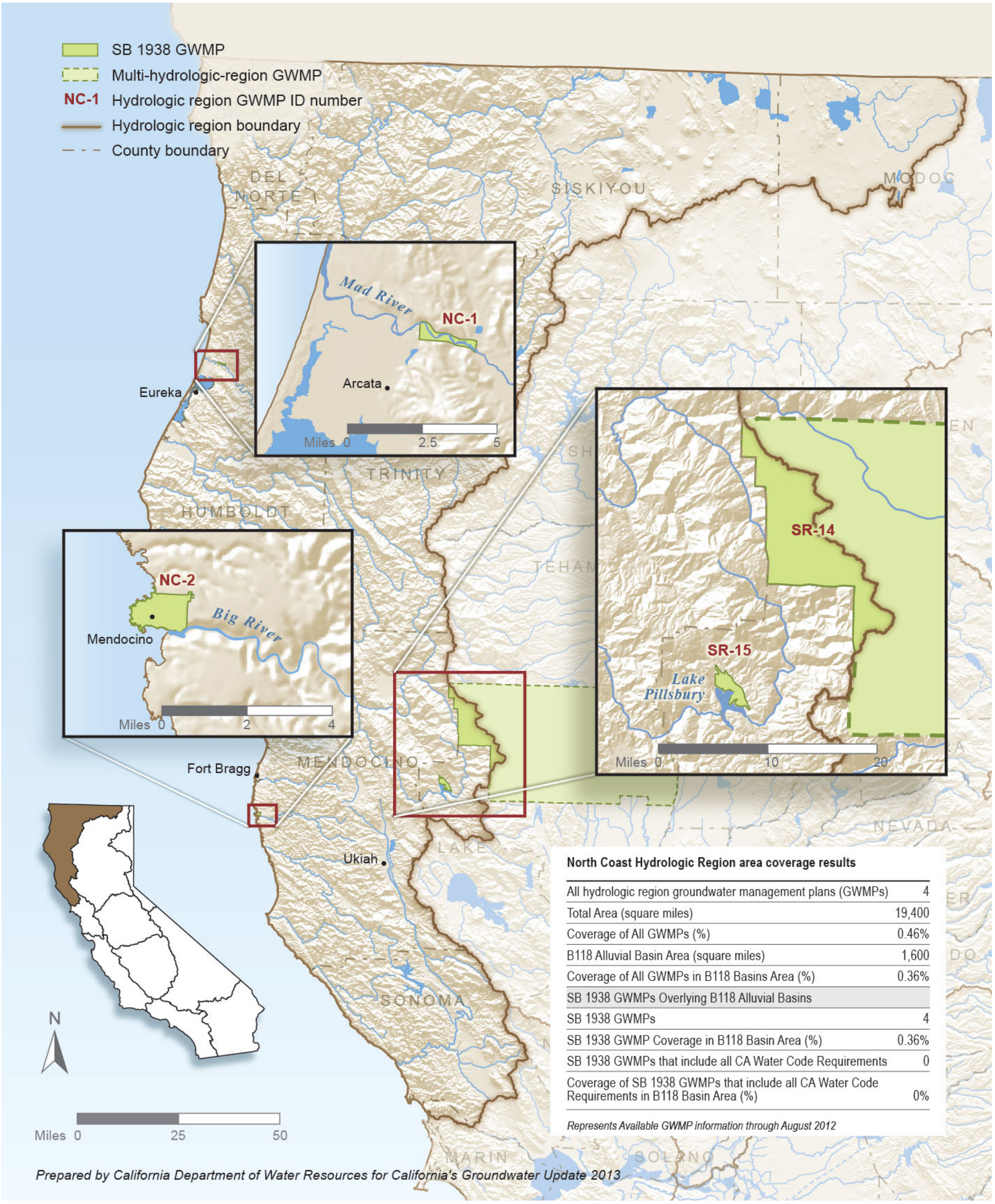
Groundwater Management Plan Inventory

Groundwater management information included in this chapter is based on GWMP documents that were readily available or submitted to DWR as of August 2012. The inventory of GWMPs identifies adopting and signatory agencies, the date of plan adoption, the location of plans by county, and the groundwater basins the plans cover. The inventory also provides the number of GWMPs developed based on AB 3030 (1992) and indicates how many were developed or updated to meet the additional groundwater management requirements associated with SB 1938 (2002).

The North Coast region includes about 1,600 square miles of Bulletin 118-2003 alluvial groundwater basins. Figure 3-12 shows the location and distribution of the GWMPs in the North

Coast region and indicates pre-SB 1938 compared with post-SB 1938 GWMPs. Table 3-14 lists the known North Coast region GWMPs as of August 2012.

