4.0 GROUNDWATER SUPPLY

This section describes the City's groundwater supply, its hydrologic availability, its water quality, various contracts that affect its use including provisions for transfers and exchange, its reliability and vulnerability, and plans and programs being undertaken related to groundwater.

This Plan projects that 2,577 AFY of groundwater will be available to the City.

4.1 Requirements for Groundwater Sources

Since groundwater is a source of supply, the City must meet the requirements of the Act detailed in Water Code Section 10631(b) (1-4) as outlined below. Where noted in italics, the item is not applicable to the City's Plan.

> "(b) If groundwater is identified as an existing or planned source of water available to the supplier, all of the following information shall be included in the plan:
>
> > (1) A copy of any groundwater management plan adopted by the urban water supplier, including plans adopted pursuant to Part 2.75 (commencing with Section 10750), or any other specific authorization for groundwater management. *The City has not adopted a groundwater management plan.*
> >
> > (2) A description of any groundwater basin or basins from which the urban water supplier pumps groundwater. For those basins for which a court or the board has adjudicated the rights to pump groundwater, a copy of the order or decree adopted by the court or the board and a description of the amount of groundwater the urban water supplier has the legal right to pump under the order or decree. For basins that have not been adjudicated, information as to whether the department has identified the basin or basins as overdrafted or has projected that the basin will become overdrafted if present management conditions continue, in the most current official departmental bulletin that characterizes the condition of the groundwater basin, and a detailed description of the efforts being undertaken by the urban water supplier to eliminate the long-term overdraft condition. *The Santa Rosa Valley Groundwater Basin has not been adjudicated, and no overdraft condition has been reported by the California Department of Water Resources (DWR; DWR is the "department" referenced in the Code). This Plan describes DWR's characterization of the groundwater basin in the most current DWR bulletin. Also, as suggested by DWR (2005), this Plan includes groundwater hydrographs for the basin, and describes groundwater level trends in the basin.*
> >
> > (3) A detailed description and analysis of the location, amount, and sufficiency of groundwater pumped by the urban water supplier for the past five years. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records.

> (4) A detailed description and analysis of the amount and location of groundwater that is projected to be pumped by the urban water supplier. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records."

The locations where the required items for groundwater are found in Chapter 4 are summarized in Table 4 -1.

Table 4-1 Index of Additional Reporting Requirements for Groundwater Supply

Requirement	Water Code Citation	Location in Document
Discussion of groundwater management plans/authority	10631(b)(1)	Section 4.1.4
Description of adjudications or legal rights to pump	10631(b)(2)	Section 4.1.6
Descriptions of DWR determinations related to groundwater	10631(b)(2)	Section 4.1.7
Description of the groundwater basin	10631(b)(2)	Section 4.2 – 4.5
Description and analysis of the location, amount & sufficiency of groundwater pumped in the last 5-years by the City	10631(b)(3)	Section 4.6.1; 4.7
Description and analysis of the amount and location of groundwater projected to be pumped by the City	10631(b)(4)	Section 4.6.2; 4.7.6.2

4.1.1 Definition of Terms

4.1.1.1 Sufficiency

Water Code Section 10631(b) requires "an analysis of the location, amount and sufficiency of the groundwater pumped by the urban water supplier for the past five years."

The City understands the relevant Government and Water Codes sections to mean that the analysis of the sufficiency of groundwater applies to the availability of water supplies to meet the projected water demands during Normal, Single Dry and Multiple Dry years within a 20-year projection. The area from which groundwater will be withdrawn to meet the City's projected demands and other public, agricultural, and industrial uses is the future public water system service area that overlies a portion of the Santa Rosa Plain Subbasin of the Santa Rosa Valley Groundwater Basin.

4.1.1.2 Overdraft

The statutes discussed above include evaluation of the condition of the groundwater basin, including whether DWR has identified the basin to be in overdraft or projected to become overdrafted. The word "overdraft" is defined in Bulletin 118 as follows (DWR, 2003b):

> "[T]he condition of a groundwater basin or subbasin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years, during which the water supply conditions approximate average conditions (DWR, 1998)."

Bulletin 118 also states, "overdraft can be characterized by groundwater levels that decline over a period of years and never fully recover, even in wet years. Water level declines without full recovery to historically high water levels do not represent overdraft. Groundwater levels can stabilize at a lower level such that the lowered levels are not exhibiting chronic decline or leading to groundwater depletion. Further, lowered groundwater levels are often necessary to create storage capacity and increase the yield of a basin. If overdraft is determined and continues for a number of years, "significant adverse impacts may occur, including increased extraction costs, costs of well deepening or replacement, land subsidence, water quality degradation, and environmental impacts" (DWR, 2003b).

A review of DWR's findings relative to whether an overdraft condition exists in the groundwater basin is discussed below along with an independent analysis based on historical groundwater level and pumpage data.

4.1.2 Description of the Groundwater Supply

The City has developed 42 groundwater wells, 26 of which are currently active. The active wells have a total rated production capacity of 6.3 mgd. The City has no emergency use wells. Table 4-2 outlines the status and production capacity of each well. The City's wells are shown in Figure 4-1.

Table 4-2 City Well Site Information

Well No.	Status	Production, gpm
1	Active	210
2	Active	100
3	Abandoned/monitoring well	0
4	Out-of-Service	0
5	Active	160
6	Active	100
7	Active	200
8	Out-of-Service	0
8A	Active	95
9	Active	200
10	Active	100
11	Active	150
12	Active	130
13	Active	130
14	Active	120
15	Out-of-Service	230
16	Active	280
17	Disconnected/monitoring well	0
18	Active	150
19	Disconnected/monitoring well	0
20	Active	100
21	Out-of-Service	150
22	Active	120
24	Disconnected/monitoring well	0
26	Disconnected/monitoring well	0
27	Active	240
29	Active	130
30	Active	220
31	Active	65
33	Active	135
34	Active	50
35	Active	120
37	Out-of-Service	0
39	Active	300
40	Active	90
41	Active	230
42	Out-of-Service	0

4.1.3 Contracts for the Groundwater Supply

There are no contracts in effect related to the groundwater supply. Transfers and exchanges of groundwater are not monitored. As noted in Section 3.4, the City has assumed that it will not rely on the Agency's groundwater.

4.1.4 Discussion of Groundwater Management Plans and Authority

There are no groundwater management plans in effect for the Santa Rosa Plain Subbasin of the Santa Rosa Valley Groundwater Basin. As described in both the Agency's 2005 Plan and in Section 4.1.5 below, the City is participating with the Agency and the United States Geological Survey (USGS) in a multi-year study of the Santa Rosa Plain Subbasin.

The City has adopted local policies related to groundwater management. Resolution No. 2004-95 (the Water Policy Resolution; see Appendix C), which was adopted on April 27, 2004, specifies that new development outside of the current City limits will not be approved if it would contribute to the City exceeding an average annual pumping rate of approximately 2,577 AFY.

4.1.5 Plans and Programs Related to the Groundwater Supply

Consistent with its General Plan, and as noted above, the City has adopted local policies related to groundwater management.

Groundwater basin studies are being conducted within Sonoma County by the Agency and the USGS, in conjunction with other stakeholders, including the City. The five-year cooperative study is designed to improve understanding of the groundwater resources, and began in December 2005 (Sonoma County Water Agency, 2004).

4.1.6 Description of Adjudications or Legal Rights to Pump

Neither the Santa Rosa Valley Basin nor the Santa Rosa Plain Subbasin (SRP Subbasin) has been adjudicated. Thus, currently there are no legal limits on the right to pump water from the basin.

4.1.7 Descriptions of DWR Determinations Related to Groundwater

DWR (1982a) described groundwater levels in the SRP Subbasin as "about in balance, with increased ground water levels in the northeast contrasting with decreased ground water levels in the south." (The SRP Subbasin was originally referred to as a "basin" in DWR 1982a.) DWR's most current bulletin (DWR, 2004, Appendix D) cites to its 1982 study to describe groundwater basin conditions. As further discussed below, more than 100 hydrographs in the Santa Rosa Valley Groundwater Basin were reviewed to update the groundwater conditions reported by DWR in 1982, and these show no indication of overdraft conditions anywhere in the basin. DWR has not made a finding of an overdraft condition of the SRP Subbasin in any of its bulletins, including its most current bulletin (DWR; 1975, 1982, 1987, and 2004.)

4.2 Groundwater Basin Description

The City is located in the southern portion of the Santa Rosa Valley (SRV) Groundwater Basin, which drains to the northwest toward the Russian River and then to the Pacific Ocean. All of the City's water supply wells are located in the SRV Groundwater Basin (Figure 4-2), and no City wells are planned to be constructed outside the SRV Basin. Figure 4-2 also shows other nearby groundwater basins including the Petaluma Valley Groundwater Basin, which is located immediately south of the SRV Groundwater Basin and drains to the southeast toward San Pablo Bay. The basin and subbasin boundaries displayed on Figure 4-2 are from DWR's web site.

