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4.5 GROUNDWATER

This section discusses the Project impacts on groundwater quality at existing and future drinking water wells, the potential for groundwater mounding or increase in groundwater levels that could cause surface water discharge in a non-stream environment, and the potential to lower groundwater levels at existing and potential future wells. To allow evaluation of these impacts, geologic units in the area are described and identified as to their water-yielding properties. Groundwater basins in the Project area are depicted, and the groundwater conditions at irrigation areas and storage sites are presented. Regional groundwater quality and reclaimed water quality are described.

IMPACTS EVALUATED IN OTHER SECTIONS

The following items are related to the Groundwater Section but are evaluated in other sections of the document:

- Subflow Resulting from Irrigation with Reclaimed Water. Impacts are evaluated in Section 4.6, Surface Water Quality and Section 4.9, Aquatic Biological Resources.

- Surface Water Discharge in a Stream Environment. This impact is evaluated in Section 4.6, Surface Water Quality.

- Groundwater Quality and Reclaimed Water Quality in Relation to Drinking Water Standards. These issues are evaluated in Section 4.7, Public Health and Safety.

AFFECTED ENVIRONMENT (SETTING)

Concepts of Groundwater Hydrology

The following section provides a summary of the basic concepts of groundwater hydrology. The material has been summarized from the Evaluation of Groundwater Resources: Sonoma County (California State Department of Water Resources 1975) and focuses on processes relevant to the Project impact evaluation.

Water is present in two zones beneath the ground surface. The upper zone is the zone of aeration (or vadose zone) where pore spaces in the geologic material are partly filled with air and partly filled with water. Wells do not produce groundwater from the vadose zone because the molecules of water adhere tightly to the various geologic materials. Water stored in this zone of aeration is called soil moisture or vadose water. Soil moisture is drawn into the rootlets of growing plants. As the plants use the water, it is transpired as vapor to the atmosphere. Under some conditions, water can flow laterally in the vadose zone in a process known as interflow (Fetter 1994).

If perched groundwater occurs in the zone of aeration, it is contained in an isolated saturated zone which occurs above a low permeability layer and is separated from the main groundwater body by an underlying unsaturated zone. The lower zone is the zone of saturation where all of the interconnected pore spaces in the geologic material are filled with groundwater, and only dissolved gaseous air is present.

Groundwater in the saturated zone is either confined or unconfined. An aquifer containing unconfined groundwater is one that is not overlain by a confining bed of relatively low permeability geologic material. The upper surface of an unconfined body of groundwater is called the water table. It is represented by the level of water in a well penetrating the saturated zone. In an unconfined aquifer the water table is assumed to be connected to the atmosphere through openings in the overlying material.

A confined aquifer is overlain by relatively impermeable material and is isolated from overlying aquifers except in areas of recharge. Groundwater contained in confined aquifers is under pressure, and the level to which the water will rise in a nonpumping well is the potentiometric surface of the groundwater. The potentiometric surface is an imaginary surface that represents the upward pressure exerted by the confined groundwater on the materials overlying it.

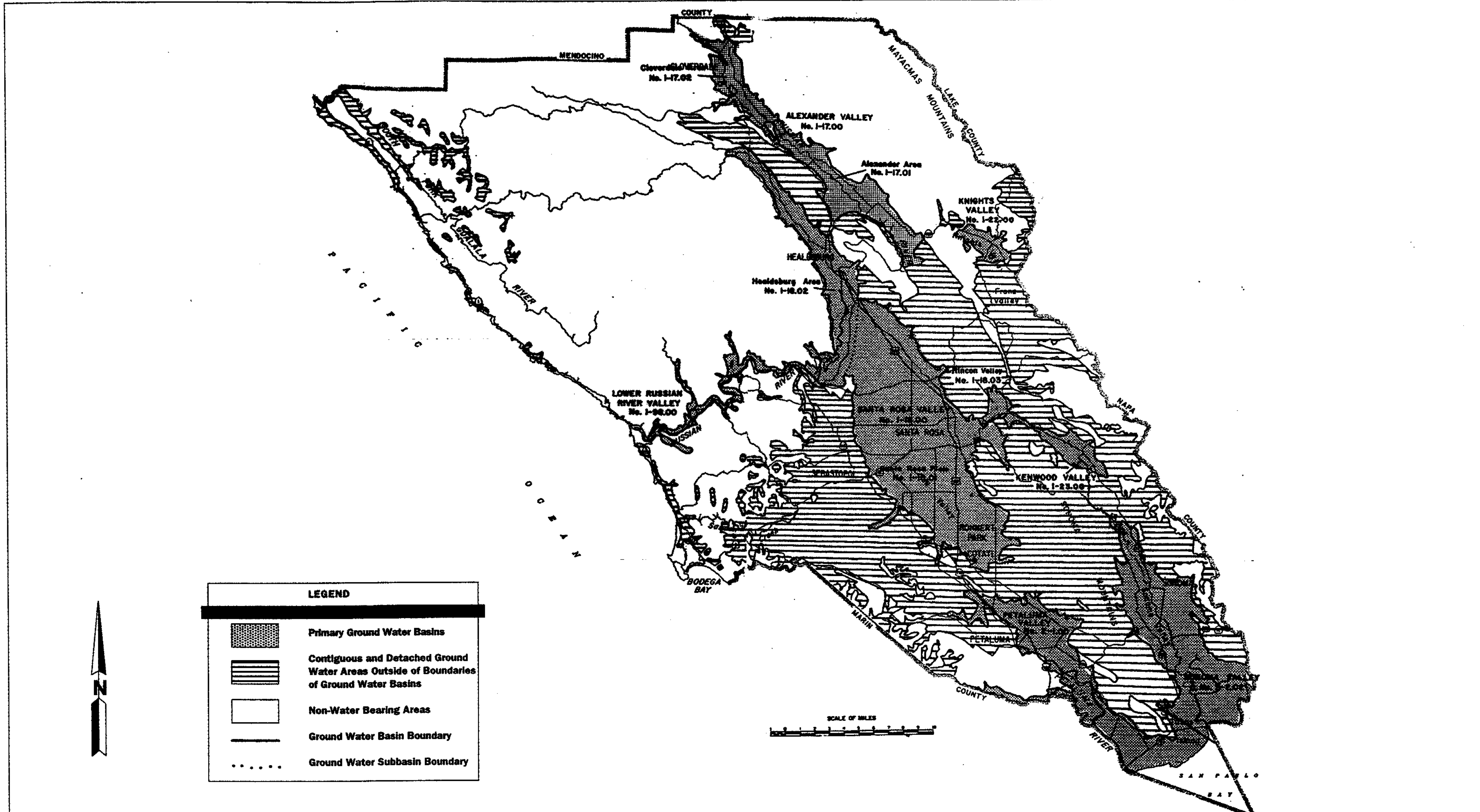
Water recharges an aquifer through precipitation, streamflow, irrigation, or other sources by entering the ground and moving downward through the zone of aeration and into the zone of saturation. Groundwater under pressure moves toward areas of lower pressure, such as pumping depressions. In cases where the pressure relief area is along a stream channel, springs form and provide streamflow even during periods of low precipitation.

The general groundwater movement pattern of a basin can be interpreted from groundwater contour maps[1] which show lines of equal elevation of the groundwater surface. Groundwater movement is perpendicular to the contour lines and moves from the higher elevation contours to the lower. The relative spacing between the contour lines indicates the hydraulic gradient of the groundwater, which is an index of the resistance encountered as the water moves through the various permeable layers.

Regional Groundwater

Sonoma County has been divided into three groundwater resource regions (Figure 4.5-1). One region contains the seven valley groundwater basins: Santa Rosa, Petaluma, Sonoma, Alexander, Kenwood, Knights, and Lower Russian River valleys (Figure 4.5-1) (California State Department of Water Resources 1975). A groundwater basin is an area that is underlain by water-bearing materials and has significant potential for groundwater development.

[1] Groundwater contour maps should not be confused with topographic maps which show ground surface topography by mapping lines of equal elevation. Although groundwater in an unconfined aquifer may mimic topography, groundwater basins and flow directions are controlled by the groundwater gradient that may or may not reflect topography.



Source: Department of Water Resources 1975

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Santa Rosa Subregional Long-Term Wastewater Project

GROUNDWATER BASINS in SONOMA COUNTY

Figure 4.5-1

Groundwater is usually available in predictable quantities nearly everywhere within the limits of the groundwater basin. The second important groundwater region in Sonoma County is the contiguous and detached groundwater areas which are located in upland areas of Sonoma and northern Marin counties. These areas are underlain by a variety of geologic materials which range in their water-yielding capabilities from high yield in the case of the Wilson Grove Formation to low yield in the case of Petaluma Formation. The third area is underlain by non-water-bearing rock and is not considered to be a predictable source of groundwater. Occasional wells may be developed in these areas yielding supplies of groundwater adequate for most domestic or stock applications.

The following description of environmental setting and impacts pertains to two groundwater basins (the Santa Rosa Plain and the Petaluma Valley), several areas of contiguous and detached groundwater in Sonoma and Marin counties (west county irrigation and reservoir sites, Sebastopol irrigation area, and portions of the urban irrigation areas), and areas of non-water bearing rock (the geysers and portions of the Tolay Creek watershed). Descriptions are based on various reports by the California State Department of Water Resources (1975, 1982a and b, 1987), which are the most current compilations of regional groundwater information. Groundwater field investigations confirmed that these sources provide valid information for characterizing the Project area.

Groundwater recharge in Sonoma and northern Marin counties generally occurs in upland areas adjacent to groundwater basins. The primary sources of recharge are precipitation and stream seepage. Recharge occurs in significant quantities wherever permeable materials are near the surface and connect with the principal groundwater body, and surface slopes are gentle enough to limit the amount of precipitation that becomes surface runoff.