Figure 3-12 Groundwater Management Plans in the North Coast Hydrologic Region



North Coast Hydrologic Region area coverage results	
All hydrologic region groundwater management plans (GWMPs)	4
Total Area (square miles)	19,400
Coverage of All GWMPs (%)	0.46%
B118 Alluvial Basin Area (square miles)	1,600
Coverage of All GWMPs in B118 Basins Area (%)	0.36%
SB 1938 GWMPs Overlying B118 Alluvial Basins	
SB 1938 GWMPs	4
SB 1938 GWMP Coverage in B118 Basin Area (%)	0.36%
SB 1938 GWMPs that include all CA Water Code Requirements	0
Coverage of SB 1938 GWMPs that include all CA Water Code Requirements in B118 Basin Area (%)	0%

Represents Available GWMP information through August 2012

Table 3-14 Groundwater Management Plans in the North Coast Hydrologic Region

Map Label	Agency Name	Date	County	Basin Number	Basin Name
NC-1	**Humboldt Bay Municipal Water District**	2006	Humboldt	1-8.01	Mad River Lowland Subbasin
-	No signatories on file	-	-	-	-
NC-2	**Mendocino City Community Services District**	2007	Mendocino	1-21	Fort Bragg Terrace Area Basin
-	No signatories on file	-	-	-	Non-Bulletin-118-Basin
SR-14	**Glenn County**	2009	Glenn	5.21.52	Colusa Subbasin
-	Provident Irrigation District	-	-	5-21.58	West Butte Subbasin
-	Glide Water District	-	-	5.21.51	Corning Subbasin
-	Willow Creek Municipal Water Company	-	-	5.61	Chrome Town Basin
-	California Water Service	-	-	5-62	Elk Creek Area Basin
-	Princeton-Codora-Glenn Irrigation District, Provident Irrigation District	-	-	5-63	Stonyford Town Area
-	Kanawha Water District	-	-	5-88	Stony Gorge Reservoir Basin
-	Glenn-Colusa Irrigation	-	-	5-89	Squaw Flat Basin
-	Orland-Artois Water	-	-	5-90	Funks Creek Basin
-	Western Canal	-	-	-	Non-Bulletin-118-Basin
SR-15	**Lake County Watershed Protection District**	2006	Lake	5-13	Upper Lake Valley
-	No signatories on file	-	-	5-14	Scotts Valley
-	-	-	-	5-16	High Valley
-	-	-	-	5-17	Burns Valley
-	-	-	-	5-18	Coyote Valley
-	-	-	-	5-19	Collayomi Valley
-	-	-	-	5-30	Lower Lake Valley
-	-	-	-	5-31	Long Valley
-	-	-	-	5-66	Clear Lake Cache
-	-	-	-	5-94	Middle Creek
-	-	-	-	1-48	Gravelly Valley (North Coast)

Note:
Table reflects the plans that were received by August 2012.

There are four submitted GWMPs in the North Coast region. Collectively, the four GWMPs cover 90 square miles, approximately 6 square miles of which fall within the boundaries of Bulletin 118-2003 alluvial groundwater basins. Two of the four GWMPs are fully contained in the North Coast region, with two plans including portions of the adjacent Sacramento River Hydrologic Region. Three of the four GWMPs cover areas overlying alluvial groundwater basins identified in Bulletin 118-2003, but two plans also include a management area that extends beyond Bulletin 118-2003 alluvial groundwater basins. The 6-square-mile area covered by GWMPs represents less than 1 percent of the alluvial groundwater basin area in the North Coast region.

The inventory and assessment of GWMPs in the North Coast region determined that all four GWMPs have been developed or updated to include the SB 1938 requirements and are considered "active" for the purposes of GWMP assessment. Yet, as of August 2012, none of the eight North Coast region groundwater basins identified as medium-priority basins under CASGEM Basin Prioritization (Table 3-3) were covered by an active GWMP (Table 3-14). Some efforts are underway to develop additional GWMPs in the North Coast, but more efforts are needed to develop and implement GWMPs that meet the requirements of SB 1938 and AB 359. A GWMP was prepared for the Santa Rosa Plain watershed in 2014. This groundwater planning effort was led by SCWA and incorporated a basin advisory panel that consisted of approximately 30 local members representing various backgrounds.

Groundwater Management Plan Assessment

In 2011 and 2012, DWR partnered with the Association of California Water Agencies (ACWA) to survey local water agencies about their groundwater management, conjunctive water management, and water-banking practices, and to develop a better understanding of existing groundwater management efforts in California. In addition to the information gleaned from the DWR/ACWA groundwater management survey, DWR independently reviewed the GWMPs to assess the following information:

- How many of the post-SB 1938 GWMPs meet the six required components included in SB 1938 and incorporated into California Water Code Section 10753.7.
- How many of the post-SB 1938 GWMPs include the 12 voluntary components included in California Water Code Section 10753.8.
- How many of the implementing or signatory GWMP agencies are actively implementing the seven recommended components listed in DWR Bulletin 118-2003.

Groundwater management planning information collected through the DWR/ACWA survey and through DWR's assessment was not intended to be punitive in nature. It is widely understood that the application of effective groundwater management in California is rife with jurisdictional, institutional, technological, and fiscal challenges. DWR is committed to assisting local agencies develop and implement effective, locally planned, and locally controlled groundwater management programs. DWR is also committed to helping promote State and federal partnerships, and to coordinate with local agencies to expand groundwater-data collection, management, and planning activities that promote effective local groundwater management. The overall intent of the GWMP assessment is to identify groundwater management challenges and successes, and provide recommendations for local and statewide improvement.

As previously mentioned, information associated with the GWMP assessment is based on data that were readily available or received through August 2012. Requirements associated with the 2011 AB 359 (Huffman) legislation, related to groundwater recharge mapping and reporting, did not take effect until January 2013 and are not included in the GWMP assessment effort conducted as part of *California Water Plan Update 2013*. The following information will only address the active plans that were determined by DWR to meet some or all of the SB 1938 requirements.