This section contains a summary of hydrogeologic conditions in the SRV Groundwater Basin based in part on DWR's online basin and subbasin descriptions (DWR, 2004). The basin description is also based on review of more than 20 previous studies in the SRP Subbasin (see also References in W&K, 2005). Additional data reviewed for this analysis included historical groundwater levels; historical pumpage; historical precipitation; groundwater quality data;

geological information, including driller's reports and geophysical logs; and published and unpublished reports and maps.

4.2.1 Santa Rosa Valley Groundwater Basin

The SRV Groundwater Basin encompasses an area of 158 square miles. There are three subbasins within this basin: the Santa Rosa Plain (SRP) Subbasin, the Healdsburg Area Subbasin, and the Rincon Valley Subbasin (DWR, 2004). DWR's descriptions from its most recent bulletin (DWR, 2004) are included in Appendix D. The City pumps groundwater from the SRP Subbasin, which has an area of 125 square miles; this is the largest of the three subbasins. The Healdsburg Area Subbasin has an area of 24 square miles, and the Rincon Valley Subbasin contains 9 square miles. The Russian River plain forms the boundary between the Healdsburg Area Subbasin and the SRP Subbasin. The Rincon Valley Subbasin is separated from the SRP Subbasin by a narrow constriction in the bedrock of the Sonoma Volcanics east of Santa Rosa. The basin and subbasin boundaries shown on Figure 4-2 are based on boundaries available at the DWR website (http://www.dwr.water.ca.gov). There is no finding of overdraft in this basin in any DWR report or online basin description.

4.2.1.1 Santa Rosa Plain Subbasin

The SRP Subbasin extends from the City in the south to the Russian River, south of Healdsburg, in the northwest. The subbasin is approximately 22 miles long and up to nine miles wide. It is drained by the Laguna de Santa Rosa, which flows north to the Russian River. The subbasin contains three primary water-bearing units: the Wilson Grove Formation, Quaternary alluvial fan deposits, and Quaternary alluvium. Groundwater quality in these formations is generally good (DWR, 2004).

As noted above, DWR (1982) described groundwater levels in the SRP Subbasin as "about in balance, with increased ground water levels in the northeast contrasting with decreased ground water levels in the south." During the period from 1990 to 2003, groundwater levels in the northern part of the subbasin continued to increase, and groundwater levels in the south showed marked increases in recent years primarily in response to decreased municipal pumping by the City. As further discussed below, more than 100 hydrographs in the SRV Groundwater Basin were reviewed to update the groundwater conditions reported by DWR in 1982, and these show no indication of overdraft conditions anywhere in the basin.

Storage capacity for the Santa Rosa Plain Subbasin was estimated at 948,000 acre-feet (AF) based on an average specific yield of 7.8 percent at depths of 10 to 200 feet (DWR, 2004; Cardwell, 1958). Average annual natural recharge from 1960 to 1975 for the entire subbasin was estimated to be 29,300 AF and average annual pumping during the same time was estimated at 29,700 AF (DWR, 1982a).

4.2.1.2 Healdsburg Area and Rincon Valley Subbasins

The Healdsburg Area Subbasin is located northwest of the SRP Subbasin and includes the flood plain of the Russian River. Quaternary alluvium, alluvial fan deposits, terrace deposits, and the Wilson Grove Formation are the principal water bearing units in the subbasin. The Quaternary

alluvium is highly permeable and receives recharge from the Russian River and its tributaries. The City of Healdsburg uses wells perforated in the alluvium for most of its groundwater supply. DWR monitors groundwater levels in eight wells in this subbasin, and water levels in all but one well have remained stable for the last 10 years (DWR, 2004).

The Rincon Valley Subbasin is located east of the City of Santa Rosa and consists of a valley approximately seven miles long and up to 2.5 miles wide. The valley is bounded by the Sonoma Mountains except where it connects with the SRP Subbasin. The Rincon Valley Subbasin drains to Brush Creek, which flows south to Santa Rosa Creek. Quaternary alluvium and alluvial fan formations are the principal water bearing units in the subbasin, and groundwater quality in these formations is generally good. DWR (2004) states that water levels remained relatively constant in the Rincon Valley between 1951 and 2000 and that the subbasin is nearly full.

4.2.2 Petaluma Valley Groundwater Basin

The Petaluma Valley Groundwater Basin encompasses an area of 72 square miles (DWR, 2003) and is not divided into subbasins. The basin boundaries shown on Figure 4-2 are based on boundaries available at the DWR website (http://www.dwr.water.ca.gov). The northwestern boundary of the basin is formed by a groundwater divide located just south of the cities of Rohnert Park and Cotati. This divide separates the basin from the SRV Groundwater Basin to the north. The Petaluma Valley Groundwater Basin extends southeast to San Pablo Bay and is bordered by the Sonoma Mountains on the east and the Mendocino Range on the west. The basin is within the watershed of the Petaluma River, which flows south to San Pablo Bay. DWR's website does not include a description of the Petaluma Valley Basin, but a 1982 report (DWR, 1982b) contains a detailed description of hydrogeologic conditions in the basin.

The primary water bearing units in the Petaluma Valley Basin include Quaternary alluvium and alluvial fan deposits especially in the northern and eastern portions of the basin. Wells completed in these units have moderate to high yields. The other major water-bearing unit is the Wilson Grove Formation, which underlies much of the valley at a depth of about 250 feet (Cardwell, 1958). The Wilson Grove Formation is exposed in the uplands along the northwestern edge of the valley. Wells completed in this formation generally have high yields (DWR, 1982b). DWR's most current bulletin for the Petaluma Valley Ground water Basin is its 1982 study (DWR, 1982b); DWR does not have an updated basin description for this basin posted on its web site. As of the 1982 study, DWR reported:

> "Since the ground water reservoirs are therefore essentially "full", an artificial recharge program to increase the volume of ground water in storage is not needed at this time." …. Hydrographs of wells monitored during the 1976-1977 drought indicate that more surface water could be stored underground if more storage were made available. This suggests that if ground water pumping were increased, more surface water could be retained as ground water recharge. At present, much water runs off the land surface as rejected recharge."

As discussed in Section 4.5.3, and as shown in Appendix E, recent water level data for most wells monitored by DWR in the northern portion of Petaluma Valley Groundwater Basin show

stable to increasing water levels. The City expects no effects on groundwater conditions in this adjacent basin due to its projected pumpage.

DWR (1982b) states that groundwater quality in the basin is generally poor due to several factors. Native groundwater quality in the alluvium and alluvial fan deposits is excellent, but much of the shallow groundwater northwest of Petaluma is contaminated with nitrates due to livestock management practices and septic systems. Groundwater near the base of the Wilson Grove Formation has naturally occurring high salinity. In the southern portion of the basin near San Pablo Bay, naturally occurring high salinity has been exacerbated by seawater intrusion. Seawater intrusion has also occurred in areas adjacent to the tidal portion of the Petaluma River (DWR, 1982b).

4.3 Geology of the Santa Rosa Valley Groundwater Basin

4.3.1 Regional Geologic Setting

Many investigations pertaining to the geology in Sonoma County and more specifically to the SRV area have been conducted. Early works include those of Osmont (1905), Dickerson (1922), and Morse and Bailey (1935). Much of the early works are summarized in Cardwell's pioneering hydrogeologic investigation of the Santa Rosa and Petaluma Valley areas (Cardwell, 1958). DWR has also conducted a series of investigations in the Santa Rosa Valley area (DWR; 1975, 1982a, and 1987); see Figure 4-3. Todd (2004) developed a detailed water budget for the upper Laguna Hydrologic Subarea, which is illustrated in Figure 4-3, that included estimates of all municipal and non-municipal (domestic, agricultural, and commercial) pumpage along with other water budget components (see additional discussion in Section 4.7). Numerous geologic maps have been generated from the various investigations. Early mapping was summarized in Weaver (1949) and subsequent maps include Fox and others (1973), Huffman and Armstrong (1980), Allen (2003), and Clahan et al. (2004, in preparation). Wagner and Bortugno (1982) is probably the most readily available large area map. Continued evaluation and interpretation of the stratigraphic and structural complexities of the geology of the area present uncertainties with even the most recent geologic maps. A brief synopsis of the major geologic formations occurring in the SRV area is provided below.

The surficial exposure of geologic units in Santa Rosa Valley consists mostly of Quaternary alluvium and alluvial fan deposits (W&K, 2005; Clahan, 2004; Allen, 2003; and DWR, 1982a). The valley is bordered by the Rodgers Creek fault to the east and the Sebastopol and Meacham Hill faults to the west. In the vicinity of the Rodgers Creek fault, the low hills and mountain ranges are predominantly composed of mafic rocks of the Sonoma Volcanics and the Petaluma Formation. West of the Sebastopol fault, the Petaluma Formation has been uplifted and is exposed along the southwestern edge of the SRP. West of the Meacham Hill fault, a broad, low topographic area contains exposures of the Wilson Grove Formation and fragments of the Franciscan complex.