Groundwater discharge occurs mostly along the major trunk streams of the Santa Rosa and Petaluma valleys. In these areas, groundwater discharges as underflow to the streams, Laguna, or adjacent low-lying areas. This water then flows as surface water toward the Russian River or San Pablo Bay. Groundwater is also lost through evapotranspiration in the extensive marsh areas of the Laguna de Santa Rosa. In the western uplands, groundwater discharges to streams in the middle to lower reaches of coastal valleys. These streams discharge to the estuaries on the coast. Water extracted from wells also contributes to removal of groundwater from the basins.

In general, the water table surface mirrors topography, although in a more subdued form. Unconfined groundwater elevations are highest at topographic high areas, and low in the lower topographic areas.

Hydrogeologic Units

Groundwater within the study area occurs in a complex system of highly variable geologic units. These units are commonly divided into non-water-yielding, variable water-yielding, and water-yielding groups. A measure of the water-yielding capacity of the geologic units is the specific yield,[2] often expressed as a percentage. The units are listed in the sequence in which they occur from lowest (oldest) to highest (youngest) (Parsons Engineering Science, Inc. 1996a).

Franciscan Complex (Jurassic-Cretaceous): Basement rocks consist of the Franciscan Complex, the oldest geologic unit within the project area. This unit consists chiefly of sandstone, shale, chert, greenstone, and serpentinite. Sandstone is the predominant rock type of the formation but large areas consist of rock melange, a mixture of broken rock masses in a sheared matrix of shale.

In the northwest trending valley that forms the Santa Rosa/Petaluma trough, bedrock of the Franciscan Complex is downwarped and is buried by thick sequences of sedimentary rock and unconsolidated sediment. In the western uplands, Franciscan bedrock is exposed at the surface or capped by a relatively thin veneer of sedimentary rock.

Rocks of the Franciscan Complex are generally non-water yielding because they are well consolidated and dense. However, zones of secondary porosity caused by joints, fractures or shear zones may locally provide low yields of water. In the Santa Rosa/Petaluma trough, the Franciscan Complex is relatively deep and generally not used as a groundwater resource. In the western uplands where the Franciscan occurs at or near the surface, small amounts of water may be obtained from water yielding zones. Well yields in the Franciscan Complex are generally low. The California State Department of Water Resources (1975) has attributed a very low specific yield of less than 3 percent to these rocks.

Petaluma Formation (late Miocene [Fox 1983]): The Petaluma Formation consists of folded terrestrial and brackish water deposits composed of clay, shale, sandstone with lesser amounts of conglomerate, and limestone. Clay is the predominant rock type of the formation.

The Petaluma Formation overlies Franciscan bedrock in a major portion of the Petaluma and Santa Rosa valleys and is overlain by and locally interfingers with the Wilson Grove Formation. The Petaluma Formation occurs along the eastern margin of the Santa Rosa/Petaluma trough where the deposits locally interfinger with and are overlain by, or in fault contact with the Sonoma Volcanics (Cardwell 1958, Fox 1983). In the central to western Petaluma Valley, northwest trending faults mark abrupt contacts between the Petaluma and Wilson Grove formations. The Petaluma Formation has a maximum thickness of 4,000 feet.

Groundwater occurs in the sandstone and conglomerate lenses that are interspersed in the predominant claystone of the Petaluma Formation. Where appreciable thicknesses of coarse-grained material are encountered, this formation can yield moderate amounts of water adequate for domestic needs, though because of the predominance of claystone, well yields are generally low (Cardwell 1958). Specific yields for this unit are low, from 3 to 7 percent (California State Department of Water Resources 1987).

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[2] Specific yield is defined as the ratio of the volume of water that a given mass of saturated rock or soil will yield (under gravity) to the volume of that mass.

Wilson Grove Formation (Late Miocene to Pliocene [Fox 1983]): The Wilson Grove Formation (formerly referred to as the Merced Formation) is one of the principal water-producing formations in Sonoma County. The formation consists of massive beds of fine- to very fine-grained marine sandstone with interbeds of clay and gravel.

The lowermost Wilson Grove Formation overlies and interfingers with the Petaluma Formation in the central portion of the Santa Rosa/Petaluma trough. On the western side of the trough the formation lies directly on Franciscan bedrock. The Wilson Grove Formation thins east of the central portion of the trough and does not extend to the eastern margin. The formation is exposed in the hills on the west side of the trough and is overlain by alluvial fan deposits in the Santa Rosa and Petaluma valleys. The formation's thickness below the Santa Rosa Plain may be as great as 800 feet. In the Petaluma Valley the maximum thickness is about 200 feet (Cardwell 1958).

In the western portion of Sonoma County, the Wilson Grove Formation forms a relatively thin veneer overlying Franciscan Complex rocks. On the topographically higher ridges the formation occurs as isolated caps on Franciscan rocks.

Groundwater in the Wilson Grove Formation is typically unconfined, but semi-confined or confined conditions can occur locally wherever laterally continuous clay beds occur. Because of its uniform high porosity and moderate permeability, this unit yields good quantities of water (Cardwell 1958). The Wilson Grove Formation has high specific yields of 10 to 20 percent (California State Department of Water Resources 1987).

Sonoma Volcanics (late Miocene to Pliocene [Fox 1983]): The Sonoma Volcanics are a thick sequence of volcanic material consisting of lava flows, tuffs and intrusive rocks (California State Department of Water Resources 1975). Locally, the volcanics interfinger with the Petaluma and Wilson Grove formations. The Sonoma Volcanics border the eastern edge of the Santa Rosa Plain and extend under the plain a short distance. In the vicinity of Petaluma Valley the volcanics are mainly restricted to the hills east of the valley. Few exposures of the volcanics occur in the western portion of the county. Productivity of water wells within this unit is highly variable, ranging from dry wells to wells with yields that are adequate for domestic purposes. Some of the better producing wells may yield 10 to 50 gallons per minute with drawdowns of 10 to 120 feet (California State Department of Water Resources 1975). Specific yields range from 0 to 15 percent (California State Department of Water Resources 1982).

Alluvial Fan Deposits (Pliocene to Recent). The alluvial fan deposits, which include the Glen Ellen Formation, are composed of a heterogeneous mixture of unconsolidated gravel, sand, silt, and silty clay. The alluvial fan deposits extend from the base of upland areas to the valley floors. The deposits are coarser in upland areas and are finer-grained in the valley. These deposits cover much of the Santa Rosa Plain and the northern and eastern portions of the Petaluma Valley and range in thickness from about 50 to 400 feet (California State Department of Water Resources 1982a, 1982b). Due to their overall coarseness, these deposits are estimated to have moderate to high specific yields of 8 to 17 percent (California State Department of Water Resources 1982a, 1982b).

Alluvium (Pleistocene to Recent). A variety of unconsolidated alluvial deposits occur as discontinuous interbeds of gravel, sand, silt, and clay. These undifferentiated alluvial deposits represent a mixture of coarse-grained stream channel and natural levee deposits, and fine-grained flood plain deposits. In upland areas surrounding the Santa Rosa/Petaluma trough and in the western uplands, alluvium occurs as superficial deposits along narrow bedrock stream valleys. Where streams emerge from upland areas, alluvium is restricted to elongate stream valleys that have been incised into underlying alluvial fan deposits. The specific yield is variable, depending on the amount of clay and the thickness of the deposits. Most deposits are less than 100 feet thick with variable specific yields, ranging from 3 to 15 percent (California State Department of Water Resources 1982a, 1982b).

Basin Deposits (Pleistocene to Recent). Basin deposits consist of organic-rich, clay and silty clay deposited in freshwater marsh and lakes. These deposits occur in low-lying areas of the Santa Rosa Plain including the central portion of the southern plain, adjacent to the Laguna de Santa Rosa and the lower reaches of tributary stream valleys. These thin deposits overlie and interfinger laterally with coarser-grained alluvial fan deposits or alluvium (California State Department of Water Resources 1982b).

The fine-grained basin deposits have low permeability and do not yield significant quantities of groundwater. They restrict infiltration and downward percolation of water and form a confining layer where they overlie coarse-grained, water-yielding deposits. These deposits have been assigned low specific yields of 3 to 7 percent (California State Department of Water Resources 1982b).

Bay Mud Deposits (Pleistocene to Recent). The bay mud deposits consist of organic-rich mud, silty mud, silt and some sand. These sediments cover much of the southern Petaluma Valley. Groundwater occurring in bay mud deposits is brackish to highly saline. Bay muds have a low permeability due to the overall fineness of these deposits. These deposits have been given a very low specific yield of less than 3 percent (California State Department of Water Resources 1982a). The deposits are not considered a reliable source of potable water.

Groundwater Basins

Project components are located throughout Sonoma and northern Marin counties. Some are located in well defined groundwater basins, some in contiguous detached sub-basins, and some in upland areas that are not within defined groundwater basins. Table 4.5-1 provides a summary of groundwater conditions at irrigation areas and storage reservoir sites.