Required GWMP Components

California Water Code Section 10753.7 requires that six components be included in a GWMP for an agency to be eligible for State funding administered by DWR for groundwater projects, including projects that are part of an IRWM program or plan. The required components of a GWMP are:

1. **Basin Management Objectives.** Basin management objectives (BMOs) include:
   A. Components relating to the monitoring and managing of groundwater levels in the groundwater basin.
   B. Groundwater quality degradation.
   C. Inelastic land surface subsidence.
   D. Changes in surface flow and surface water quality that directly affect groundwater levels or quality or are caused by groundwater pumping in the groundwater basin.
   E. A description of how recharge areas identified in the plan substantially contribute to the replenishment of the groundwater basin.
2. **Agency Cooperation.** The plan will involve other agencies that enable the local agency to work cooperatively with other public entities whose service area or boundary overlies the groundwater basin.
3. **Mapping.** The plan will include a map that shows the area of the groundwater basin as defined in DWR Bulletin 118-2003, the area of the local agency that is subject to the plan, and the boundaries of other local agencies that overlie the groundwater basin for which the agency is developing a GWMP.
4. **Recharge Areas.** Commencing January 1, 2013, the GWMP shall include a map identifying the recharge areas for the groundwater basin, and provide the map to the appropriate local planning agencies and all interested persons, after adoption of the GWMP.
5. **Monitoring Protocols.** The local agency shall adopt monitoring protocols designed to detect changes in groundwater levels, groundwater quality, inelastic surface subsidence (in groundwater basins for which subsidence has been identified as a potential problem), and flow and quality of surface water that directly affect groundwater levels or quality or are caused by groundwater pumping in the basin.
6. **GWMPs Located Outside Bulletin 118-2003 Groundwater Basins.** Plans located outside DWR Bulletin 118-2003 alluvial groundwater basins will incorporate the above components and shall use geologic and hydrologic principles appropriate to those areas.

Three of the six components required subcomponents that were also evaluated. The requirement to develop a map of recharge areas was not required until January 1, 2013; consequently, the requirement was not evaluated. The requirement for local agencies located outside a Bulletin 118-2003 groundwater basin was not applicable for any of the GWMPs in the North Coast region.

DWR determined that none of the four active GWMPs incorporated all of the required components. Table 3-15 identifies the percentage of the four active plans that meet the required components and subcomponents of California Water Code 10753.7. A detailed description of the individual component assessment is presented in the following sections.

Table 3-15 Assessment for GWMP Requirement Components in the North Coast Hydrologic Region

SB 1938 Required Components	Percentage of Plans that Meet Requirement
Basin Management Objectives	25%
BMO: Monitoring/Management Groundwater Levels	100%
BMO: Monitoring Groundwater Quality	100%
BMO: Inelastic Subsidence	75%
BMO: SW/GW Interaction and Affects to Groundwater Levels and Quality	50%
Agency Cooperation	50%
Map	75%
Map: Groundwater basin area	100%
Map: Area of local agency	100%
Map: Boundaries of other local agencies	75%
Recharge Areas (1/1/2013)	Not Assessed
Monitoring Protocols	0%
MP: Changes in groundwater levels	100%
MP: Changes in groundwater quality	75%
MP: Subsidence	50%
MP: SW/GW Interaction and Affects to Groundwater Levels and Quality	25%
Met all required components, and subcomponents:	**0%**

Notes:
GW = groundwater, SW = surface water
Table reflects assessment results of SB 1938 plans that were received by August 2012.

Basin Management Objectives

The BMO assessment consisted of each of four required BMO subcomponents evaluated as part of the GWMP assessment. The subcomponents include the monitoring and management of (1) groundwater levels, (2) groundwater quality, (3) inelastic land subsidence, and (4) surface-water–groundwater interaction.

The assessment indicated that one of the four GWMPs met the overall BMO requirement by providing measurable objectives and actions that will occur when specific conditions are met for each of the BMO subcomponents. Three GWMPs did not meet the overall BMO component, but did have the required information for two of the four BMO subcomponents that relate to the monitoring and management of groundwater levels and groundwater quality. As a result, these GWMPs were found to be in partial compliance.

The BMO subcomponent that was most commonly missing or not adequately addressed in the four active GWMPs was the requirements for the monitoring and management of surface water and groundwater interaction. Most of these plans mentioned the requirement, but were vague about how such a program would be initiated, measured, and managed. One GWMP did not have provisions in place to detect or address potential inelastic subsidence within their management boundaries or within the groundwater basin as a whole. All four of the plans met the requirements for monitoring and management of groundwater levels and groundwater quality.

Agency Cooperation

Two of the four active GWMPs in the North Coast region provided sufficient details on how the agency was going to coordinate and share groundwater management activities with neighboring agencies and local governments.

Mapping

The mapping requirement of SB 1938 has three subcomponents. The GWMPs are required to provide one or more maps that depict the GWMP area, the associated Bulletin 118-2003 groundwater basin(s), and all neighboring agencies located within the groundwater basin(s). The GWMP assessment determined that three of the four GWMPs met all three of the requirements for mapping. The most common detail left off the required maps was identification of the neighboring agencies that share the same groundwater basin(s).

Monitoring Protocols

The monitoring protocol component consists of four subcomponents. In accordance with SB 1938, GWMPs are required to establish monitoring protocols for assessing groundwater levels, groundwater quality, inelastic land subsidence, and surface-water–groundwater interaction.