The basement complex in the SRV Basin is formed by the Mesozoic Franciscan complex, which is the oldest geologic unit in the area. The Franciscan consists largely of clastic and chemical

sediments of marine origin intercalated with pillow basalts and more basic igneous rock, and weakly metamorphosed marine sedimentary rocks.

Unconformably overlying the Franciscan basement complex are sequences of volcanic and volcano-clastic rocks of late Tertiary age (late Miocene and Pliocene) known as the Toulay and Sonoma volcanics. The Tolay Volcanics have been described by Morse and Bailey (1935) as a series of lava flows, breccia, tuff, and agglomerate that extends beneath the southern Santa Rosa Plain at a depth of about 2,100 feet (DWR, 1982a). The Sonoma Volcanics consist of a Pliocene age series of lava flows, agglomerates, tuffs, and intercalated sediments of volcanic debris forming a very complex assemblage of flows, dikes, plugs, mudflows, breccias, pumice beds, and stratified (volcanic in origin) materials. Rocks have been folded, intensely faulted, and eroded causing considerable differences in the formation between adjacent areas. The Sonoma Volcanics are exposed in the Sonoma Mountains east of the SRP.

Interbedded and interfingered with the Tolay and Sonoma volcanics are non-marine, transitional marine and marine sedimentary rocks of the Wilson Grove Formation (formerly known as the Merced Formation), the Petaluma Formation, and the Cotati Formation. The Wilson Grove Formation is a late Miocene marine deposit consisting predominantly of massive beds of coarse to fine-grained sandstone and thin interbeds of clay and silty clay, lenses of gravel and pebbles. Material is largely derived from the Franciscan Formation and to a much lesser extent from the Sonoma Volcanics. The Petaluma Formation is late Miocene to Pliocene in age and largely consists of strongly folded continental and shallow marine to brackish-water deposits of clay, shale, and sandstone, some conglomerate and nodular limestone. Clay is particularly abundant in this unit. The Cotati Formation is similar in age to the upper Petaluma Formation and is classified as Petaluma Formation on older maps. It consists of marine transitional deposits, primarily massive sandstone and conglomerate.

A Quaternary (Pliocene and Pleistocene) sequence of alluvial deposits, described as primarily consolidated alluvial fan deposits but also containing fluvial and lacustrine deposits, overlies and interfingers with the Tertiary units in the Cotati Valley. This sequence was formerly known as the Glen Ellen Formation, and some reports still use this terminology. In the southern portion of the SRP, the consolidated alluvial fan deposits are overlain by largely unconsolidated Quaternary (Pleistocene and Holocene) alluvium, including alluvial fan deposits.

The stratigraphic relationship between the western and eastern areas remains obscure due to poor exposures and because it is covered by the younger deposits in the Santa Rosa Plain. A generalized relationship of interfingering and interbedding of the western marine deposits with transitional marine and non-marine deposits is believed to occur beneath the Valley. Allen (2003) mapped a region just west of the City of Cotati that contains interbedded Wilson Grove and Petaluma Formation, which extend beneath the Valley.

Surface geophysical survey interpretations indicate that up to 2.5 to 3 kilometers of Tertiary and younger deposits underlie the SRP (Allen, 2003; Mclaughlin & Sarna-Wojcicki, 2003). Investigators (Cardwell, 1958; DWR, 1978 and 1982a; and Allen, 2003) have developed various interpretations of the depositional relationships. These interpretations tend to show an interfingering and/or interbedding relationship between the Wilson Grove Formation to the west

with the Petaluma Formation and Sonoma Volcanics to the east. Interpretation of these relationships are largely based on limited deep borehole information from a few oil and gas test holes, deep water wells, and/or projections of measured angles of dip at surface exposures (Allen, 2003) and need further study to better understand this complex environment.

As noted above, the USGS is working with the Agency and other participating agencies and water companies, including the City, to complete an update to the Santa Rosa Plain Subbasin Study (USGS, 2003 and 2007).

4.3.2 Faults

The SRV Groundwater Basin is in the northwest trending structural province of the Coast Ranges. Folds and faults have deformed or displaced all formations with the exception of the younger alluvium. The syncline forming the Santa Rosa Valley was named the Windsor syncline by Gealey (1951). The northwest trending faults at the margins of the Santa Rosa Valley have displaced the formations and, therefore, control much of the shape of the valley and the thickness of the water-bearing deposits. One of the primary faults in the area is the Rodgers Creek fault, located between the valley and Sonoma Mountain to the east. In the northern portion of the groundwater basin, the Healdsburg fault is generally considered a continuation of the Rodgers Creek fault. The Meacham Hill and Tolay faults are located west of the valley in the Wilson Grove Formation Highlands Groundwater Basin. There are often multiple smaller faults in the vicinity of these major faults, and these areas are described or mapped as "fault zones" in some reports.

Several buried faults have been mapped within the valley, most notably the Sebastopol fault, which extends from the southern portion of the subbasin northwest to Sebastopol. Although the Sebastopol fault is mapped near the southwestern boundary of the City, its location is approximate because the fault trace is not exposed at the surface. The Petaluma Valley fault was first proposed by Collins (1992) and Wright and Smith (1992). It is located primarily in the Petaluma Valley Groundwater Basin but is shown on some maps intersecting the Sebastopol fault just west of the City.

DWR (1982a and 1987) investigated the hydraulic properties of the Sebastopol fault, but the results were inclusive. Water level hydrographs of the City's wells show similar trends to, and response to pumpage as, nearby City of Cotati wells located on opposite sides of the mapped location of the fault. This suggests that the Sebastopol fault does not act as a significant barrier to groundwater flow. Data are not available to determine the hydraulic properties of faults in the Rohnert Park area, but water level data shown on hydrographs and contour maps indicate there is flow across the faults. There is no evidence that faults in the vicinity of Rohnert Park act as significant barriers to groundwater flow.

4.3.3 Groundwater Production Zones

In the southern SRP Subbasin, groundwater is produced largely from the upper 800 feet of the sedimentary deposits. For the evaluation of local hydrogeologic conditions, two geologic cross sections were prepared, and the cross-section locations are shown on Figure 4-4. Cross-section A-A' (Figure 4-5) has a southwest to northeast orientation and is roughly perpendicular to the

longitudinal axis of the valley. Cross-section B-B' (Figure 4-6) has a northwest to southeast orientation and is roughly parallel to the valley's longitudinal axis. The cross sections were originally developed based on review of water well driller's reports for the City of Rohnert Park and available geophysical electric logs (W&K, 2005).

Local hydrogeology was evaluated by constructing vertical profiles of water supply wells operated by the Cities of Rohnert Park and Cotati and some nearby private wells in addition to the geologic cross sections. The well profiles show the geologic materials as recorded on individual water well driller's reports, an interpreted profile of the geophysical electric log for each well or borehole where available, and the depth of perforated or screened intervals in the well casing. The cross sections show geologic materials and perforated intervals for wells that lie along or near the cross section location. Six working cross sections were prepared for the area, and two of these are included in this Plan.

The well profiles and cross sections provide a generalized depiction of the subsurface geologic conditions that was used to divide the aquifer into depth zones to facilitate the analysis of groundwater levels. These zones do not represent laterally extensive aquifers but are strictly depth based for purposes of evaluating hydrogeologic conditions. These designations are based on an approximate correlation to the geologic units and on water well completion depths. The vertical zones of the aquifer system were designated:

- Shallow (0 to 200 foot depth),
- Intermediate (200 to 600 foot depth, comprised of upper and lower sequences as described below),
- Deep (600 to 800 foot depth), and
- Lower (depths greater than 800 feet).

Information about the construction of the City's wells is summarized in Appendix E. This Appendix includes a table outlining the perforated interval of the wells along with the capacities (pumping rates) and other information. The City's wells pump predominantly from the intermediate zone, but several wells are also completed partially in the deep and lower zones of the aquifer system.

4.3.3.1 Shallow Zone

The shallow zone appears to consist largely of clays and sandy clays with a few thin sand to gravel beds (Figure 4-5). The sands appear to occur largely towards the margins of the Valley in the northern part of the southern SRP Subbasin. Somewhat more sand occurs further south possibly deposited by alluvial fan sources in the Copeland and Lichau Creek areas. The depositional system appears to have been small alluvial fans grading into a fluvial plain or possibly lacustrine area.