Table 4.5-1

Groundwater Conditions at Reservoir Sites and Irrigation Areas

Project Component	Groundwater Basin	Hydrogeologic Unit / Presence of Springs	Typical Depth to Ground-Water	Approximate Flow Direction	Ground-water Quality	Approximate Number of Wells[1]
Urban Irrigation	Santa Rosa Plain	Alluvial Fan Deposits	~100'	West	Good	N/A
Sebastopol Agricultural Irrigation	Detached sub-basin of the Santa Rosa Plain	Wilson Grove Formation	20'-80'	North	Good	N/A
Stemple Agricultural Irrigation	Stemple Creek Detached sub-basin	Wilson Grove Formation and Franciscan Complex	10' - 100'	West	Problems with nitrate	N/A
Americano Agricultural Irrigation	Americano Creek Detached sub-basin	Wilson Grove Formation	10' - 40'	West	Good	N/A
North of Petaluma Agricultural Irrigation	Petaluma Valley	Petaluma Formation and Alluvial Fan Deposits	10' - 20'	Southeast	Problems with nitrates	N/A
East of Rohnert Park/Adobe Road Agricultural Irrigation	Santa Rosa Plain/Petaluma Valley	Alluvial Fan deposits and Petaluma Formation	10'-60'	West	Good	N/A
Lakeville/bay flats Agricultural Irrigation	Petaluma Valley	Petaluma Formation and Alluvial Fan Deposits	0' - 150'	South southeast	Brackish water	N/A
Tolay Reservoir	Detached sub-basin	Alluvium, Sonoma Volcanics, Petaluma Formation; Several springs mapped	20' - 60'	Southeast	No data available, likely to be similar to Petaluma	0
Adobe Road Reservoir	Petaluma Valley	Alluvium, Sonoma Volcanics, Petaluma Formation; Several springs mapped	10'-120'	Southwest	Elevated nitrate levels	20

Table 4.5-1

Groundwater Conditions at Reservoir Sites and Irrigation Areas

Project Component	Groundwater Basin	Hydrogeologic Unit / Presence of Springs	Typical Depth to Ground-Water	Approximate Flow Direction	Ground-water Quality	Approximate Number of Wells[1]
Lakeville Reservoir	Petaluma Valley	Alluvium, Petaluma Formation; Several springs mapped	20'-80'	South	Elevated nitrate levels	4
Sears Point Reservoir	Detached sub-basin of the Tolay watershed	Alluvium, Petaluma Formation; Several springs mapped	10' -20'	Southeast	No data available, likely to be similar to Petaluma	1
Two Rock Reservoir	Detached sub-basin of the Stemple Creek watershed	Alluvium, Wilson Grove Formation, Franciscan Complex; Year-round stock ponds indicate springs	0' - 220'	West	Elevated nitrate levels	25
Bloomfield Reservoir	Detached sub-basin of the Americano Creek watershed	Wilson Grove Formation; Numerous springs mapped	10' - 190'	South	Good	3
Carroll Road Reservoir	Detached sub-basin of the Americano Creek watershed	Wilson Grove Formation; Numerous springs mapped	10' - 175'	South	Good	14
Valley Ford Reservoir	Detached sub-basin of the Americano Creek watershed	Wilson Grove Formation; Several springs mapped	10' - 90'	South	Good	4

Table 4.5-1

Groundwater Conditions at Reservoir Sites and Irrigation Areas

Project Component	Groundwater Basin	Hydrogeologic Unit / Presence of Springs	Typical Depth to Ground-Water	Approximate Flow Direction	Ground-water Quality	Approximate Number of Wells[1]
Huntley Reservoir	Detached sub-basin of the Stemple Creek watershed	Wilson Grove and Franciscan Complex, Springs concentrated along the geo-logic contact	10’ - 150’	South	Elevated Nitrate levels	5

Source: Parsons Engineering Science, Inc., 1996

Notes:
1 Based on review of California State Department of Water Resources well records, CH2M Hill (1990) study, and site reconnaissance.

Santa Rosa Plain

The Santa Rosa Plain is the largest groundwater basin in the Project area and is situated in the Coast Ranges geomorphic province in Sonoma County (Figure 4.5-1). The plain lies in a northwest trending structural depression between the Mendocino Range on the west and the Mayacamas and Sonoma mountains on the east. The Santa Rosa Plain is connected to the Russian River plain by a gap in the hills at the northern end of the plain. The Santa Rosa Plain has low relief with an average ground surface elevation of approximately 145 feet above mean sea level (California State Department of Water Resources 1987).

The Santa Rosa Plain is composed of geologic units with variable water-yielding properties. Generally, the stratigraphically lowest water-yielding unit is the Petaluma Formation which reaches thicknesses of 1,000 feet in the central portion of the Plain. The Wilson Grove Formation overlies the Petaluma Formation in the western and central portion of the plain with thicknesses as great as 800 feet. On the eastern margin of the plain, where the Wilson Grove Formation is absent, the Sonoma Volcanics locally overlie and interfinger with the Petaluma Formation. Unconsolidated alluvial fan deposits[3] up to 500 feet thick, form the uppermost geologic unit over much of the Plain. A variety of younger alluvial material composed of clay, silt, sand, and gravel forms discontinuous deposits on or near the surface of the Plain. Relatively small, thin patches of fine-grained marsh-like deposits classified as basin deposits are scattered over the surface of

3 Most of the geologic units in the Santa Rosa Plain previously mapped as the Glen Ellen Formation are classified as alluvial fan deposits (California Department of Water Resources 1982).

the Plain. The total thickness of deposits in the central portion of the Plain probably exceeds 2,000 feet (California State Department of Water Resources 1982).

In the Santa Rosa Plain the water table is typically shallow (Figure 4.5-3). In the 1950s groundwater levels were generally 5 to 20 feet below the ground surface (Cardwell 1958). Comparison of groundwater contours from 1960 to 1975 indicates that groundwater levels in some areas of the plain have dropped while other areas have risen or remained the same (California State Department of Water Resources 1982). Groundwater levels have risen in the vicinity of Santa Rosa where groundwater use has decreased over this time period. In the southern portion of the plain, groundwater use has increased causing a decline in water levels in that area. Because these variations tend to offset each other, the groundwater basin as a whole is viewed as being in balance (California State Department of Water Resources 1982). Most of the groundwater in this basin appears to be in unconfined aquifers although there is evidence that some deeper portions are under semi-confined to confined conditions (California State Department of Water Resources 1987).

Groundwater in the plain generally moves toward the Laguna de Santa Rosa which is adjacent to and parallel with the western margin of the basin (Cardwell 1958). Therefore, the predominant flow direction is toward the southwest. The primary source of the recharge for groundwater in the Santa Rosa Plain is from infiltration of rainfall and seepage from streams (Cardwell 1958). Recharge is dependent on topography, surface soil conditions, and vegetation.

Groundwater of the Santa Rosa Plain is used for irrigation, domestic, industrial, and municipal water supply. Many wells that serve rural agricultural residential uses are shallow and extract a relatively minor amount of water from the aquifer. These wells are widely distributed in the Santa Rosa Plain.

Industrial and municipal wells tend to be clustered in and around urban areas and extend to depths ranging from 450 to greater than 1,000 feet. The cities of Rohnert Park, Cotati, and Sebastopol and Sonoma State University obtain water from the Santa Rosa Plain groundwater basin. The single largest user of groundwater in the area is the City of Rohnert Park, which operates approximately 40 wells primarily located north and west of the City. Pumping of groundwater for water supply has caused a lowering of the water table in the vicinity of Rohnert Park. In general, however, high groundwater levels in the Santa Rosa Plain indicate that the major portion of the aquifer is at or near its storage capacity.

Petaluma Valley

The Petaluma Valley groundwater basin comprises approximately 60,000 acres extending from Penngrove south to the Marin County line and San Pablo Bay. The groundwater basin includes the Two Rock area to the west and extends east to the crest of the Sonoma Mountains, which separates the Petaluma Valley from the Sonoma Valley (Figure 4.5-1).

The Petaluma Valley groundwater basin occurs as a northwest trending trough underlain by the essentially non-water-yielding Franciscan Complex. The two primary water-yielding units are the Wilson Grove Formation and the alluvial fan and alluvium deposits. The Wilson Grove Formation overlies the Franciscan Complex in the west and central portion of the trough. In this basin, the Wilson Grove Formation has a maximum thickness of over 200 feet. The Wilson Grove Formation does not occur at the eastern margin of the basin where the Petaluma Formation, a relatively low water-yielding unit, directly overlies the Franciscan Complex. Alluvial fan deposits and alluvium generally occur at the surface in low-lying portions of the valley and overlie both the Wilson Grove and the Petaluma formations. The alluvial fan and alluvium deposits have a maximum thickness of approximately 100 feet in this basin.

Although the Petaluma Valley is generally considered to be a single groundwater basin, groundwater occurs in vertically and horizontally discontinuous hydrologeologic units. The sands and gravels of the Wilson Grove Formation generally form continuous hydrogeologic units. The other geologic units of the basin generally contain discontinuous coarse-grained lenses. This discontinuity is evidenced by the unique water quality that can be found in relatively isolated hydrogeologic units (California State Department of Water Resources 1982b).

Generally, the groundwater basin is unconfined at shallow depths although semi-confined to confined conditions can be encountered deeper in the basin (Cardwell 1958). The depth to groundwater is shallow, ranging from 10 to 25 feet below the ground surface in the spring to 15 to 40 feet in the autumn (Cardwell 1958). The elevation of the water table in the uplands is higher than in the valley floor area, but usually occurs at depths of 50 to 75 feet below the ground surface.

Groundwater extraction satisfied the City of Petaluma's water needs during the late 1950s and early 1960s. However, problems with salt water intrusion attributed to this municipal use resulted in groundwater pumpage being reduced in 1962 when water deliveries from the Russian River began. In the early 1980s, 15 percent (900 acre-feet/year) of the City of Petaluma's municipal water was supplied by groundwater (California State Department of Water Resources 1982b). The City currently relies on the Sonoma County Water Agency to supply all of its water needs and City wells are not used. Groundwater remains the primary source of domestic and irrigation water needs in the unincorporated areas of Petaluma Valley.

Americano/Stemple Area

The watersheds of Americano and Stemple creeks are located in southwestern Sonoma County and northeastern Marin County. These west-flowing creeks are located in relatively steep terrain, drain directly into the Pacific Ocean, and are not part of the Russian River watershed. Refer to Section 4.4, Surface Water Hydrology, for a discussion of the watersheds of Americano and Stemple creeks.