The monitoring protocols assessment determined that none of the four GWMPs met all of the required monitoring protocol subcomponents. The protocols for the monitoring of groundwater levels were detailed in each of the four plans. The review determined that three GWMPs included the monitoring protocols for water quality, two GWMPs included plans for monitoring inelastic land subsidence, and one GWMP provided details that identify the interaction of surface water and groundwater levels and how they relate to water quality and groundwater pumping.

Voluntary GWMP Components

In addition to the six required components, California Water Code Section 10753.8 provides a list of 12 components that may be included in a GWMP. The voluntary components include the following:

1. The control of saline water intrusion.
2. Identification and management of wellhead protection areas and recharge areas.
3. Regulation of the migration of contaminated groundwater.
4. The administration of a well abandonment and well destruction program.
5. Mitigation of conditions of overdraft.
6. Replenishment of groundwater extracted by water producers.
7. Monitoring of groundwater levels and storage.
8. Facilitating conjunctive use operations.
9. Identification of well construction policies.
10. The construction and operation by the local agency of groundwater contamination cleanup, recharge, storage, conservation, water recycling, and extraction projects.
11. The development of relationships with State and federal regulatory agencies.
12. The review of land use plans and coordination with land use planning agencies to assess activities which create a reasonable risk of groundwater contamination.

The percentage of GWMPs in the North Coast region that included the voluntary components is shown in Table 3-16. The assessment of some voluntary components was expanded to include subcomponents, which helped determine a level of inclusion. In many cases, if the GWMP included one or more of the subcomponents, the plan was considered to fully meet the voluntary component.

Table 3-16 Assessment of GWMP Voluntary Components in the North Coast Hydrologic Region

Voluntary Components	Percentage of Plans that Include Component
Saline Intrusion	50%
Wellhead Protection and Recharge	50%
Groundwater Contamination	75%
Well Abandonment and Destruction	75%
Overdraft	75%
Groundwater Extraction and Replenishment	50%
Monitoring	100%
Conjunctive Use Operations	25%
Well Construction Policies	75%
Construction and Operation	75%
Regulatory Agencies	75%
Land Use	25%

Notes:
GWMP = groundwater management plan
Table reflects assessment results of SB 1938 plans that were received by August 2012.

Table 3-16 shows that all four of the GWMPs in the North Coast region included the voluntary components groundwater monitoring. Three of the four GWMPs included planning details for groundwater contamination, well abandonment policies, overdraft, well construction policies, construction and operation projects, and coordination with regulatory agencies. Half, or fewer, of the GWMPs includes details concerning saline intrusion, wellhead protection and recharge, groundwater extraction and replenishment, conjunctive use operations, and land use.

It is not clear from the assessment whether the low percentages of voluntary component activity were the result of the GWMP not being updated to incorporate recent voluntary component activities, agencies feeling these were not needed, or both. For example, the construction and operation projects component can include one or more projects covering groundwater contamination cleanup, recharge, storage, conservation, water recycling, and extraction. Many of these projects can take years to plan, fund, and implement. Continuing to update GWMPs with newly required component activities can be time consuming and expensive. Based on DWR's discussions with a several GWMP entities around the state, it was apparent that agencies do not regularly update their GWMPs as new projects are implemented. It is likely that the construction and operation of newly developed projects have not been listed in the most recent GWMP document.

In summary, one of the four GWMPs in the North Coast region incorporated all 12 of the voluntary components, one plan incorporated 10 of the voluntary components, and the remaining two plans incorporated five or fewer of the voluntary components.

Bulletin 118-2003–Recommended GWMP Components

Bulletin 118-2003, Appendix C, provides a list of seven recommended components related to management, development, implementation, and evaluation of a GWMP that should be considered to help ensure effective and sustainable groundwater management. A summary of the the recommended components in Bulletin 118-2003 are provided below.

1. **Guidance.** Establish an advisory committee to assist in GWMP development and implementation.
2. **Management Area.** Describe the physical setting, aquifer characteristics, and background data.
3. **BMOs, Goals, and Actions**. Describe how the current or planned actions help meet the overall BMOs and goals.
4. **Monitoring Plan Description.** Describe groundwater monitoring type, location, frequency, and aquifer interval.
5. **IRWM Planning**. Describe efforts to coordinate with other land use or water management planning.
6. **Implementation.** Develop status reports with management actions, monitoring activities, groundwater basin conditions, and achievements.
7. **Evaluation.** Develop periodic assessments of conditions in relation to management objectives.

Table 3-17 identifies what percentage of the North Coast region GWMPs include the seven recommended components outlined in Bulletin 118-2003. Results from the GWMP assessment showed that three of the four GWMPs discussed the plans' management area, provided a detailed monitoring plan description, included details for implementation of their GWMP, and discussed future evaluations of their plans.

Two of the four GWMPs intend to create an advisory committee to guide the planning and implementation of their GWMP, stated how each of the adopted management objectives helps to attain their goals, and described how current and planned actions by the managing entity will help meet the adopted management objectives. One plan included information on their involvement in IRWM planning in their area.

In summary, one of the four GWMPs in the North Coast region incorporated all recommended components in Bulletin 118-2003, and three of the four GWMP incorporated five or fewer of the recommended components.

DWR/ACWA Survey — Key Factors for Successful GWMP Implementation

As noted in the previous section, DWR partnered with ACWA to survey its member agencies on various topics covering groundwater management. The survey respondents were asked to identify which of the listed components helped make their GWMP implementation successful. The participants were asked to provide additional insights and list additional components, but not to rank their responses in terms of importance. One agency from the North Coast region participated in the survey. Table 3-18 is a summary of the response from the single participating agency.