4.3.3.2 Intermediate Zone

Water supply wells operated by the Cities of Rohnert Park and Cotati are constructed primarily in the intermediate zone, with perforated intervals between depths of 200 to 600 feet. Based on review of well profiles and geologic cross sections, this zone consists of a complex sequence of largely thin (and rare occurrences of thick) sand and sand to gravel deposits interbedded with deposits of sandy clay to clay (Figures 4-5 and 4-6). The correlation of individual sand and gravel beds between wells is generally poor. The intermediate zone appears to be the most complex stratigraphically of the four zones, and it is difficult to identify specific formations based on individual drillers' logs. Geologic cross sections prepared by DWR (1982a) suggest that the Rohnert Park wells are completed primarily in Quaternary alluvial fan formations. Deeper wells may also be completed partially in the underlying Wilson Grove Formation, especially in the northern portion of Rohnert Park.

An upper sand sequence in the upper intermediate zone (between depths of about 200 to 400 feet) occurs in the northern portion of the southern SRP Subbasin (Figure 4-5). In general, the sand to sand and gravel beds in this zone appear to be slightly thicker and more numerous than in the lower intermediate zone (400 to 600 feet). Some clay is present in almost all strata between depths of 400 and 600 feet. Although bed correlation remains poor, the character of the geophysical log responses appears to be more of an alluvial plain or fluvial nature. The sandy deposits of this upper sequence appear to be concentrated along the Valley axis (Figure 4-6); and, these deposits may be lacking east of Rohnert Park (Figure 4-5). In addition, the base of the upper sand sequence appears to rise somewhat to the southeast (Figure 4-6). It is unclear whether this rise is related to a southeastern sourced depositional pattern or basin tectonics.

A sand sequence consisting of many thin sand beds occurs in the lower intermediate zone (400 to 600 feet) in the northern half of the southern SRP Subbasin. The sequence may be either upper interbedded Wilson Grove-Petaluma Formation or Quaternary alluvial fan deposits. East of Rohnert Park, a thicker sequence of high-resistivity beds may represent a marginal-fault trapped area (Figure 4-6). In the central southern SRP Subbasin, this sandy sequence tends to be thinner and finer grained. In the south, a thicker, high-resistivity, gravelly sequence is present (Figure 4-6), and it is unknown whether it correlates with the Tertiary "Sands and Gravels of Cotati" mapped by Clahan and others (2004).

4.3.3.3 Deep Zone

Underlying the intermediate zone, the deep zone is defined as occurring at depths between 600 to 800 feet. The deep zone is best defined in the northern portion of the southern SRP as an approximately 100 to 150 foot interval of thin to thicker sand and gravel beds with interbeds of clays (Figure 4-5). These beds appear to rapidly thin or pinch out to the south. Correlation of the deep zone to surficial map units is difficult. It is unclear whether the deposits in the deep zone represent Tertiary sedimentary deposits (interbedded Wilson Grove-Petaluma) or Quaternary non-marine deposits.

4.3.3.4 Lower Zone

Underlying the deep zone, the lower zone is defined as occurring at depths between 800 to 1,500 feet. The three deepest wells (in the southern SRP Subbasin (RP-14, RP-15, and RP-16) encountered low resistivity, fine-grained clays at these depths. The units encountered by the wells constructed to depths greater than 800 feet are believed to be older Tertiary sedimentary units, probably Petaluma Formation or interbedded Wilson Grove-Petaluma Formation or equivalent. Because of the limited deep borehole information, it is difficult to correlate the lower zone laterally beneath the City. Because of the fine-grained nature of this zone, and the limited potential aquifer thickness, it appears the lower zone represents a poor target for groundwater production.

4.3.4 Well Yields and Aquifer Characteristics

Aquifer characteristics refer to the ability of aquifers to transmit and store groundwater. Aquifer characteristics are generally estimated using data from long-term constant rate pumping tests. The ability of the aquifer to transmit water is referred to as transmissivity (permeability times saturated thickness).

Specific capacity can be used to estimate aquifer transmissivity using the following empirical equation for a confined aquifer:

$$T = Q/s * 2000$$

Where: T = transmissivity of the well, in gallons per day/ft (gpd/ft)

Q = yield of the well, in gpm

s = drawdown in the well, in ft.

The Rohnert Park municipal wells have yields ranging from about 50 to 300 gpm (W&K, 2005). Specific capacity data from well efficiency tests of 31 Rohnert Park wells show that the specific capacities vary over an order of magnitude, ranging from 0.6 to 6.1 gpm/ft of drawdown. Based on the above empirical formula, the transmissivity of the intermediate zone in the vicinity of Rohnert Park is estimated to range from about 1,000 to 12,000 gpd/ft. The average transmissivity of the Rohnert Park wells is about 5,000 gpd/ft.

Overall, the specific capacity and transmissivity values calculated from tests conducted in the Rohnert Park wells are indicative of low yielding formation materials. The data suggest that the intermediate zone, from which the majority of the municipal groundwater extraction occurs, has a transmissivity of less than 15,000 gpd/ft. Well yields are correspondingly low, averaging about 180 gpm for the Rohnert Park wells.

DWR addressed well yields and aquifer characteristics in the SRP Subbasin in various studies (DWR; 1975, 1979, 1982a, and 1987). DWR's first report on groundwater resources in Sonoma County contains descriptions of well yields for various formations in the County (DWR, 1975). Specific capacity data were also provided for some formations. Wells completed in the Petaluma Formation typically are low-yielding (5 to 300 gpm). For the Merced Formation, which is one of

the primary water-bearing units in the subbasin, DWR (1975) reported yields of 20 to 1,000 gpm. For the overlying Quaternary alluvial fan deposits (previously known as the Glen Ellen Formation), DWR (1975) reported yields of 3 to 500 gpm and specific capacities of 0.5 to 20 gpm/ft of drawdown.

DWR (1987) contains results of five aquifer tests conducted in the SRP Subbasin. Transmissivities estimated from the test results ranged from about 6,000 gpd/ft for a well completed in the Merced Formation near the City of Windsor to more than 80,000 gpd/ft for a well completed primarily in Quaternary alluvial fan deposits in the City of Santa Rosa. Aquifer storativity was estimated for three of these tests, and estimates ranged from 0.0010 to 0.0017.

The southernmost test was conducted in the Agency's Todd Road well located in the southern SRP Subbasin about three miles southeast of Sebastopol. This well is completed primarily in Quaternary alluvial fan deposits, and the transmissivity was estimated to be 10,000 to 15,000 gpd/ft based on the test results. This is similar to the highest transmissivities estimated for the Rohnert Park wells.

Cardwell (1965) and DWR (1983) addressed well yields and aquifer characteristics in the Healdsburg Area Subbasin. Groundwater is produced primarily from alluvium and river channel deposits that have relatively high yields of 200 to 1,000 gpm (Cardwell, 1965). Some groundwater is also produced from lower-yielding Quaternary alluvial fan deposits, and many domestic wells in the Healdsburg area are completed in this formation (DWR, 1982a). Yields of 1 to 140 gpm and a specific capacity of 2 gpm/ft of drawdown were reported by Cardwell (1965).

The geology of the SRV Groundwater Basin is stratigraphically and structurally complex. Prior analyses of groundwater level responses to local groundwater extraction have reported on the semi-confined to confined nature of the deeper aquifers in the southern SRP. Particularly, DWR (1982a) notes that there are differences in the water level declines observed in three piezometers completed to different depths and also that there are confining layers between the perforated intervals of the piezometers. The deepest of the three piezometers was further noted as similar in depth to most of the City wells; the water level difference in this zone was attributed to the response of "pressure aquifers" (i.e., confined aquifers).

4.4 Precipitation

The City lies within the watershed of the Laguna de Santa Rosa, which is a tributary of the Russian River. The City lies in a region that has a "Mediterranean" climate, meaning the normal weather pattern is a dry summer season with little or no rain. Typically, over 96 percent of the region's annual precipitation falls during the months of October through April.

An isohyetal map showing mean annual precipitation contours in the vicinity of the City is presented on Figure 4-7. This map was obtained from an Agency (1983) report, and the associated period of record and gauge locations are unknown. The mean annual precipitation is about 30 inches near the City and increases in an easterly direction to more than 45 inches at Sonoma Mountain.

Sonoma County precipitation gauges with long periods of record are located north and northwest of the City. Annual precipitation data from 1905 to 2005 (Figure 4-8) are from the Santa Rosa gauge, which is located north of the City of Santa Rosa at an elevation of 174 feet.[1] The lowest annual rainfall during this period was 12.78 inches during the 1977 water year (October 1, 1976 to September 30, 1977), and the highest annual rainfall was 55.68 inches in the 1983 water year. The mean annual precipitation was 29.99 inches, which is similar to the annual mean precipitation for the City shown on Figure 4-8. This represents an annual precipitation volume of 2.5 AF/acre.

The long-term precipitation characteristics at the Santa Rosa gauge are shown by plotting the cumulative departure from the mean annual precipitation (Figure 4-9). This plot shows alternating wet, average, and dry periods of various durations, which are indicated by the slope of the cumulative departure curve. An upward slope indicates a wet period, and a downward slope indicates a dry period on the cumulative departure curve.