The Americano/Stemple area is not within a discrete groundwater basin but is considered to be part of the continuous and detached groundwater area (Figure 4.5-1). Three main geologic units, the Franciscan Complex, the Wilson Grove Formation, and alluvium are present in the area; all of these units contain some groundwater and have been developed for water supply to some degree.

In the coastal groundwater basins underlying the watersheds of Stemple and Americano creeks, groundwater moves from upland recharge areas to trunk streams or main branches of the Stemple and Americano creeks. Deeper groundwater flows continue toward the estuaries on the coast. Groundwater seeps typically occur at cliff-face exposures at the contact between the Wilson Grove and the Franciscan Complex.

The Wilson Grove Formation is the major aquifer in the area and includes permeable gravel, shell lenses, and minor layers of fine-grained material. In general, yields from this formation are high (California State Department of Water Resources 1975).

The Franciscan Complex in the Americano/Stemple area is extensively fractured and faulted and can locally provide small amounts of water to wells. Generally, the Franciscan provides only low yields to domestic wells, stock watering wells, and springs. Limited alluvial deposits along the stream valleys provide water to shallow domestic wells.

In the Americano/Stemple area, groundwater in shallow wells is typically less than 30 feet below the ground surface. In wells of intermediate depth (200 to 400 feet), groundwater levels generally range from approximately 20 to 90 feet below the ground surface; wells over 400 feet deep contain water at depths ranging from approximately 50 to 150 feet.

The Americano/Stemple area is characterized by a relatively low density of wells relative to the more intensively developed Santa Rosa Plain and Petaluma Valley; wells in this area tend to be concentrated in valleys between upland areas. These wells, which range in depth from less than 20 feet to about 500 feet, serve domestic and agricultural water users.

Groundwater Quality

Twenty-one monitoring wells were installed in the Project area. Well sites were selected to provide groundwater quality data at each reservoir site and in agricultural irrigation areas. Two of the wells, one in the Two Rock subbasin and one in the Tolay Creek watershed were dry bore-holes. As a result, no new groundwater quality data were available for the Tolay Creek watershed. Groundwater quality data from the Lakeville Hillside reservoir site were applied to the Tolay Creek watershed because both areas have similar geologic conditions and are located a similar distance from San Pablo Bay. Refer to Figures 4.5-2 through 4.5-10 for groundwater monitoring well locations. Two project technical reports: *Hydrogeology of Storage/Reuse Areas and Evaluation of Potential Impacts to Groundwater* and *Well Installations and Groundwater Monitoring Results* (Parsons Engineering Science, Inc. 1996a and b), contain detailed information about the groundwater investigation.

Because of the relatively small number of wells located in each watershed, groundwater quality data from the wells cannot be viewed as a complete characterization of the range of values that could be encountered in a watershed. The data is useful because it establishes the general groundwater quality and allows comparison of existing groundwater quality at the nine reservoir sites. Groundwater quality, and specifically nitrate concentration, varies substantially from one season to the next and from location to location. Groundwater quality may vary significantly among hydrogeologic units. Therefore, the depth of a well and the screened interval (the portion of the well casing that is perforated and contributes water to the well) will influence groundwater quality. Groundwater, particularly in the shallow zone, may be influenced by agricultural uses of the land. Agricultural use in Sonoma County tends to be most intense in low lying, valley floor areas. Most of the wells installed for this project are located in the axis of the main valley (often the only accessible location) and may not be representative of the reservoir subbasin.

Santa Rosa Plain

The Santa Rosa Plain includes the Rohnert Park irrigation area and urban irrigation areas. Groundwater quality in the Santa Rosa Plain is generally good to excellent, although groundwater tends to be hard with high calcium and magnesium concentrations (City of Santa Rosa and U.S. Bureau of Reclamation 1990). Data from the project groundwater sampling program indicate that the secondary maximum contaminant level (MCL) for iron is typically exceeded. Chemical characteristics are variable, depending on geologic factors, adjacent land uses, well extraction, and infiltration.

Excellent quality water is usually obtained from alluvium and alluvial fan deposits. The Wilson Grove Formation generally produces high quality water, although high iron, manganese, sodium, and total dissolved solids have been reported in wells tapping the lower portion of the Wilson Grove Formation.

Many shallow domestic wells and older shallow wells (particularly in the eastern portion of the Santa Rosa Plain) lack adequate sanitary seals. These older wells may serve as a direct conduit for agricultural runoff, potentially contaminated with animal waste, to enter the shallow groundwater and degrade its quality.

Petaluma Valley

The Petaluma Valley includes the North Petaluma and bay flats irrigation areas. The Adobe Road, Lakeville Hillside, Tolay, and Sears Point reservoir sites are considered to be part of the Petaluma Valley groundwater basin[4].

Two significant groundwater quality issues have been reported in the Petaluma Valley groundwater basin. One concern is sea water intrusion. Southeast of the City of Petaluma, wells seemed to be affected by salt water intrusion or brackish water originating in marine deposits (e.g., bay mud deposits). Water quality degradation associated with intrusion involves increased sodium, salinity, total dissolved solids, boron, hardness, iron, and manganese. The California State Department of Water Resources (1982b) reported that the extent of sea water intrusion remained the same or decreased between the early 1960s and early 1980s.

Nitrate contamination is the primary groundwater quality issue in the Petaluma Valley. The presence of nitrate in groundwater is usually the result of infiltration of surface contamination from fertilizers, animal waste from livestock or poultry farms or from septic tank leach fields. The major source of nitrate in the northwest portion of the valley appears to be livestock and poultry farming operations. Nitrate contamination is generally confined to the shallow groundwater zone (California State Department of Water Resources 1986). One well in the vicinity of the Lakeville reservoir site (LN-01), sampled as part of this project, exceeded the drinking water standard (maximum contaminant level or MCL) for nitrate.

Water quality data collected from the monitoring wells indicate that the primary MCL for aluminum is typically exceeded in the vicinity of the Adobe Road and Lakeville reservoir sites. The secondary MCL for iron is exceeded in all of the wells sampled for this project (Parsons Engineering Science, Inc. 1996) in the Petaluma Valley and Tolay watershed. Total dissolved solids (TDS)[5] concentrations at two wells in the Lakeville area (LN-01 and LM-01) exceeded the secondary MCL (500 mg/L). One well at the Lakeville agricultural area (LN-01) exceeded the primary MCL for chloride.

Americano/Stemple Area

A previous groundwater monitoring study involving 27 wells in the Americano/Stemple area indicated that groundwater in the area showed evidence of infiltration of bacteria from surface or near surface sources (CH2M Hill 1990). Coliform bacteria were detected in most of the wells sampled; only two wells were found to be consistently free of bacteria. In general, contamination by microorganisms is limited to shallow aquifers, near the ground surface; typical

4 The Tolay Creek watershed is considered to be a subbasin with similar geologic and groundwater conditions as the Petaluma Valley.

5 Total dissolved solids indirectly measures boron, chloride, bicarbonate, sodium, calcium, magnesium, potassium, sulfate and nitrate.

contaminant sources include septic tanks, dairies, feedlots, and poultry ranches. Several wells contained low concentrations of metals (barium, zinc, copper, selenium, and silver) from an unknown source. Metals were detected in concentrations below established drinking water standard maximum contaminant levels (MCLs).

Some wells sampled in the CH2M Hill study were old and not equipped with sanitary seals. Groundwater quality results of that study may not have been representative of the groundwater basin. The groundwater sampling program described above was implemented to provide additional information for this EIR/S and to determine if previously collected data were representative. Results indicate that groundwater in the Americano/Stemple area has been affected by agricultural practices. Nitrate concentrations at two Stemple Creek locations, including the Two Rock well (STRL-01), exceeded the MCL for nitrate. Three of the four monitoring wells installed in the Stemple Creek area (SS-01, STRL-01, and SHL-01) exceeded the MCL (500 mg/L) for TDS[6]. One well at the Two Rock reservoir site (STRL-01) exceeded the MCL for chloride.[6]

The Geysers

The geysers area is underlain by bedrock of the Franciscan Complex. No significant regional aquifers or potential drinking water sources are known in the immediate vicinity of the geysers. Small volumes of unconfined, perched groundwater may be present in surficial landslide and alluvial deposits. In addition, small discontinuous volumes of groundwater may be present within 50 to 1,000 feet of the ground surface occurring in fractured non-reservoir rock in the vicinity of the geysers. The predominant source of both types of groundwater is infiltrating precipitation. Groundwater in the geothermal reservoir (2,000 to 12,000 feet below the ground surface) is hot, of poor quality, and is used to generate electricity at the geysers steamfield.

Reclaimed Water Quality

The following discussion provides a comparison of the quality of groundwater within the Project area to the quality of reclaimed water from the Laguna WWTP. This information has been summarized from project groundwater technical reports (Parsons Engineering Science, Inc. 1996b). The technical reports include data tables that list analytical results for all constituents sampled at each well.

As indicated in the Evaluation Criteria (Table 4.5-3) groundwater quality impacts are evaluated based on public health effects, which are measured by the MCL. The discussion below summarizes the location of wells where constituents were detected above the MCL. The concentration of constituents in wells is compared with the average values measured in the Laguna WWTP reclaimed water.

6 Reclaimed water from the Laguna Wastewater Treatment Plant does not exceed the MCL for this constituent.

Metals

Water quality data collected from the monitoring wells indicate that metals such as aluminum, magnesium, zinc, and nickel may occur at higher concentrations in groundwater at the reservoir sites than in the reclaimed water. The average levels of metals in reclaimed water are below all the respective maximum contaminant level (MCLs). Metals in excess of the MCLs were detected in wells in Petaluma Valley, Americano and Stemple creeks watershed, and the Lakeville Hillside subbasin, discussed above. Metals tend to bind to soil particles and are not generally soluble in groundwater (USEPA 1981).