Table 3-17 Assessment of DWR Bulletin 118-2003–Recommended Components in the North Coast Hydrologic Region

Recommended Components	Percentage of Plans that Include Component
GWMP Guidance	50%
Management Area	75%
BMO, Goals, and Actions	50%
Monitoring Plan Description	75%
IRWM Planning	25%
GWMP Implementation	75%
GWMP Evaluation	75%

Notes:
BMO = basin management objectives, GWMP = groundwater management plan,
IRWM = integrated regional water management
Table reflects assessment results of SB 1938 plans that were received by August 2012.

Data collection, information sharing, developing an understanding of common interest, and stakeholder participation were reported as important components to their groundwater management planning successes. Having adequate surface water supplies, as well as adequate storage and infrastructure systems, were also deemed important. In addition, sufficient funding and time necessary to develop a GWMP were indicated as factors important to success. Further research is needed to better understand the key factors that contribute to successful implementation of effective groundwater management.

Table 3-18 Survey Results for Key Components Contributing to Successful GWMP Implementation in the North Coast Hydrologic Region

Key Components that Contributed to Success	Respondents
Sharing of Ideas and Information with other Water Resource Managers	1
Data Collection and Sharing	1
Adequate Surface Water Supplies	1
Adequate Regional and Local Surface Storage and Conveyance	1
Outreach and Education	-
Developing an Understanding of Common Interest	1
Broad Stakeholder Participation	1
Water Budget	-
Funding	1
Time	1

Notes:
GWMP = groundwater management plan
Results from an online survey sponsored by the California Department of Water Resources and conducted by the Association of California Water Agencies (2011 and 2012).

DWR/ACWA Survey — Key Factors Limiting GWMP Success

Survey participants were also asked to identify key factors that impeded implementation of their GWMP. Table 3-19 shows the survey results. The single respondent indicated limited funding was an impediment to the success of groundwater planning. Funding is a challenging factor for many agencies because the implementation and the operation of groundwater management projects typically are expensive, and the sources of funding for projects typically are limited to either locally raised funds or grants from State and federal agencies. The single respondent also reported that unregulated pumping, as well as access to planning tools, were factors that limited the success of GWMP implementation. Data collection and sharing was an additional concern. Additional research is needed to better understand the full extent to which these limitations affect successful groundwater management.

DWR/ACWA Survey — Opinions of Groundwater Sustainability

Finally, the survey asked if the respondents were confident in the long-term sustainability of their current groundwater supply. The single respondent felt long-term sustainability of their groundwater supply was possible.

Groundwater Ordinances

Groundwater ordinances are laws adopted by local authorities, such as cities or counties, to manage groundwater. In 1995, the California Supreme Court declined to review a lower court decision (*Baldwin v. Tehama County*) that says State law does not occupy the field of groundwater management and does not prevent cities and counties from adopting ordinances to manage and regulate groundwater. Since 1995, the *Baldwin v. Tehama County* decision has remained untested. As a result, the precise nature and extent of the authority of cities and counties to regulate groundwater is still uncertain.

Table 3-19 Survey Results for Factors that Limited the Successful GWMP Implementation in the North Coast Hydrologic Region

Limiting Factors	Respondents
Participation Across a Broad Distribution of Interests	-
Data Collection and Sharing	-
Funding for Groundwater Management Planning	1
Funding for Groundwater Management Projects	1
Funding to Assist in Stakeholder Participation	1
Understanding of the Local Issues	-
Outreach and Education	-
Groundwater Supply	-
Surface Storage and Conveyance Capacity	-
Access to Planning Tools	1
Unregulated Pumping	1
Lack of Governance	-

Notes:
GWMP = groundwater management plan
Results from an online survey sponsored by the California Department of Water Resources and conducted by the Association of California Water Agencies — 2011 and 2012.

There are a number of groundwater ordinances that have been adopted by counties in the North Coast region. The most common ordinances are associated with groundwater wells that regulate well construction, in addition to well abandonment and destruction. Lake, Modoc, and Siskiyou counties have ordinances that address groundwater export permits, Glenn and Siskiyou counties have ordinances that require guidance committees, but only Glenn County addresses groundwater management. None of the ordinances in the North Coast region address groundwater recharge. Table 3-20 lists the ordinances adopted in the North Coast region.

Special Act Districts

Greater authority to manage groundwater has been granted to a few local agencies or districts created through a special act of the Legislature. The specific authority of each agency varies, but the agencies can be grouped into two general categories: (1) agencies having authority to limit export and extraction (upon evidence of overdraft or threat of overdraft); or (2) agencies lacking authority to limit extraction, but having authority to require reporting of extraction and to levy replenishment fees. There are no special act districts in the North Coast region.

Table 3-20 Groundwater Ordinances for the North Coast Hydrologic Region

County	Groundwater Management	Guidance Committees	Export Permits	Recharge	Well Abandonment and Destruction	Well Construction Policies
Del Norte	-	-	-	-	Yes	-
Glenn	Yes	Yes	-	-	Yes	Yes
Humboldt	-	-	-	-	-	Y
Lake	-	-	Yes	-	Yes	Yes
Mendocino	-	-	-	-	Yes	Yes
Modoc	-	-	Yes	-	-	Yes
Siskiyou	-	Yes	Yes	-	Yes	-
Sonoma	-	-	-	-	Yes	Yes
Trinity	-	-	-	-	-	Yes

Note:
Table represents information as of August 2012.