4.5 Groundwater Conditions

DWR evaluated historical groundwater level data for its 1982 investigation of the SRP area and concluded that the "Santa Rosa Plain groundwater basin as a whole is about in balance, with increased groundwater levels in the northeast and decreased groundwater levels in the south" (DWR, 1982a). It appears that this statement refers to the area now known as the SRP Subbasin, but historical data suggest that groundwater conditions in all subbasins of the SRV Basin were "in balance" in 1982. Since DWR's 1982 study (DWR, 1982a), groundwater levels in the north increased, and groundwater levels in the south (including the Rohnert Park area) show large increases in recent years primarily in response to decreased municipal pumping. In this section, historical groundwater level data are used to assess groundwater conditions since 1982 in order to determine if the basin is still "in balance."

In order to update DWR's evaluation of groundwater resources in the basin and subbasin and assess groundwater level trends and conditions, all available water level data were obtained from DWR and other sources, including the Cities of Rohnert Park and Cotati, the Agency, the USGS, and Todd. Water level data for monitoring wells located at leaky underground fuel tank (LUFT) sites within the City's UGB were also downloaded from the State Water Resources Control Board (SWRCB) Geotracker system (http://geotracker.swrcb.ca.gov).

As summarized in Table 4-3, hydrographs were reviewed for 147 wells, including 133 wells in the SRV Basin and 14 wells in the northern portion of the Petaluma Valley Basin. This included 123 wells in the SRP Subbasin, two wells in the Rincon Valley Subbasin, and eight wells in the

[1] The period of record for the Santa Rosa gauge is generally from 1905 to the present, but there are missing data for portions of the 1937, 1979, 2000, and 2001 water years. Precipitation for these years was estimated using data from the Graton station, located west of Santa Rosa.

Healdsburg Area Subbasin. Figures 4-10 and 4-11 show the locations of wells with water level hydrographs. The individual hydrographs for 147 of these wells are included in Appendix E and are summarized below. The data reviewed includes more than 100 wells owned and/or operated by others than the City. Many of these wells are located in the neighboring basin or subbasins, but were reviewed (as suggested in DWR's guidance (DWR, 2005)) to provide an updated evaluation of groundwater conditions that affect the City.

The water level hydrographs were also categorized according to zone(s) of predominant completion and monitoring entity. Most wells have perforation data that allow them to be classified by zone. As indicated in Table 4-3, 59 wells are classified as shallow, 24 as intermediate, and two as deep. There are also 34 wells classified as shallow and intermediate and 12 as intermediate and deep. Because most municipal and agricultural pumpage is from the intermediate zone, wells that are partially completed in the intermediate zone typically have hydrographs similar to wells completed exclusively in the intermediate zone.

Table 4-3 Hydrographs Reviewed for City of Rohnert Park UWMP

Groundwater Basin or Subbasin		No. of Wells by Aquifer Designation[1]						No. of Wells by Monitoring Entity							Total
Basin	**Sub-basin**	**Shallow Zone**	**Shallow & Intermediate Zone**	**Intermediate Zone**	**Intermediate & Deeper Zones**	**Deep Zone**	**Unknown**	**DWR**	**SWRCB[2]**	**City of Cotati**	**City of Rohnert Park**	**SCWA**	**Todd**	**USGS**	
Santa Rosa Valley	Santa Rosa Plain	46	32	22	12	2	8	49	9	3	43	6	1	11	*123*
	Rincon Valley	1	0	1	0	0	0	2	0	0	0	0	0	0	*2*
	Healds-burg	1	0	0	0	0	7	8	0	0	0	0	0	0	*8*
Subtotal		*48*	*32*	*23*	*12*	*2*	*15*	*59*	*9*	*3*	*43*	*6*	*1*	*11*	*133*
Petaluma Valley	--	11	2	1	0	0	1	11	1	0	0	0	0	3	*14*
Total		**59**	**34**	**24**	**12**	**2**	**16**	**70**	**10**	**3**	**43**	**6**	**1**	**14**	**147**

1. Aquifer zonation:

Shallow Zone	<200 feet
Shallow and Intermediate Zone	<600 feet
Intermediate Zone	200 - 600 feet
Intermediate and Deeper Zones	>200 feet (Includes three wells completed partially in the shallow zone)
Deep Zone	600-800 feet

2. There are ten LUFT sites within the City of Rohnert Park UGB and City of Cotati UGB, each with multiple monitoring wells. Hydrographs were generated for one representative well from each site.

Wells with water level data have varying periods of record, and a few hydrographs show historical data dating back to the 1940s. The period of record for most of the wells begins in the 1970s or 1980s. A number of wells were monitored by the USGS in the early 1950s on a one-time basis (Cardwell, 1958). Although slightly more than half of the wells have current data, water level measurements have apparently been discontinued in the other wells. In the SRV Basin, for example, 77 hydrographs (53% of the total) have water level data to the present.

4.5.1 Water Level Hydrographs for Santa Rosa Plain Subbasin

Most of the water level data available for the SRV Groundwater Basin are from wells within the SRP Subbasin, and water level hydrographs in this subbasin are discussed by zone.

4.5.1.1 Shallow Zone

Hydrographs for most shallow zone wells in the SRP Subbasin exhibit relatively stable long-term groundwater levels, indicating little response to changes in pumpage or variations in climatic conditions (Figure 4-12). Regardless of increases or decreases in pumpage or the occurrence of dry, normal, or wet years, spring water levels in the shallow zone are essentially stable for all of the historical monitoring record. There are a few exceptions to this general trend.

Most shallow zone wells in the SRP Subbasin have periods of records beginning in 1989 and exhibit stable or increasing groundwater level trends. One shallow well with a longer period of record (6N/8W-15J3) shows historical water level declines similar to those of some intermediate zone wells but has had stable water levels since the late 1980s and water level increases since 2003.

4.5.1.2 Intermediate Zone

Water levels measured in intermediate zone wells typically reflect confined conditions with lower depths to water and greater seasonal fluctuations. Water levels in these wells are influenced by municipal and agricultural pumping from the intermediate zone. Prior analyses of groundwater level responses to local groundwater extraction have reported on the semi-confined to confined nature of the deeper aquifers in the southern SRP. DWR (1982a) reported differences in water levels (pieziometric heads) were observed in three piezometers completed at different depths in the aquifer system. The deepest of the three piezometers was further noted by DWR (1982a) as similar in depth to most of the City wells; the water level difference in this zone was attributed to the response of "pressure aquifers" (i.e., confined aquifers).

In the southern portion of the SRP Subbasin, water levels in intermediate zone wells generally follow the trend of the City's pumping, with lower water levels during years of increased pumping and higher water levels during years of reduced pumping (Figures 4-12 and 4-17). This means that water levels were lowest in the late 1980s, stabilized in the 1990s, and have increased significantly in recent years. Notably, groundwater levels in the intermediate zone in the southern portion of the SRP Subbasin have increased to elevations significantly above those observed in the early 1980's (the time of DWR's 1982 study). Where historical records are available, current groundwater levels also appear to be higher than those recorded in the 1970's. For example, the groundwater elevations observed in January 1972 and March 1980 in City of Rohnert Park Well No. 8 were 89 and 79 feet, mean sea level (msl), respectively, whereas in March 2006, it was 105 feet, msl (Figure 4-12).

As previously reported by DWR (1982a), the basin is "in balance"; the updated analysis shows no evidence of overdraft conditions occurring in the groundwater basin.

4.5.2 Rincon Valley and Healdsburg Area Subbasins

Water level data are much more limited for the Rincon Valley and Healdsburg Area Subbasins. As indicated on Table 4-3, data from DWR were only available to prepare hydrographs for two wells in the Rincon Valley Subbasin and eight wells in the Healdsburg Area Subbasin. These hydrographs are included in Appendix E and described below.

In the Rincon Valley Subbasin, hydrographs were prepared for one shallow-zone and one intermediate-zone well. Both wells have periods of record from 1989 to 2006. The shallow well (well 7N/7W-06H2) is 100 feet deep and had a spring depth to water ranging from 15 to 27 feet. During most of the 1990s, the spring depth to water was about 20 feet, with seasonal fluctuations of about 15 feet. From 2000 to 2004, spring water levels declined to about 27 feet, and seasonal fluctuations increased to more than 20 feet. In 2006, the spring depth to water had recovered to 20 feet. Overall, water levels appear to be stable in this well.

The intermediate zone well in Rincon Valley (well 7N/7W-09P1) is 296 feet deep and had a spring depth to water of about 82 feet in 1990. Water levels have increased considerably since that time (to about 46 feet in 2003), and have been stable since 2003 with a recent rise of three feet in 2006. Seasonal fluctuations have decreased from about 20 feet in the early 1990s to about 5 feet in recent years.