Salts and Other Chemical Constituents

The average concentration of total dissolved solids (TDS), fluoride, nitrite, nitrate, and phosphate in the reclaimed water was higher than in groundwater at some locations within the project site. The average concentrations of these constituents, except nitrate, are below the MCLs defined by State and Federal drinking water standards. Only nitrate and nitrite are regulated by primary drinking water standards for protection of public health. Section 4.7, Public Health and Safety provides a detailed discussion of reclaimed water quality in relation to drinking water standards under the topic Human Exposure to Reclaimed Water.

The only water quality constituent in exceedence of the MCL in reclaimed water is nitrate. The MCL for nitrate is 10 milligrams/liter (mg/L). The average detected level of nitrate in reclaimed water from the Laguna Plant is 16.3 mg/L. The average level expected after the completion of upgrades to the Laguna Plant (see Section 3.2, Interim Project) is 14.6 mg/L or lower. The nitrate levels detected in groundwater at the Two Rock subbasin well and Lakeville well were 71.8 mg/L and 12.0 mg/L, respectively. Nitrate is taken up by plants and is readily immobilized in the unsaturated zone. However, once in the groundwater, nitrate is stable and mobile. The only reduction in nitrate levels in groundwater would be through dilution by groundwater that contains little or no nitrate (USEPA 1981).

Coliform

The average detected level of total coliform[7] in reclaimed water has historically been below the detection limit of 2.2 most probable number/100 milliliter (MPN/100 mL). The North Coast Region Water Quality Control Plan (Basin Plan) contains a water quality objective of 1.1 MPN/100 mL for total coliform (North Coast Regional Water Quality Control Board 1995). Total coliform was detected in groundwater from two wells in the Stemple Creek watershed (3.1 and 165.2 MPN/100 mL) and one well in the Lakeville Hillside area (>200.5

[7] Coliform bacteria are indicator organism whose presence is evidence that pollution (associated with fecal contamination from humans or other warm-blooded animals) has occurred. Indicator organisms may be accompanied by pathogens, but do not necessarily cause disease themselves. Indicators have the following general characteristics: they are absent from unpolluted waters, are present in greater numbers than pathogenic organisms, have greater survival time than pathogens, and their detection is more reliable and less time-consuming.

MPN/100mL). Groundwater contamination by coliform is generally the result of input from contaminated surface water (from cattle, poultry, or other animals).

Removal of microorganisms, including bacteria and viruses, occurs in the soil through filtration, adsorption, desiccation, radiation, predation and exposure to other adverse conditions. Coliform does not remain viable in groundwater and soon dies and is filtered out (USEPA 1981). Fecal coliform are normally not found in groundwater after reclaimed water has percolated through five feet of soil (USEPA 1981).

Regulatory Framework

Department of Health Services Guidelines for Use of Reclaimed Water

Criteria for reclaimed water quality are established in Title 22 of the California State Code of Regulations (Title 22, California State Code of Regulations, §60301 et. seq.). Title 22 specifies treatment requirements and establishes water quality standards for reclaimed water (Regulations for Use of Reclaimed Water). The California State Department of Health Services is the agency responsible for development and implementation of the regulations for use of reclaimed water. The Department is currently developing amendments to Title 22 that provide new regulations for the use of reclaimed water and in that effort has developed draft regulations that have not yet been adopted but are used as a guideline for reclaimed water use. The goal of the Department of Health Services draft regulations is to protect public health and at the same time provide alternative methods for disposal of treated wastewater.

Department of Health Services regulations are proposed to regulate the use of reclaimed water for groundwater recharge in spreading basins. The proposed storage reservoirs are intended to operate as storage basins and reclaimed water would not be designated to recharge the groundwater. However, some reclaimed water would inevitably flow from the bottom of the reservoir and may enter the regional groundwater system. Therefore, the Guidelines established for spreading basins have been applied to the proposed reservoir sites.

The draft reclaimed water regulations specify the allowable concentration of total organic carbon (TOC), suspended solids, and biochemical oxygen demand (BOD) in oxidized water. In addition, turbidity of filtered wastewater would be limited to an average of two (2) nephelometric turbidity units (NTUs). The draft regulations also limit the concentration of radioactive material, minerals, inorganic chemicals, nitrogen, and organic chemicals in the reclaimed water. The volume of water that may be used for recharge depends on the depth to groundwater, storage capacity of the receiving aquifer, retention time underground, and horizontal distance from the source of reclaimed water to domestic water supply wells. These draft regulations were used to develop significance criteria for the groundwater impacts of the Project.

Groundwater and Geothermal Resources in Geysers Area

Groundwater resources in the geysers area are regulated by the California State Division of Oil and Gas and Geothermal Resources (Division of Oil & Gas) and the County of Sonoma. Permits for injection are secured through the Division of Oil & Gas with appropriate review from the North Coast Regional Water Quality Control Board. Additional regulation is provided by the U.S. Bureau of Land Management with delegated authority under the Federal Land Policy and Management Act and Geothermal Steam Act. The Bureau of Land Management is also responsible for protection and management of water resources within lands under its jurisdiction.

Groundwater Nondegradation Policy

In 1968, the State Water Resources Control Board adopted Resolution 68-16, "Statement of Policy with Respect to Maintaining High Quality of Waters in California State," establishing a nondegradation policy for the protection of water quality. Under this policy, whenever the existing quality of water exceeds the quality necessary to maintain present and potential beneficial uses of the water, existing water quality must be maintained. This policy pertains to both surface waters and the groundwater of the State.

The Water Quality Control Plan (Basin Plan) for the North Coast Region (North Coast Regional Water Quality Control Board 1994) establishes water quality objectives that are considered to be necessary to protect present and probable future beneficial water uses. As indicated in Section 4.6, Surface Water Quality, this project would require waste discharge requirements approved by the North Coast Regional Water Quality Control Board. The Regional Board would consider potential groundwater impacts of the Project in the context of the adopted Basin Plan and would require that best practicable treatment or discharge control be included in approved Waste Discharge Requirements.

Some degradation of water quality may be considered acceptable if it can be demonstrated that the project would be “consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial uses of such water and will not result in water quality less than that prescribed in the policies” (Resolution No. 68-16). The California State Water Code specifically allows increases of salinity associated with water reclamation projects: "A regional board may not deny issuance of water reclamation requirements to a project which violates only a salinity standard in the basin plan." (Division 7, Chapter 7, Section 13523.5 of the California State Water Code). Therefore, it is possible that Waste Discharge Requirements may be approved that could result in some increase in chemical concentrations in groundwater above background levels. However, in no case may increases in chemical concentrations cause adverse impacts to groundwater resources. Nitrate levels in excess of the maximum contaminant limit for drinking water (10mg/L) would be considered an adverse effect. Waters in which salinity, as measured by total dissolved solids, exceed 3,000 mg/L are considered unsuitable for water supply (State Water Resources Control Board Resolution No. 88-63, "Sources of Drinking Water).

Groundwater Goals, Objectives, and Policies

Table 4.5-2 identifies goals, objectives, and policies which provide guidance for development in relation to groundwater in the project area. The table also indicates which criteria in this section are responsive to each set of policies.

Table 4.5-2

General Plan Goals, Objectives, and Policies - Groundwater

Adopted Plan Document	Document Section	Document Numeric Reference	Policy	Relevant Evaluation Criteria[1]
Sonoma County General Plan	Resource Conservation Element	Objective RC-3.1 Objective RC-3.3	Preserve and enhance the quality of groundwater resources and preserve watersheds and groundwater recharge areas by avoiding the placement of potential pollution sources in areas with high percolation rates	1,2,4,5
Sonoma County General Plan	Resource Conservation Element	Policy RC-3a	Grading, filling and construction should not substantially reduce or divert any stream flow that would affect groundwater recharge	4,5
Petaluma General Plan	Community Health and Safety Element	Objective (r)	Protect areas that are critical to the maintenance of water quality, including critical groundwater recharge areas	1,2,4,5
Rohnert Park General Plan	Safety Element	Principle 6	Protect groundwater from contamination	1,2,4,5

Source: Harland Bartholomew and Associates, Inc., 1995

1. The evaluation criteria can be found in Table 4.5-3.

EVALUATION CRITERIA WITH POINT OF SIGNIFICANCE

For the purposes of this EIR/EIS groundwater quality impacts are evaluated based on the constituents that are contained in the reclaimed water in concentrations that could cause drinking water to fail to meet state and federal drinking water standards. Drinking water standards were selected because they are the most stringent water quality standards applicable to groundwater and because drinking water represents the most restrictive beneficial use of Sonoma County groundwater.

The purpose of and rationale for the drinking water standards, potential health effects of water pollution, and identification of constituents of concern, are discussed in Section 4.7, Public Health and Safety. Based on the results of groundwater analysis for this and other projects, the chief constituent of concern for groundwater quality for this Project is nitrate (refer to the Setting Section, Groundwater Quality).

According to Appendix G of the CEQA Guidelines, a project will normally have a significant effect on the environment if it would alter the direction or rate of flow of groundwater; change the quantity of groundwater, either through direct addition or withdrawals or through interception of an aquifer by cuts or excavation; or adversely affect groundwater quality. Groundwater impacts were evaluated for significance based on the criteria listed in Table 4.5-3. The groundwater concepts presented there are discussed further in methodology.