Court Adjudication of Groundwater Rights

Another form of groundwater management in California is through the courts. When the groundwater resources do not meet water demands in an area, landowners may turn to the courts to determine how much groundwater can be rightfully extracted by each overlying landowner or appropriator. The court typically appoints a watermaster to administer the judgment and to periodically report to the court.

There are 24 groundwater adjudications in California as of August 2012. The Scott River Valley is the only adjudicated groundwater basin in the North Coast region. Table 3-21 provides a list of the adjudications in the region. Figure 3-13 shows the location groundwater adjudication in the North Coast region.

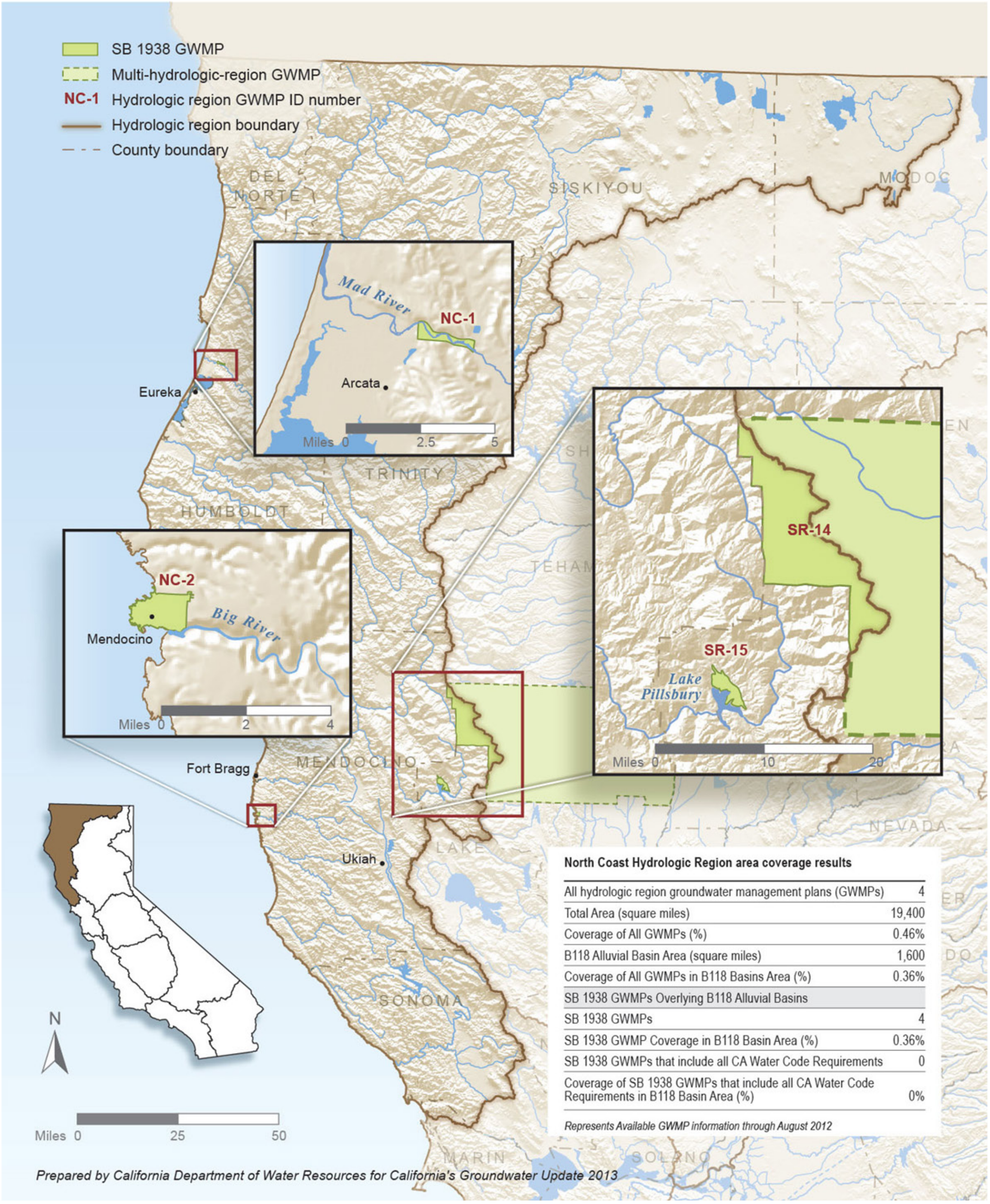
Table 3-21 Groundwater Adjudications in the North Coast Hydrologic Region

ID	Court Judgment	Basin Number	Basin/Subbasin	County	Judgment Date
A-15	Scott River Stream System[a]	1-5	Scott River Valley Basin	Siskiyou	1980

Notes:
[a]Groundwater pumping was restricted within approximately 500 feet of the Scott River.
Table represents information as of April 2013.