In the Healdsburg Area Subbasin, hydrographs were prepared for one shallow zone well and seven wells of unknown depth. The shallow zone well (8N/9W-22E1) is 45 feet deep and has a period of record from 1989 to 2006. The spring depth to water in this well was about 31 feet in 1990 and rose to six feet by 1999. The spring depth had increased to five feet by 2006. Seasonal fluctuations are typically about 15 feet in this well.

The hydrographs of wells of unknown depth in the Healdsburg Area Subbasin all show stable to increasing water levels in recent years. Only one well (9N/10W-12C1) northeast of Healdsburg shows evidence of historical water level declines. This well has the longest period of record (1964 to 2006) and shows that the spring depth to water declined from about 12 feet in the mid 1960s to about 25 feet in 2003. By 2006, the spring depth to water was 15 feet. The other wells have shorter periods of record but show generally stable water levels prior to 2006 and relatively large water level increases in 2006.

4.5.3 Petaluma Valley Groundwater Basin

Hydrographs for 14 wells in the northern portion of the Petaluma Valley Groundwater Basin (north of the City of Petaluma) are included in Appendix E. As indicated on Table 4-3, this includes eleven shallow zone wells, two shallow and intermediate zone wells, one intermediate zone well, and one well of unknown depth. Eleven of these wells have recent water level data until at least 2004, and eight of these show stable to increasing water levels in recent years.

Well 5N/7W-20B2, located in the northern portion of the City of Petaluma, is a shallow well with a depth of 158 feet and has a very long period of record (1953-2006). The spring depth to water in this well declined from 8 feet in the mid 1950s to about 70 feet in the early 1960s. Water levels have increased since that time and have been stable at 20 to 30 feet, msl since 1999.

Although the City's urban growth boundary extends slightly into the Petaluma Valley Groundwater Basin, none of the City's wells are located in this basin. Consequently, the City expects no effects on future groundwater conditions in this basin due to its projected pumpage.

4.5.4 Groundwater Elevation Contours

Historical groundwater elevation contours are available from USGS and DWR reports. Cardwell (1958) prepared a spring 1951 contour map for the SRP and Rincon Valley Subbasins and the northern portion of the Petaluma Valley Groundwater Basin. More data were available for this period than any other historical or recent period because the USGS conducted a one-time round of water level measurements in approximately 450 wells in April 1951. The majority of these wells are shallow, and the shapes of the contours on the Cardwell map primarily reflect groundwater conditions in the shallow zone. The portion of the Cardwell map showing the southern SRP Subbasin is shown on Figure 4-13. The overall direction of groundwater flow in the SRP was westerly toward the Laguna de Santa Rosa in the valley trough and ultimately to the northwest. West of the valley trough, there was a steeper gradient for groundwater flow toward the Laguna de Santa Rosa from the hills west of the valley.

Groundwater elevations and flow directions in 2004 were similar to those shown on Cardwell's 1951 contour map. Contours of equal groundwater elevation in the shallow zone for spring 2004 (Figure 4-14) show that the direction of groundwater flow in the southern portion of the SRP Subbasin is generally westerly toward the Laguna de Santa Rosa, and the gradient for flow in the valley is relatively flat. At the eastern and western margins of the SRP Subbasin, there is a much steeper gradient for groundwater flow into the valley.

In the northern portion of the Petaluma Valley Basin, the direction of groundwater flow is generally to the south toward the City of Petaluma and away from the groundwater divide that separates the two groundwater basins. The 2004 contours shown on Figure 4-14 indicate that the approximate location of the groundwater divide is similar to the southern boundary of the SRP Subbasin as mapped by DWR. Based on groundwater elevation contours on either side of the divide, the location of the divide appears to be essentially the same as it was in 1951 based on Cardwell's map (Figure 4-13). The lack of movement of the groundwater divide is supported by water level hydrographs for shallow wells near the divide, which indicate that shallow groundwater levels have generally been stable for at least the last 15 years. Hydrographs for wells near the divide such as T6N/R7W-30R1, T5N/R8W-02H1, and T5N/R8W-01L2 are included in Appendix E.

Contours of equal groundwater elevation for the intermediate zone for spring 2004 (Figure 4-15**)** in the southern portion of the SRP Subbasin show that the direction of groundwater flow beneath the City was generally to the northwest, but a cone of depression was present beneath the western portion of the City. Due to the semi-confined nature of the portion of the aquifer system from which the City's wells produce water, groundwater elevations in the intermediate zone are lower than in the shallow zone, especially in the central and western portions of the City. A spring 2006 contour map (Figure 4-16) prepared for the City of Cotati Urban Water Management Plan (W&K, 2006) shows that groundwater levels have risen significantly since 2004 and the cone of depression beneath the western portion of the City had largely disappeared by 2006.

4.5.5 Groundwater Quality

Groundwater produced by the City is tested for a total of 139 constituents, including bacteria, pesticides, herbicides, fungicides, organic chemicals, inorganic chemicals, nitrates, radioactivity, corrosivity, trihalomethanes, iron, and manganese.

Groundwater produced from the City's wells meets primary state drinking water standards. Overall mineral content for all zones, as indicated by specific conductance (electrical conductance; EC), ranges from 270 to 620 μmhos/cm. The average EC levels are 300 μmhos/cm in intermediate zone wells and 434 μmhos/cm in wells completed in multiple zones. EC values are below the recommended secondary Maximum Contaminant Level (MCL) of 900 μmhos/cm. Other water quality concerns in the Rohnert Park area include elevated nitrate, arsenic, iron, and manganese concentrations in some wells. Nitrate concentrations in City wells perforated in the intermediate zone or in multiple zones range from non-detect to 23 mg/L, which is less than the primary MCL of 45 mg/L. Samples collected from five wells in 1997 exceeded secondary MCLs for iron and manganese, which do not pose health hazards but are considered nuisance pollutants. However, treatment can be used to reduce iron and manganese to levels that meet the secondary MCLs (Dyett & Bhatia, 2000).

Arsenic is naturally occurring in the area, and concentrations in City wells range from 2 to 12 μg/L with an average of about 5 μg/L. Arsenic concentrations at the upper end of the range of detected concentrations occur in City wells completed in the northwestern area in the deep and lower zones (well depths greater than 600 feet). Arsenic concentrations in these deeper wells are at levels near or above the federal MCL of 10 μg/L.

Organic chemicals introduced through known point sources could influence groundwater quality conditions in the future. No serious or widespread issues that affect community water supplies due to organic chemical sources are known to be present in the City.

4.6 City's Groundwater Supply

4.6.1 Historical City Pumpage

Historically, the City's primary water source was groundwater. In 2003, the City began a shift toward greater use of Agency water and reduced groundwater pumping. The Act requires that an agency proposing to utilize groundwater provide a description of the proposed pumpage[15] and the historic sufficiency of the supply based on information that is readily available[16].

The City has revised its operational strategy from one of relying largely upon groundwater for supply to a strategy which balances Agency supply, groundwater, and recycled water. Historical

[15] Water Code Section 10631(b) (4).

[16] Water Code Section 10631(b) (3).

pumpage data for the City were reviewed from 1970 to through 2005 (Figure 4-17). Table 4-4 illustrates the City's historical groundwater use for the five-year period from 2001-2005. Raw data for 2006 is available but has not yet been correlated with data from other wells, and so it not included in this Plan. The next Plan update will include this information.

Table 4-4 (DWR Table 6) Amount of Groundwater Pumped by the City (2001-2005)

Basin Name (s)	2001 AFY	2002 AFY	2003 AFY	2004 AFY	2005 AFY
Santa Rosa Plain Subbasin	4,482	4,212	3,556	1,520	846
% of Total Water Supply	52.4%	52.4%	45.6%	19.5%	12.7%

The City's pumpage has decreased significantly since reaching a high of 5,487 acre-feet (AF) in 1995. City pumpage had decreased to 3,556 AF by 2003 and further decreased to 1,520 AF in 2004 and to 846 AF in 2005. The 2005 pumpage is similar to the City's pumpage in 1970. The 2004 and 2005 pumpage volumes are less than the average pumping rate of 2.3 million gallons per day (mgd) (total of 2,577 AFY) specified in the City's 2004 Water Policy Resolution. In 2003, the City began to reduce its use of groundwater as a source of supply to meet its water demands due to implementation of its General Plan commitments to secure a greater percentage of its supply from the Agency.

4.6.2 Projected City Pumpage

Table 4-5 illustrates the groundwater usage proposed for the future. The City's groundwater use through 2030 is projected in accordance with its Water Policy Resolution. The City will balance groundwater, recycled water, and Agency supply in accordance its voluntary commitments outlined in the Temporary Impairment MOU. Actual use under all circumstances will be in accordance with the Water Policy Resolution.