Table 4.5-3

Evaluation Criteria with Points of Significance - Groundwater

Evaluation Criteria	As Measured by	Point of Significance	Justification
1. Will the Project degrade groundwater quality at existing drinking water wells, resulting in a public health hazard?	a. Groundwater from existing domestic drinking water wells exceeds established MCL for Nitrate as defined by State and Federal drinking water standards.	Nitrate levels in groundwater greater than 10 mg/L	State and Federal water quality regulations
	b. Number of documented domestic wells within 20% contribution zone	Greater than 0 wells	The California State Department of Health Services, Office of Drinking Water draft regulations for the use of reclaimed water. (Revised Wastewater Regulations, Title 22, Draft, dated 30 June 1993) Use of these draft regulations for criteria was agreed to by Bruce Burton of the California State Department of Health Services (personal communication, 19 April 1996).

Table 4.5-3

Evaluation Criteria with Points of Significance - Groundwater

Evaluation Criteria	As Measured by	Point of Significance	Justification
	c. Travel time from the reservoir to the closest documented domestic well	Less than 6 months	The California State Department of Health Services, Office of Drinking Water draft regulations for the use of reclaimed water
	d. Distance from the reservoir to the closest documented domestic well	Less than 500 feet	The California State Department of Health Services, Office of Drinking Water draft regulations for the use of reclaimed water
2. Will the Project degrade groundwater quality at future drinking water wells, resulting in a public health hazard?	Number of developable[1] parcels within 20% contribution zone[2]	Greater than 0 parcels	State and Federal water quality regulations. The California State Department of Health Services, Office of Drinking Water draft regulations for the use of reclaimed water.
3. Will the Project cause groundwater mounding or increase groundwater levels that cause surface water discharge in a non-stream environment?	Groundwater levels that are raised to within 6 feet of the surface	Groundwater that is raised to within 6 feet of the surface	Elevated water tables can interfere with the operation of leachfields or can result in surface runoff and flooding.
4. Will the Project lower groundwater levels at existing wells?	Number of documented wells subject to lower groundwater levels	Greater than 0 wells	The reduction of groundwater levels can cause existing wells to cease providing water for their intended uses.
5. Will the Project lower groundwater levels in areas that could have been developed for future water supply?	Number of developable parcels that would be subject to lower groundwater levels	Greater than 0 parcels	The reduction of groundwater levels can eliminate potential future water supply.

Source: Parsons Engineering Science, Inc., 1996

Notes:

1 A developable parcel refers to a currently undeveloped parcel for which a building permit could be issued based on all criteria except the requirement to prove water supply.

2 The 20% contribution zone was chosen as the criterion because it is the largest area of potential groundwater effect and includes the areas that could be within the 500-foot or 6-month limits. A 50% reclaimed water contribution is allowed by the draft regulations only for water treated by removal of organics and does not apply to this Project.

METHODOLOGY

The EIR/EIS impacts analysis is based on a review of relevant hydrogeologic literature and technical reports prepared for impact evaluation for this Project. Potential Project impacts were summarized from the following Technical Reports:

- *Hydrogeology of Storage/Reuse Areas and Evaluation of Potential Impacts to Groundwater* (Parsons Engineering Science, Inc. 1996a)
- *Well Installations and Groundwater Monitoring Results* (Parsons Engineering Science, Inc. 1996b)
- *Baseline Hydrology and Irrigation Drainage Evaluation for West and South County Reclamation Alternatives*, (Questa Engineering Corporation 1995a)

Groundwater Contribution from Reservoirs

Available information was used to construct groundwater contours in the vicinity of each reservoir site. Hydraulic conductivity[8] (K) values were estimated for each reservoir subbasin based on results of geotechnical testing at the reservoir sites. A three-dimensional numerical model was used to verify and refine the K values so that they were consistent with existing groundwater contours. The estimated K values were used to calculate the leakage (measured as a volumetric discharge or the volume of water that flows through a cross sectional area over time) or input into the groundwater system from each reservoir. Comparison of the current groundwater discharge (without the reservoir) and groundwater discharge with the reservoir was used to determine the percent contribution from each reservoir within its groundwater subbasin. Dilution calculations were made to estimate the zone of 20 percent contribution of reclaimed water at each reservoir site.

Some of the factors included in the analysis of the reservoir's contribution to groundwater discharge were the size of the reservoir relative to the reservoir subbasin, the average height of the water level in the reservoir relative to water levels under existing conditions, the distance to the main stream valley, and the assumed hydraulic conductivity.

The estimated areas that could have groundwater contribution from the reservoir in excess of 20 percent (herein referred to as the greater than 20 percent contribution zone) are shown in Figures 4.5-2 to 4.5-10. Concentrations of reclaimed water within the 20 percent contribution zone would range from nearly 100 percent reclaimed water at the base of the reservoir to 20 percent at the downgradient edge of the zone. Outside the boundary of the zone, concentrations would be less than 20 percent. The zone describes contributions at equilibrium, which may take several years to achieve. The concentration of reclaimed water outside the zone is not predicted to exceed 20 percent. The 20 percent reclaimed water concentration was developed by the Department of Health Services as an acceptable level for wells adjacent to reclaimed water recharge areas.

[8] A coefficient describing the rate at which fluid can move through a permeable medium.

The quality of reclaimed water that may seep from reservoirs is not necessarily the same as that measured in reclaimed water at the treatment plant, because biological activity in a thermally stratified storage reservoir affects reclaimed water quality. In particular, dissolved oxygen can be depleted, nitrate can be converted to ammonia, and sulfur compounds can be converted to hydrogen sulfide in the bottom layer of a thermally stratified reservoir. Thermal stratification can exist from mid-spring through summer. For purposes of the surface water quality impacts analysis, maximum ammonia and hydrogen sulfide formation was assumed because ammonia is a greater concern for aquatic biota than nitrate. The groundwater impacts evaluation assumed that nitrate levels in reclaimed water would not be reduced by conversion to ammonia, because drinking water standards for nitrate are the primary concern for groundwater.

Groundwater Level Increase

To determine the potential impact of the reservoirs on groundwater levels, WinFlow, a two-dimensional analytical model was used. The gradient in the vicinity of the reservoir under existing conditions was used to establish baseline conditions. The same hydraulic parameters (i.e., hydraulic conductivity, storativity[9], porosity and aquifer thickness) that were estimated previously were used in this modeling.

During the installation of monitoring wells in the downgradient vicinity of the reservoir sites, confined groundwater conditions were encountered in geologic units underlying alluvial deposits. It is likely that leakage from the reservoir sites would contribute to an increase in pore pressures in the confined unit, and that groundwater level increases would be somewhat less than projected by the model.

Well Locations

Three sources of information were used to locate wells. California State Department of Water Resources well logs were reviewed. In some areas, particularly the more rural areas where access was available, wells were located based on visual evidence (i.e., water tower) or anecdotal information from residents. A third source of well locations was the groundwater monitoring program conducted in 1989 and 1990 (CH2M Hill 1990). This third source of information was only available for wells in the Stemple Creek and Americano Creek watersheds. Some of these wells may represent duplicates of other wells, particularly since wells documented on California State Department of Water Resources well logs could not always be precisely located. Well locations in the vicinity of the reservoir are shown in Figures 4.5-2 to 4.5-10.

The use of water from rural wells could not always be determined. It has been assumed for the purposes of this analysis that all of the wells are used for domestic drinking water, although some of these wells are used only for irrigation. It is likely that some of the documented wells are no longer in service and that other wells are in use within the reservoir subbasins that have not been documented in this study.

9 Storativity is the volume of water that a permeable unit releases from or takes into storage per unit surface area of the aquifer per unit change in head.

Data from Groundwater Monitoring Wells

Groundwater monitoring wells were installed as part of the groundwater evaluation for this Project to provide information about water levels and groundwater quality in the vicinity of reservoir sites and irrigation areas (Parsons Engineering Science, Inc. 1996b). Up to two wells were installed in each subbasin with a maximum of four wells in a single watershed. Groundwater from these wells was analyzed during a single sampling event in the Fall of 1995.

Analysis of the currently available data and application of computer modeling permits a general evaluation of potential impacts at each of the reservoir subbasins. However, analytical results for the Project groundwater impact evaluation cannot be applied to the entire groundwater subbasin and a well-by-well impact analysis is not possible. For these reasons it is recommended that a groundwater monitoring program be initiated upon selection of a Project reservoir site (refer to the Mitigation Monitoring Program). Pre-construction groundwater monitoring data would provide detailed information and would permit meaningful comparison of year-round, subbasin-wide baseline data with post-reservoir quarterly monitoring data.

ENVIRONMENTAL CONSEQUENCES (IMPACTS) AND MITIGATION MEASURES

No Action (No Project) Alternative

Impact: **5.1.1-5. Will the No Action Alternative impact groundwater based on evaluation criteria 1 through 5?**

Analysis: *No Impact; Alternative 1.*

The No Action Alternative will not result in new facilities or operations that could provide inputs to groundwater.

Mitigation: No mitigation is needed.

Headworks Expansion Component

Impact: **5.2.1-5. Will the headworks expansion component impact groundwater based on evaluation criteria 1 through 5?**

Analysis: *No Impact; All Alternatives.*

The headworks expansion component will not involve construction of facilities that could affect groundwater.

Alternative 1 does not have a headworks expansion component.

Mitigation: No mitigation is needed.