All surface water rights and much of the groundwater rights in the Scott River Watershed, excluding the tributaries below Scott Valley, are adjudicated. In 1950, a court decree was issued by Siskiyou County Superior Court for Shackleford Creek, and then in 1958 for French Creek. The California Water Code was amended in 1970 to allow the Scott River surface water system and the supporting groundwater underflow to be considered interconnected. In 1980, the Scott River Adjudication was established through the Scott River Stream System Decree No. 30622. The Scott River Stream System Decree adjudicated the remainder of the valley's surface water claims and incorporated a stipulated portion of the interconnected Scott Valley Groundwater Basin. The 1980 Scott River Adjudication acknowledges interconnection between the Scott River

Figure 3-13 Groundwater Adjudications in the North Coast Hydrologic Region



surface water system and the adjacent groundwater aquifer, and the contribution of the local groundwater basin toward the Scott River base flow. This documented interconnection of surface water and groundwater systems is being used to support a recent landmark lawsuit addressing the impacts of groundwater pumping on surface water systems in the Scott Valley. The 2010 lawsuit (*Environmental Law Foundation, et al. v. State Water Resources Control Board and Siskiyou*

County) is being reviewed in the courts and has the potential to significantly affect the way groundwater is managed, not only in Scott Valley but also in other parts of California.

The 2010 lawsuit by the Environmental Law Foundation et al. alleges the State and Siskiyou County are failing to exercise their authority, under the public trust doctrine, by failing to manage and regulate groundwater extractions that contribute to important base flows in the Scott River. The lawsuit claims that years of approving well-drilling permits have seriously depleted the local aquifer, and created severe water depletion of the Scott River, which was once an important salmon-bearing tributary to the Klamath River and is still home to federally and State-protected Coho salmon. The lawsuit focuses on the groundwater aquifer areas outside the interconnected groundwater–surface-water zone identified in the 1980 adjudication.

In the 1983 landmark "Mono Lake Case" (*National Audubon Society v. Superior Court*), the California Supreme Court recognized that the public trust doctrine applies to surface water management and regulation in California. The 1983 ruling required the waters of California (and its aquatic wildlife) to be held in public trust for the common good and to be protected by the State against depletion or damage by private interests. The court also found that reconsideration and curtailment of long-standing water rights were authorized, if necessary, to protect the public trust. Regardless, the courts have not yet ruled if the public trust doctrine applies to groundwater depletion and the affect it has on nearby surface water systems, which is a prevalent issue affecting many of California's groundwater basins.

The pending landmark lawsuit holds great potential significance because the public trust doctrine has not previously been applied toward regulation and management of groundwater use, and percolating groundwater has not previously been subject to regulation by the SWRCB. If successful, the lawsuit could set a precedent and change the way groundwater is managed in California. If the State is required to take the public trust doctrine into account for allocation and use of interconnected surface-water–groundwater resources, then many California groundwater users could expect an increase in State management and regulation of groundwater, and increased oversight of local groundwater management practices.

Other Groundwater Management Planning Efforts

Groundwater management is also occurring through other avenues. IRWM incorporates the physical, environmental, societal, economic, legal, and jurisdictional aspects of water management into regional solutions through an open and collaborative stakeholder process to promote sustainable water use. UWMPs incorporate long-term resource planning to meet existing and future water demands. AWMPs advance irrigation efficiency that benefits both farms and the environment.

Integrated Regional Water Management Plans

IRWM improves water management and supports economic stability, environmental stewardship, and public safety. IRWM plans involve multiple agencies, stakeholders, individuals, and groups, and cross jurisdictional, watershed, and political boundaries. The methods used in IRWM planning include developing water management strategies that relate to water supply, water quality, water use efficiency, operational flexibility, land and natural resources stewardship, and groundwater resources. Statewide, the majority of IRWM plans address groundwater management in the form of goals, objectives, and strategies. These IRWM plans defer implementation of groundwater management and planning to local agencies through local GWMPs. Few IRWM plans actively manage groundwater. Efforts by these IRWM RWMGs may include creating groundwater contour maps for groundwater basin operations criteria, monitoring groundwater elevations, and monitoring groundwater quality.

The North Coast region, like the San Francisco Bay Hydrologic Region, is unique in that it is fully covered by one IRWM plan. Although the North Coast IRWM plan addresses groundwater resources in its goals and objectives, similar to other IRWM plans throughout the State, it does not actively manage local groundwater resources. Instead, it defers groundwater management to local entities with groundwater management plans. It also identifies county, State, federal, and tribal entities that address groundwater management issues, such as county general plans, CWP, the EPA Underground Injection Control Program, or tribal/reservation plans. Regional prioritization of GWMP development and implementation of local groundwater management planning is one of the goals of the North Coast IRWM region. Figure 3-14 shows the areas of the North Coast region covered by IRWM plans as of September 1, 2011. Table 3-22 lists the status of the IRWM planning areas by hydrologic region. More information about IRWM planning can be found at http://www.water.ca.gov/irwm/index.cfm.

Urban Water Management Plans

UWMPs are prepared by California's urban water suppliers to support their long-term resource planning and to ensure adequate water supplies are available to meet existing and future water demands. UWMPs include system descriptions, demands, and supplies, as well as water shortage reliability and water shortage contingency planning. In addition, the Water Conservation Bill of 2009 (SB X7-7) requires urban water suppliers to:

- Develop a single standardized water-use reporting form for urban water suppliers.
- Develop method(s) by July 1, 2011, to identify per capita targets, and update those methods in four years to meet the 20-percent-reduction goal by 2020.
- Develop technical methodologies and criteria for calculating all urban water use.
- Convene a task force to develop alternative best management practices for commercial, industrial, and institutional water use.

Urban use of groundwater is one of the few uses that meter and report annual groundwater extraction volumes. The groundwater extraction data is currently submitted with the UWMP and then manually translated by DWR staff into a database. Online methods for urban water managers to directly enter their water use along with their UWMP updates are being evaluated. Additional information regarding urban water management and UWMPs can be found at http://www.water.ca.gov/urbanwatermanagement/.