Table 4-5 (DWR Table 7) Amount of Groundwater Projected to be Pumped by the City

Basin Name(s)	2005 AFY	2010 AFY	2015 AFY	2020 AFY	2025 AFY	2030 AFY
Santa Rosa Plain Subbasin	846	2,577	2,577	2,577	2,577	2,577
% of Total Water Supply	12.7%	25.4%	25.1%	25.1%	25.1%	25.1%

4.7 Groundwater Supply Sufficiency

4.7.1 Setting

The upper Laguna watershed, located in the southern portion of the SRV Groundwater Basin and above the USGS gauge at Stony Point Road, was selected for purposes of analyzing the sufficiency of groundwater (Figure 4-18). This 25,000-acre area is considerably larger than the City's existing service area (about 5,600 acres), as shown on Figure 4-18. This area is located within a nationally-recognized hydrologic unit, the Russian River Hydrologic Unit; the Russian River Unit is comprised of numerous CalWater Hydrologic Units. CalWater is a spatial dataset of watersheds in California, developed by the Interagency Watershed Mapping Committee

(IWMC), often referred to as the "CalWater Committee". Similar to a subbasin, watershed areas are often selected for the purpose of collecting and analyzing data[17]. As discussed further below, the area was selected in part because it had previously been used by Todd (2004) for purposes of developing a water budget. The upper Laguna watershed is considered to be an appropriate area for calculating a water budget because the watershed boundaries best represent the true hydrologic boundaries of the groundwater system in the foothill areas (Todd, 2004). The direction of groundwater flow in a basin is usually similar to that of surface water, which follows the topography of the ground surface. Todd (2004) states: "[a]n important assumption is that the surface water drainage divides that define the watershed also generally represent groundwater divides." Todd also notes: "local groundwater flow is parallel to and generally does not cross the surface watershed divide/study area boundary". The watershed boundaries thus generally serve as groundwater divides, and groundwater flow across these divides can be assumed to be zero. If basin boundaries had been used for the water budget, an estimate of groundwater inflow across these boundaries would have been required. This subsurface inflow has not been previously estimated for the entire basin. Therefore, it is more accurate in this Plan to use the upper watershed area described above that has been previously evaluated for water budget analysis purposes (Todd, 2004).

4.7.2 Water Budget Estimate of Groundwater Recharge

A water budget provides a means to estimate inflows to and outflows from a study area and assess the change in groundwater storage occurring during a selected period of analysis. A water budget is one method that can be employed to estimate groundwater recharge or basin yield. Todd (2004) developed a detailed water budget for the upper Laguna hydrological area that included estimates of all municipal and non-municipal (domestic, agricultural, and commercial) pumpage along with other water budget components. For purposes of estimating the average annual rate of groundwater recharge in this area during the 1987-2001 period, a modified version of the Todd (2004) water budget was used for this Plan. This estimated recharge rate was then compared with current and historical pumpage to evaluate the sufficiency of groundwater from the basin to meet historical water demands.

The primary inflow components of the water budget (shown below on Table 4-6) are rainfall, imported surface water, subsurface inflow, and return flows from pumped groundwater. The primary outflow components are evapotranspiration, stream outflow, consumption of imported

[17] For many years, State and Federal agencies have been working through the committee to map the watersheds and hydrologic units in the State of California. The North Coast is defined by CalWater as Hydrologic Region (HR) 1. Each Hydrologic Region is broken up into Hydrologic Units, with each unit indicating an entire major river basin. Large tributaries of major rivers are designated as Hydrologic Areas (HA). In turn, HAs are subdivided into Hydrologic Sub-Areas (HSA) (North Coast Regional Partnership et al., 2007). As related to the above analysis, and using the area descriptors as used by CalWater, the Russian River is the main Hydrologic Unit, the "Middle Russian River" is the Hydrologic Area, and the "Laguna" is the Hydrologic Subarea, or "Super Planning Watershed." CalWater identifies the "Laguna de Santa Rosa" is a "Planning Watershed" within the Laguna Hydrologic Subarea. Previously, Todd (2004) referred to its water budget area as the "southern watershed of the Laguna de Santa Rosa"; similarly W&K (2005) refers to essentially the same water budget analysis area as the upper Laguna de Santa Rosa watershed. In this Plan, for purposes of consistency with the CalWater nomenclature, the water budget analysis area is referred to as the upper Laguna watershed.

water, and groundwater pumpage. Subsurface outflow was assumed to be zero due to the use of watershed boundaries to define the water budget analysis area. Groundwater recharge was estimated to be about 8,300 AFY based on the water budget (Table 4-6). As shown in Table 4-6, there is a positive change in groundwater storage. Table 4-7 shows the total estimated groundwater recharge of 8,264 AFY for the water budget period. The Todd (2004) water budget and the empirical analysis of pumpage and groundwater levels provide similar estimates of recharge that resulted in a positive change in groundwater storage. The observed groundwater level trend with stable to slightly increasing levels during 1990 to 1997 supports the computation of a positive change in groundwater storage (W&K, 2005).

Table 4-6 Revised Water Budget for Water Years 1987-2001 (Modified from Todd, 2004)

		Estimate (AFY)
Inflows		
Rainfall		73,908
Imported Water		2,604
Subsurface Inflow		355
Return Flows from Pumped Groundwater		
	Sewered	372
	Septic	701
	Agriculture	193
Total Inflows		**78,133**
Outflows		
Evapotranspiration		44,074
Stream Outflow		22,557
Subsurface Outflow		0
Phreatophytes, etc ET		455
Imported Water Consumed/Exported		2,428
Groundwater Pumped		
	Sewered	5,913
	Septic	1,077
	Agriculture	1,478
Total Outflows		**77,982**
Computed Change in Storage		**151**
Groundwater Recharge (Extracted from Water Budget)		
Deep Percolation from Precipitation and Streams		6,822
Deep Percolation from Imported Water		176
Return Flows from Pumped Groundwater		1,266
Total Estimated Recharge		**8,264**

Table 4-7 Groundwater Recharge Estimated from Water Budget for Water Years 1987-2001

Deep Percolation from Precipitation and Streams	
Rainfall (includes streamflow)	73,908 AFY,
Evapotranspiration	-44,074 AFY
Stream Outflow	-22,557 AFY
Phreatophytes etc. ET	-455 AFY
Subtotal	**6,822 AFY**
Deep Percolation from Imported Water	
Imported Water	2,604 AFY
Imported Water Consumed/Exported	2,428 AFY
Subtotal	**176 AFY**
Return Flows from Pumped Groundwater	
Sewered	372 AFY
Septic	701 AFY
Agriculture	193 AFY
Subtotal	**1,266 AFY**
Total Estimated Recharge	**8,264 AFY**

4.7.3 Empirical Analysis of Groundwater Conditions

In addition to evaluating the minimum of 5 years of historical City pumpage as required by Water Code Section 10631(b)(3), City pumpage data from 1970 through 2005 and pumpage data and estimates for other pumpers in the study area were evaluated to determine the relationship between historical pumpage and groundwater level trends. Annual pumpage data were obtained for Sonoma State University (SSU) and the City of Cotati. Metered data were not available for private, commercial, and agricultural pumpers, and pumpage estimates were derived by Todd (2004) based on population census data, planned land use, and/or water use estimates. These estimates were subsequently extended to cover the 1970 through 2005 period (Table 4-8).

Table 4-8 Summary of Historical, Current and Future Groundwater Pumpage for the Study Area

Entity		Pumpage in AFY[1]						
		1970	1980	1990	2003[2]	2004[3]	2005[3]	Future (2025)[4, 5]
City of Rohnert Park		907	3,978	5,222	3,556	1,520	846	2,577
Cotati and Sonoma State University	City of Cotati	201	492	562	273	102	47	382
	Sonoma State Univ.	38	51	70	139	139	139	220
Private and Commercial	Multi-family Dwelling Units (Todd's sewered & septic from Todd, 2004)	177	220	253	274	274	274	274
	Single Family Dwelling Units (sewered & septic from Todd, 2004)[6]	750	933	1,073	1,145	1,145	1,145	2,044
	Commercial Parcels	162	202	232	248	248	248	310
	Accommodations	21	26	30	32	32	32	32
	Graton Rancheria Casino							100
Agricultural	Agricultural pumpage (based on irrigated acres)	1,735	1,224	1,488	1,411	1,411	1,411	1,411
Total pumpage		3,992	7,126	8,929	7,078	4,871	4,142	7,350

[1] For 1970, 1980, 1990 City pumpage is metered.

[2] Pumpage values for SSU and the Cities of Rohnert Park and Cotati are metered and are for the 2003 calendar year; private and commercial and agricultural pumpage values are estimated.

[3] Pumpage values for the Cities of Rohnert Park and Cotati are metered for the 2004 and 2005 calendar year; SSU, private and commercial, and agricultural pumpage use 2003 pumpage estimates.