Urban Irrigation Component

Table 4.5-4

Groundwater Impacts by Component - Urban Irrigation

Evaluation Criteria	Point of Significance	Impact	Type of Impact	Level of Significance
5.3.1. Will the urban irrigation component degrade groundwater quality at existing drinking water wells, resulting in a public health hazard?	a. Nitrate levels in groundwater greater than 10 mg/L b. Greater than 0 wells in 20 percent contribution zone c. Less than 6 months travel time from reservoir to well d. Less than 500 feet from reservoir to well	<10 mg/L Points of significance not applicable for irrigation	O&M	❍
5.3.2. Will the urban irrigation component degrade groundwater quality at future drinking water wells, resulting in a public health hazard?	Greater than 0 parcels	0 parcels	O&M	==
5.3.3. Will the urban irrigation component cause groundwater mounding or increase groundwater levels that cause surface water discharge in a non-stream environment?	Groundwater that is raised to within 6 feet of the surface	None within 6 feet of the ground surface	O&M	==
5.3.4. Will the urban irrigation component lower groundwater levels at existing wells?	Greater than 0 wells	0	O&M	==
5.3.5. Will the urban irrigation component lower groundwater levels in areas that could have been developed for future water supply?	Greater than 0 parcels	0	O&M	==

Source: Parsons Engineering Science, Inc., 1996

Notes:
1. Type of Impact:
O&M — Operation and Maintenance

2. Level of Significance:
== No impact
❍ Less than significant impact; no mitigation proposed

Impact: **5.3.1. Will the urban irrigation component degrade groundwater quality at existing drinking water wells, resulting in a public health hazard?**

Analysis: *Less than Significant; Alternatives 2 and 3.*

Nitrate is the only constituent of concern because nitrate is present in reclaimed water at levels that exceed the MCL for drinking water. The EPA Process Design Manual for Land Treatment of Municipal Water (USEPA 1981) was used to assess urban irrigation impacts on water quality (Questa Engineering Corporation 1995b). Nitrate levels in reclaimed water are below the nitrate requirements of crops. Therefore, nitrate in reclaimed water will be taken up by the plants (primarily grass) and little, if any will migrate beyond the root zone. Available nitrate will be used by the plants and will not affect groundwater quality in the irrigation areas. Only minor increases in nitrate levels in groundwater will occur.

No Impact; Alternatives 1, 4, and 5.

The alternatives do not have an urban irrigation component.

Mitigation: No mitigation is proposed.

Impact: **5.3.2-5. Will the urban irrigation component impact groundwater based on evaluation criteria 2 through 5?**

Analysis: *No Impact; All Alternatives.*

Areas that are currently irrigated with groundwater could experience an increase in groundwater levels as irrigation pumping declines and groundwater levels return to pre-pumping levels. Groundwater modeling indicates that urban irrigation will not result in mounding.

Groundwater levels will not decline.

Alternatives 1, 4, and 5 do not have an urban irrigation component.

Mitigation: No mitigation is needed.

Pipeline Component

Table 4.5-5

Groundwater Impacts by Component - Pipeline

Evaluation Criteria	Point of Significance	Impact	Type of Impact	Level of Significance
5.4.1. Will the pipeline component degrade groundwater quality at existing drinking water wells, resulting in a public health hazard?	Nitrate levels in groundwater greater than 10 mg/L	<10mg/L	C, O&M	==
5.4.2. Will the pipeline component degrade groundwater quality at future drinking water wells, resulting in a public health hazard?	Greater than 0 parcels	0	C, O&M	==
5.4.3. Will the pipeline component cause groundwater mounding or increase groundwater levels that cause surface water discharge in a non-stream environment?	Groundwater that is raised to within 6 feet of the surface	None during construction; pipeline failure may have temporary mounding, but not within 6 feet of surface.	C, O&M	❍
5.4.4. Will the pipeline component lower groundwater levels at existing wells?	Greater than 0 wells	0	O&M	==
5.4.5. Will the pipeline component lower groundwater levels in areas that could have been developed for future water supply?	Greater than 0 parcels	0	O&M	==

Source: Parsons Engineering Science, Inc., 1996.

Notes:	1. Type of Impact:		2. Level of Significance:
C	Construction	==	No impact
O&M	Operation and Maintenance	❍	Less than significant impact; no mitigation proposed

Impact: **5.4.1, 2, 4, and 5. Will the pipeline component impact groundwater based on evaluation criteria 1, 2, 4, and 5?**

Analysis: *No Impact; All Alternatives.*

Construction of transmission pipelines will involve trenching along roadways where shallow groundwater could occasionally be encountered. Trenching 6 to 14 feet deep will not significantly affect groundwater levels. Construction activities could locally increase turbidity in groundwater, however, these effects would be temporary and localized.

Groundwater will not be depleted in event of pipeline rupture.

Alternatives 1 and 5B do not have a pipeline component.

Mitigation: No mitigation is needed.

Impact: 5.4.3. Will the pipeline component cause groundwater mounding or increase groundwater levels that cause surface water discharge in a non-stream environment?

Analysis: *Less than Significant; Alternatives 2, 3, 4, and 5A.*

Construction of transmission pipelines will involve trenching along roadways where shallow groundwater could occasionally be encountered. Neither construction nor operation of pipelines will cause mounding, however, pipeline failure could result in the rapid release of water. Water released by this mechanism will flow overland or in channels as surface water. Because this event will be a rapid, one time release, little or no infiltration to groundwater is expected. Therefore, groundwater mounding impacts will not occur.

No Impact; Alternatives 1 and 5B.

These alternatives do not have a pipeline component.

Mitigation: No mitigation is needed.

Storage Reservoir Component

Table 4.5-6

Groundwater Impacts by Component - Storage Reservoir, Criterion 1

Evaluation Criteria	Point of Significance	Impact	Type of Impact[1]	Level of Significance[2]
1. Will the storage reservoir component degrade groundwater quality at existing wells, resulting in public health hazards?				
a. Projected groundwater quality at existing drinking water wells.	Nitrate levels greater than 10 mg/L	16.3 mg/L	O&M	⊙
b. Number of documented domestic wells within 20 percent contribution zone	Greater than 0 wells		O&M	
• Tolay Extended		0		--
• Adobe Road		20		⊙
• Tolay Confined		0		--

Table 4.5-6

Groundwater Impacts by Component - Storage Reservoir, Criterion 1

Evaluation Criteria	Point of Significance	Impact	Type of Impact[1]	Level of Significance[2]
• Lakeville Hillside		4		⊙
• Sears Point		0		--
• Two Rock		25		⊙
• Bloomfield		12		⊙
• Carroll Road		14		⊙
• Valley Ford		4		⊙
• Huntley		5		⊙
c. Travel time from the reservoir to the closest documented domestic well	Less than 6 months		O&M	
• Tolay Extended		166 years		==
• Adobe Road		67 years		==
• Tolay Confined		166 years		==
• Lakeville Hillside		67 years		==
• Sears Point		133 years		==
• Two Rock		100 years		==
• Bloomfield		133 years		==
• Carroll Road		5 years		==
• Valley Ford		67 years		==
• Huntley		33 years		==
d. Distance from the reservoir to the closest documented domestic well	Less than 500 feet		O&M	
• Tolay Extended		5,000 feet		==
• Adobe Road		2,000 feet		==
• Tolay Confined		5,000 feet		==
• Lakeville Hillside		2,000 feet		==
• Sears Point		4,000 feet		==
• Two Rock		3,000 feet		==
• Bloomfield		4,000 feet		==
• Carroll Road		250 feet		⊙
• Valley Ford		2,000 feet		==
• Huntley		1,000 feet		==

Source: Parsons Engineering Science, Inc., 1996

Notes:
1. Type of Impact:
O&M Operation and Maintenance

2. Level of Significance:
== No impact
⊙ Significant impact before mitigation; less than significant

impact after mitigation

Impact: **5.5.1A. Will the storage reservoir component degrade groundwater quality at existing wells, resulting in public health hazards, as measured by projected nitrate levels?**

Analysis: *Significant; Alternatives 2 and 3.*

Reclaimed water with elevated nitrate concentrations (possibly in excess of MCL) could enter the regional groundwater system and result in increased nitrate levels. The reservoir contribution of nitrate will diminish with distance from the dam. Refer to Figures 4.5-2 to 4.5-10 at the end of this impact discussion for the area below each reservoir where 20 percent or greater contribution to groundwater could occur.

The estimated Project contribution of nitrate beyond the 20 percent or greater contribution zone will be 3.3 mg/L or less. This will not cause exceedences of the MCL in areas where the existing levels of nitrate in groundwater are low. However, in areas where existing levels of nitrate are close to the MCL, the resulting concentration could exceed the MCL; this could occur both within and at the margins of the 20 percent contribution zone. In areas where nitrate concentrations in the groundwater are in excess of the MCL, the reservoir contribution could make the exceedence worse. Existing nitrate levels at some monitoring wells in the vicinity of the Lakeville and Two Rock sites showed concentrations that exceed the MCL.

No Impact; Alternatives 1, 4, and 5.

These alternatives do not have a storage reservoir component.

Mitigation: *Alternatives 2 and 3.*

2.3-12. Provide replacement water supply for affected wells.

Alternatives 1, 4, and 5. No mitigation is needed.

After Mitigation: *Less than Significant after Mitigation; Alternatives 2 and 3.*

With provision of an alternative water supply, where needed, this impact will no longer be significant.

Impact: **5.5.1B, C, D. Will the storage reservoir component degrade groundwater quality at existing wells resulting in public health hazards, as measured by the number of documented domestic wells within 20 percent contribution zone, travel time from the reservoir to the closest domestic well; and distance from the reservoir to the closest documented domestic well?**

Analysis: *Significant; Alternatives 2B, 2D (Lakeville Hillside reservoir), and 3.*

Adobe Road

The Adobe Road reservoir site is entirely underlain by the Petaluma Formation. Wells downgradient of this reservoir could be affected by the reservoir if they were screened[10] in the Petaluma Formation. Groundwater inputs from the Adobe Road reservoir could affect a large area of the Petaluma Valley. The greater than 20 percent zone extends from the reservoir downgradient to the Petaluma River (Figure 4.5-3).

Most of the wells east of Adobe Road are at least partially screened in the Petaluma Formation and could be impacted by the reservoir. The wells west of Adobe Road are screened in the alluvial deposits and will probably not be impacted by the reservoir.