Agricultural Water Management Plans

AWMPs are developed by water and irrigation districts to advance the efficiency of farm water management while benefitting the environment. The AWMPs provide another avenue for local groundwater management. Some of the efficient water management practices being implemented include controlling drainage problems through alternative land use, using recycled water that

Figure 3-14 Integrated Regional Water Management Plans in the North Coast Hydrologic Region

otherwise would not be used beneficially, improving on-farm irrigation systems, and lining or piping ditches and canals. In addition, SB X7-7 requires that agricultural water suppliers:

- Report the status of AWMPs and efficient water management plans, and evaluate their effectiveness.
- Adopt regulations for measuring the volume of water delivered and for a pricing structure based on quantity delivered.
- Develop a method for quantifying efficiency of agriculture water use and a plan for implementation.
- Propose new statewide targets for regional water management practices for recycled water, brackish groundwater, and stormwater runoff.
- Promote implementation of regional water management practices through increased incentives and removal of barriers.

New and updated AWMPs addressing the SB X7-7 requirements were required to be submitted to DWR by December 31, 2012 for review and approval. More information about AWMPs can be found at http://www.water.ca.gov/wateruseefficiency/agricultural/agmgmt.cfm.

Table 3-22 Status of Integrated Regional Water Management Plans in the North Coast Hydrologic Region

Hydrologic Region	IRWM Plan Name	Date	IRWM Plan Status	IRWM Map Number
North Coast	North Coast	2007	Active	21
-	Total Number of IRWM Planning Regions:			1
-	Number of Active IRWM Plans:			1
-	Number of IRWM Plans In Development:			0
-	Number of IRWM Plans that Cross Hydrologic Boundaries:			0

Notes:
IRWM = integrated regional water management
Table represents information as of August 2012.

Conjunctive Management Inventory

Conjunctive management, or *conjunctive use*, refers to the coordinated and planned use and management of both surface water and groundwater resources to maximize the availability and reliability of water supplies in a region to meet various management objectives. Managing both resources together, rather than in isolation, allows water managers to use the advantages of both resources for maximum benefit.

Conjunctive management of surface water and groundwater has been utilized for decades by numerous coastal and inland groundwater basins throughout the North Coast region. Some examples include Eureka Plain, Eel River Valley, Santa Rosa Valley, Smith River Plain, Wilson Grove, Big Valley, Tule Lake Valley, Scott Valley, and Shasta Valley groundwater basins. Many agencies have erected systems of physical barriers to allow more efficient percolation of ephemeral runoff from surrounding mountains.

As part of *California Water Plan Update 2013*, an inventory and assessment of conjunctive management programs was conducted. The overall intent of this effort was to (1) provide a statewide summary of conjunctive water management program locations, operational methods, and capacities; and (2) identify the challenges, successes, and opportunities for growth. The results of the inventory would be shared with policy-makers and other stakeholders to enable an informed decision-making process regarding groundwater and its management. Additional information regarding conjunctive management in California, as well as a discussion of associated benefits, costs, and issues can be found in *California Water Plan Update 2013,* Volume 3, Chapter 9, "Conjunctive Management and Groundwater Storage."

The statewide conjunctive management inventory and assessment consisted of literature research, an online survey, personal communication with local agencies, and a documented summary of the conjunctive management programs in California. Information from these efforts was compiled into a comprehensive spreadsheet of projects and historic operational information. This information was updated and enhanced with data from a coordinated DWR/ACWA survey.

The online survey, administered by ACWA, requested the following conjunctive management program information from its member agencies:

- Location of conjunctive use project.
- Year project was developed.
- Capital cost to develop the project.
- Annual operating cost of the project.
- Administrator/operator of the project.
- Capacity of the project in units of acre-feet.

Although initial response to the DWR/ACWA survey was encouraging, the number of survey participants and the completeness of those responses were limited. In an attempt to build on the survey and develop a greater understanding of the size and diversity of conjunctive management projects in California, staff from each of DWR's four region offices in the Division of Integrated Regional Water Management contacted, either by telephone or through e-mail, each of the local agencies identified as having a conjunctive water management program. DWR's follow-up request for information included additional details regarding:

- Source of water received.
- Put and take capacity of the groundwater bank or conjunctive use project.
- Type of groundwater bank or conjunctive use project.
- Program goals and objectives.
- Constraints on development of conjunctive management or groundwater banking (recharge) program.

Statewide, 89 conjunctive management and groundwater recharge programs were identified. Because of confidentiality concerns expressed by some local agencies, information for some existing conjunctive management programs was not reported. Conjunctive management and groundwater recharge programs in the planning and feasibility stage were not included in the inventory. A statewide map and series of tables listing the conjunctive management projects identified by DWR, grouped by hydrologic region, with information specific to the 11 questions noted in this section, is provided in Appendix D. The project locations shown on the map represents the implementing agency's office address and does not represent the project location.

Conjunctive Management Inventory Results

Although 89 conjunctive management programs were identified in California as part of the DWR/ACWA survey, and although incidental and planned conjunctive management is known to occur in many groundwater basins in the North Coast region, no agencies in the region responded to the survey.

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Edmund G. Brown Jr.
Governor
State of California

John Laird
Secretary for Natural Resources
Natural Resources Agency

Mark Cowin
Director
Department of Water Resources