[4] Rohnert Park pumpage is 2.3 mgd (2577 AFY) from the 2004 Water Policy Resolution. Non-City pumpage is estimated by Todd (2004, Table 12 and the text) except for agricultural. Agricultural is kept constant from 2003 to 2025 (personal communications, Lex McCorvey, Sonoma County Farm Bureau, January 2005 and August 2007). The total increase of Non-City pumpage from 2003 to 2025 is 36%.

[5] While the City is not required by Section 10631(b) to project pumpage for a 20-year horizon for the area outside the City's service area, projected pumpage for 2030 in the upper Laguna area is likely to be similar to that shown for 2025. Specifically, the projected pumpage for the City would remain at 2,577 AF. Agricultural pumpage is expected to remain at 1,411 AF or less. The City of Cotati projected a groundwater use of 90 AFY in 2030 (W&K, 2006). Most other projections for 2030 (commercial, SSU, casino, and accommodations groundwater use) are expected to be about the same as estimated for 2025. The projected groundwater use for single-family dwelling units located outside the City's SOI is not expected to significantly increase beyond that estimated for 2025.

[6] Pumpage for single-family dwelling units is calculated based on an estimated number of dwelling units and a water demand of 0.53 AFY per unit in the upper Laguna watershed area. Although the current Penngrove Water Company (PWC) well is located outside this area, the PWC well pumpage (avg. 37 AFY historical pumpage for 1991-2002) is included in the total historical and current pumpage as shown (1970 – 2005). The 2025 total pumpage includes 163 AFY estimated to be produced from a replacement PWC well; the location of this planned well is unknown, but it is assumed that it would be located within the Canon Manor area in the upper Laguna watershed area.

The City provided monthly pumpage data for 2004 and 2005, but metered pumpage was not available for the City of Cotati, SSU, or non-municipal wells (i.e., private, commercial and agricultural wells) in the study area. Therefore, the 2003 pumpage estimate for non-City wells in the study area was also used for 2004 and 2005. Table 4-8 summarizes the historical and current metered and unmetered annual pumpage. Figure 4-17 shows the historical and current pumpage from 1970 to 2005 for the City and other entities along with the total estimated non municipal pumpage in the study area. Total estimated pumpage in the study area decreased from 7,078 AF

in 2003 to 4,871 AF in 2004 and to 4,142 AF in 2005. City pumpage accounted for about 50% of the total pumpage in 2003, about 31% in 2004, and about 20% in 2005.

Based on data provided by other public agencies, future pumpage by the City of Cotati and SSU was projected to increase from approximately 412 in 2003 to 602 AFY by 2025. Based on the Sonoma County Land Use Audit (2003) and communications with the Sonoma County Farm Bureau (January 2005 and August 2007), an increase in agricultural land use in the area south of Santa Rosa and in the vicinity of Rohnert Park is not expected. The Land Use Audit indicates that by 2025 urban growth is expected to extend beyond the current Urban Growth Boundaries. The North Coast Integrated Regional Water Management Plan (July 2007) also reports "the trend for agricultural land in the past few decades has been one of transformation to urban uses." Although future agricultural pumpage could decrease by 2025, it was conservatively assumed to remain at 2003 levels (about 1,400 AFY). Future private and commercial pumpage are projected to experience the largest increase, from about 1,700 to 2,760 AFY. The total 2025 projected pumpage for the study area (City and non-City) ranges from 6,099 to 7,350 AFY depending on assumptions about future non-City pumpage (Table 4-8). Based on evaluation of historical groundwater extraction and water level trends primarily for data from 1990 to 1997 (see Appendix E; see also W&K, 2005), groundwater recharge is estimated to be somewhat less than 8,400 AFY (i.e., total recharge must be greater than the total pumpage of 8,722 AFY minus the groundwater inflow of 355 AFY, or at least 8,400 AFY; however, because this was a wetter than normal period, recharge is expected to be somewhat less that 8,400 AFY). During 1990 to 1997 when groundwater levels were stable to slightly increasing, a positive change in groundwater storage was exhibited with inflows exceeding outflows, and the pumpage was sustainable.

4.7.4 Hydrologic Availability of the Groundwater Supply

The City's groundwater supply has not historically been subject to hydrologic variability.

As discussed in Section 4.5, groundwater levels in the shallow zone have generally been stable except for small responses to changes in precipitation. In the intermediate zone, larger responses or fluctuations in water levels occur in direct response to pumpage. Groundwater levels in the intermediate zone show little response to changes in precipitation; most of the water level changes that have been observed in the Rohnert Park area are associated with pumpage rather than climatic conditions. Correspondingly, the City's management strategy, which further reduces groundwater utilization by the City, provides an additional buffer against hydrologic variability because the City's groundwater resource can be managed in conjunction with other water sources to maximize reliability.

4.7.5 Reliability and Vulnerability of the Groundwater Supply

There are no physical constraints to groundwater pumping. The City has more than adequate capacity from its well field to pump the 2,577 AFY it anticipates utilizing.

4.7.6 Summary of Groundwater Supply and Sufficiency

4.7.6.1 Summary of the City's Groundwater Supply

The City has revised its operational strategy from one of relying largely upon groundwater for supply to a conjunctive use strategy which balances Agency supply, groundwater and recycled water. Table 4-9 illustrates the availability of the groundwater supply under a range of hydrologic conditions.

Table 4-9 Summary of City's Anticipated Groundwater Use

Hydrologic Condition	Through 2030 (AFY)	Comment
Normal Water Year	2,577	Groundwater supply will be use to enhance reliability. Use will consistent with the Water Policy Resolution
Single Dry Water Year	2,577	
Multiple Dry Water Year 1	2,577	
Multiple Dry Water Year 2	2,577	
Multiple Dry Water Year 3	2,577	

4.7.6.2 Summary of Groundwater Sufficiency

Maintaining sustainable groundwater supplies is one of the primary goals of groundwater management. As described above, DWR (1982a) described groundwater levels in the SRP Subbasin as "about in balance, with increased ground water levels in the northeast contrasting with decreased ground water levels in the south." In order to update DWR's 1982 (DWR, 1982a) evaluation of groundwater resources in Sonoma County and provide a current assessment of groundwater level trends and conditions, more than 100 water level hydrographs in the SRV Groundwater Basin were prepared and reviewed. The updated analysis of groundwater levels showed an overall improvement in groundwater conditions compared to DWR's 1982 study. Groundwater levels were generally stable in the northeast but show significant improvement in the south. The overall water level trends reflect the basin's response to recharge and discharge (including pumpage). Although historical pumpage has not been expressly quantified for the SRP Subbasin since DWR's 1982 study, groundwater level trends within the basin indicate that historical pumpage has been sustainable. Thus, as previously reported by DWR (1982a), the basin is "in balance"; the updated analysis shows no evidence of overdraft conditions occurring in the groundwater basin.

Following the updated analysis of basin-wide groundwater conditions, and finding that groundwater supplies within the basin had been sufficient to meet historical water groundwater demands, the upper Laguna watershed, located in the southern portion of the SRV Groundwater Basin was selected for purposes of analyzing the future sufficiency of groundwater to meet the City's projected demands. A water budget was one of the analyses employed to evaluate the sufficiency of the groundwater supply, based on a 20-year projection. As discussed above, the watershed was determined to be an appropriate area for calculating a water budget (i.e., an accounting of all inflows and outflows to this area to assess the change in groundwater storage) because the watershed boundaries provided the best available representation of true hydrologic boundaries. Accordingly, inflow and outflow across most of the boundaries was assumed to be

zero. In summary, this water budget analysis area allowed for a more accurate and reasonable analysis of future groundwater supply sufficiency to meet the City's projected demands than was possible for the entire SRV Groundwater Basin.

Future pumpage for the City and also pumpage by others (including other entities such as the City of Cotati and SSU and also private domestic, agricultural, and commercial wells) for the surrounding area was projected to 2025, including build out of Specific Plan areas that are in the planning stages. The maximum City pumpage in 2025 was assumed to be 2,577 AFY. As a result, future pumpage by the City is expected to be significantly less than the City's historical pumpage, which reached a high of 5,487 AF in 1995.

As a complement to the water budget analysis, an empirical analysis of the historical groundwater level and pumpage data resulted in an estimated range of pumpage within which the City and other pumpers in the southern portion of the SRP Subbasin could operate without causing persistent groundwater level declines. On the whole, groundwater levels within the SRP Subbasin have remained in balance and significantly increased in the southern portion of the SRP Subbasin since DWR's 1982 study (DWR, 1982a). As described in Sections 4.7.2 and 4.7.3, the City's as well as other projected pumpage for a 20-year horizon falls within a range that is historically demonstrated to have been sustainable. Thus, groundwater supplies from the basin are sufficient to meet the City's projected groundwater demands and also those of other pumpers.