Twenty wells have been identified in the Adobe Road subbasin. Four of these wells are located on the upgradient boundary of the reservoir and would not be affected by the reservoir. The area to the west of Adobe Road is served by municipal water from the City of Petaluma (1995). The remaining six wells are located just east of Adobe Road. Although California State Department of Water Resources well logs indicate that at least one former City well is located in the groundwater impact area, the City no longer uses groundwater as a municipal supply.

The nearest documented well will not receive a contribution of reclaimed water for about 67 years.

Lakeville Hillside

The Lakeville Hillside reservoir is entirely underlain by the Petaluma Formation. Wells downgradient of this reservoir could be affected if they are screened in the Petaluma Formation.

Four wells have been identified in the Lakeville Hillside subbasin. All of the wells are located downgradient and within the greater than 20 percent contribution zone from the reservoir (Figure 4.5-5). At least three of these wells are screened in the Petaluma Formation and could receive reclaimed water inputs from the proposed reservoir. The screened interval of the fourth well is unknown.

The nearest documented well will not receive a contribution of reclaimed water for about 67 years.

Sears Point

The Sears Point reservoir is part of Alternative 2D, but has no impact regarding these criteria. Refer to the “No Impact” discussion below.

Two Rock

Two Rock reservoir site is underlain by the Franciscan Complex. It is anticipated that the leakage from the reservoir will be confined to that hydrogeologic unit and will not affect overlying units of Wilson Grove

[10] Screened interval is the portion of the well casing that is perforated and therefore contributes water to the well. A well is described as partially screened in a particular formation if the casing is perforated in more than one geologic unit and can draw water from both. For example, a well with its casing perforated in both the Petaluma Formation and alluvial deposits is partially screened in the Petaluma Formation.

Formation and alluvial deposits. Based on a review of the California State Department of Water Resources well logs, some of the downgradient wells at the Two Rock reservoir site are screened exclusively in the alluvial deposits, but several appear to be screened in both alluvial deposits and the Franciscan Complex. The reservoir could contribute to some flow in the wells screened at least partially in the Franciscan Complex.

Twenty-six wells have been identified in the Two Rock subbasin (Figure 4.5-6). One of these wells is located in a tributary valley where groundwater will not be affected by the reservoir. The remaining wells are scattered in downgradient locations and are all located within the greater than 20 percent contribution zone for the proposed Two Rock reservoir.

The nearest documented well will not receive a contribution of reclaimed water for about 130 years.

Bloomfield

The Bloomfield reservoir site is underlain by Wilson Grove Formation and groundwater contribution from the reservoir will be confined to that formation. Most of the wells downgradient of the reservoir are at least partially screened in the Wilson Grove Formation and could be affected by reclaimed water inputs from the reservoir.

The downgradient extent of the greater than 20 percent contribution zone from the Bloomfield reservoir is estimated to be at the downstream boundary of the Carroll Road subbasin. Three wells have been identified in the Bloomfield subbasin, all are located near the downstream extent of the subbasin and within the reservoir's greater than 20 percent contribution zone. A cluster of domestic wells in the main valley is located just upgradient from the Bloomfield reservoir subbasin, outside of the influence of the reservoir. It is estimated that the nine wells located in the main valley in the vicinity of the Carroll Road reservoir site could also be within the greater than 20 percent contribution zone from the Bloomfield reservoir (Figure 4.5-7).

The nearest documented well will not receive a contribution of reclaimed water for at least 130 years.

Carroll Road

The Carroll Road reservoir site is underlain by Wilson Grove Formation and groundwater contribution from the reservoir will be confined to that formation. Most of the wells downgradient of the reservoir are at least partially screened in the Wilson Grove Formation and could be affected by reclaimed water inputs from the reservoir.

Seventeen wells have been located in the Carroll Road North subbasin. Three of these wells are located in the footprint of the proposed reservoir and will be removed during reservoir construction. The remaining wells are located downgradient of the reservoir and are within the greater than 20 percent contribution zone from the reservoir (Figure 4.5-8).

The nearest documented well, which is located approximately 250 feet downgradient of the dam could receive a contribution of reclaimed water within about 8 years of reservoir installation.

Valley Ford

The Valley Ford reservoir site is underlain by Wilson Grove Formation and groundwater contribution from the reservoir will be confined to that formation. Most of the wells downgradient of the reservoir are at least partially screened in the Wilson Grove Formation and could be affected by reclaimed water inputs from the reservoir.

Review of available information indicates that there are five wells located in the Valley Ford reservoir subbasin. One of these wells is located in the footprint of the proposed reservoir and will be removed during reservoir construction. The remaining wells are located at the downgradient reaches of the subbasin and are near the edge of the greater than 20 percent contribution zone.

The nearest documented well will not receive a contribution of reclaimed water for about 67 years.

Huntley

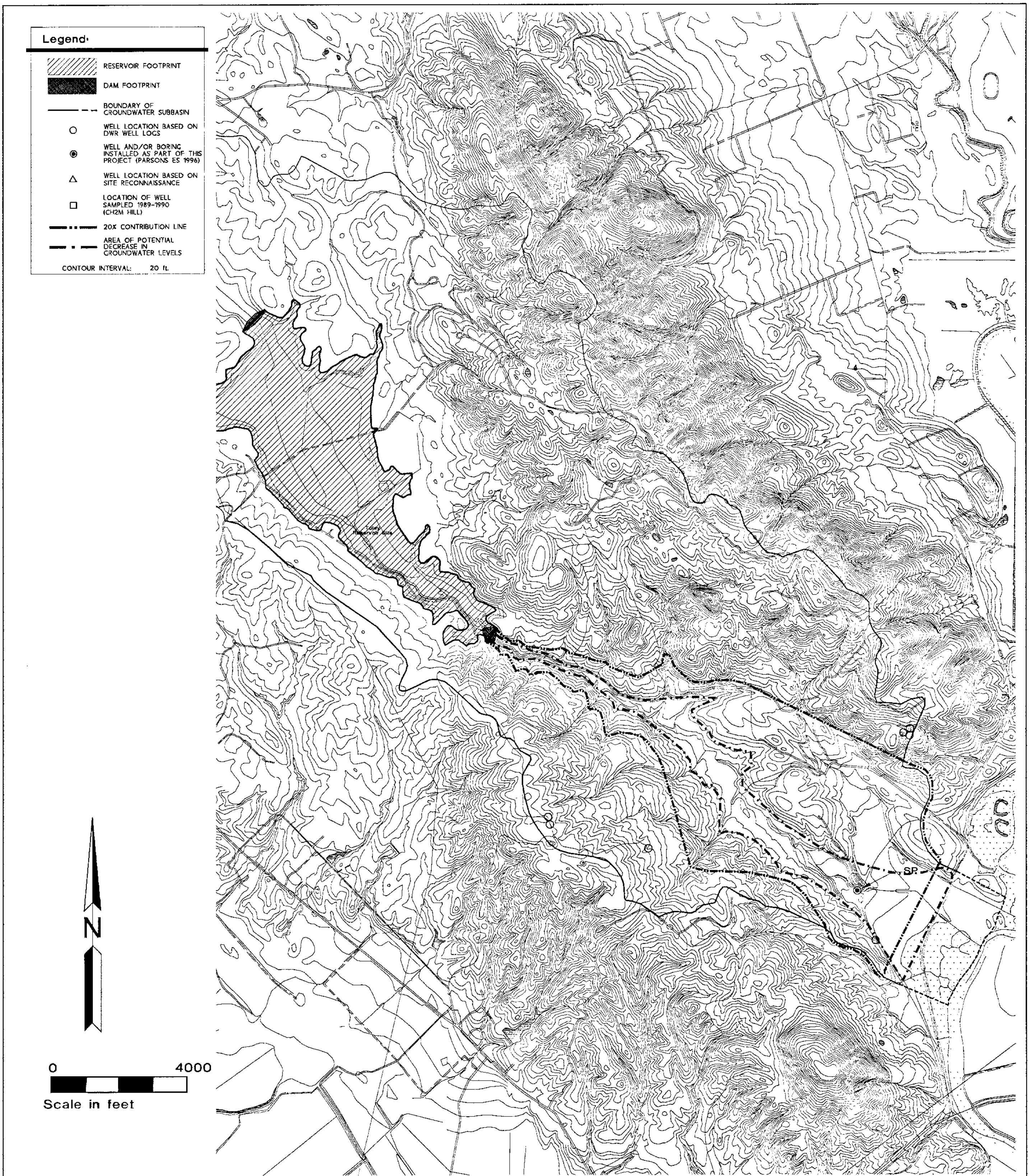
The Huntley reservoir site is underlain by Franciscan Complex. It is anticipated that the leakage from the reservoir will be confined to that hydrogeologic unit and would not affect overlying units of Wilson Grove Formation and alluvial deposits. Information regarding well screening was not available. However, if downgradient wells were screened in the Franciscan Complex they could be affected by the reservoir.

Seven wells have been identified in the Huntley subbasin. One of these wells is located in the footprint of the reservoir and will be removed during reservoir construction. Five of the wells are located downgradient and within the greater than 20 percent contribution zone from the reservoir. One well was located on a topographic high on the upgradient boundary of the subbasin and groundwater will not be affected by reclaimed water impacts from the proposed reservoir (Figure 4.5-10).

The nearest documented well will not receive a contribution of reclaimed water for about 33 years.

No Impact; Alternatives 1, 2A, 2C, 4, and 5.

Both proposed configurations of the Tolay reservoir and the Sears Point reservoir are primarily underlain by the Petaluma Formation. It is unlikely that leakage from the reservoir will contribute substantial groundwater to other geologic units in the Tolay watershed (i.e., Franciscan Complex, Sonoma Volcanics, and the alluvial deposits).



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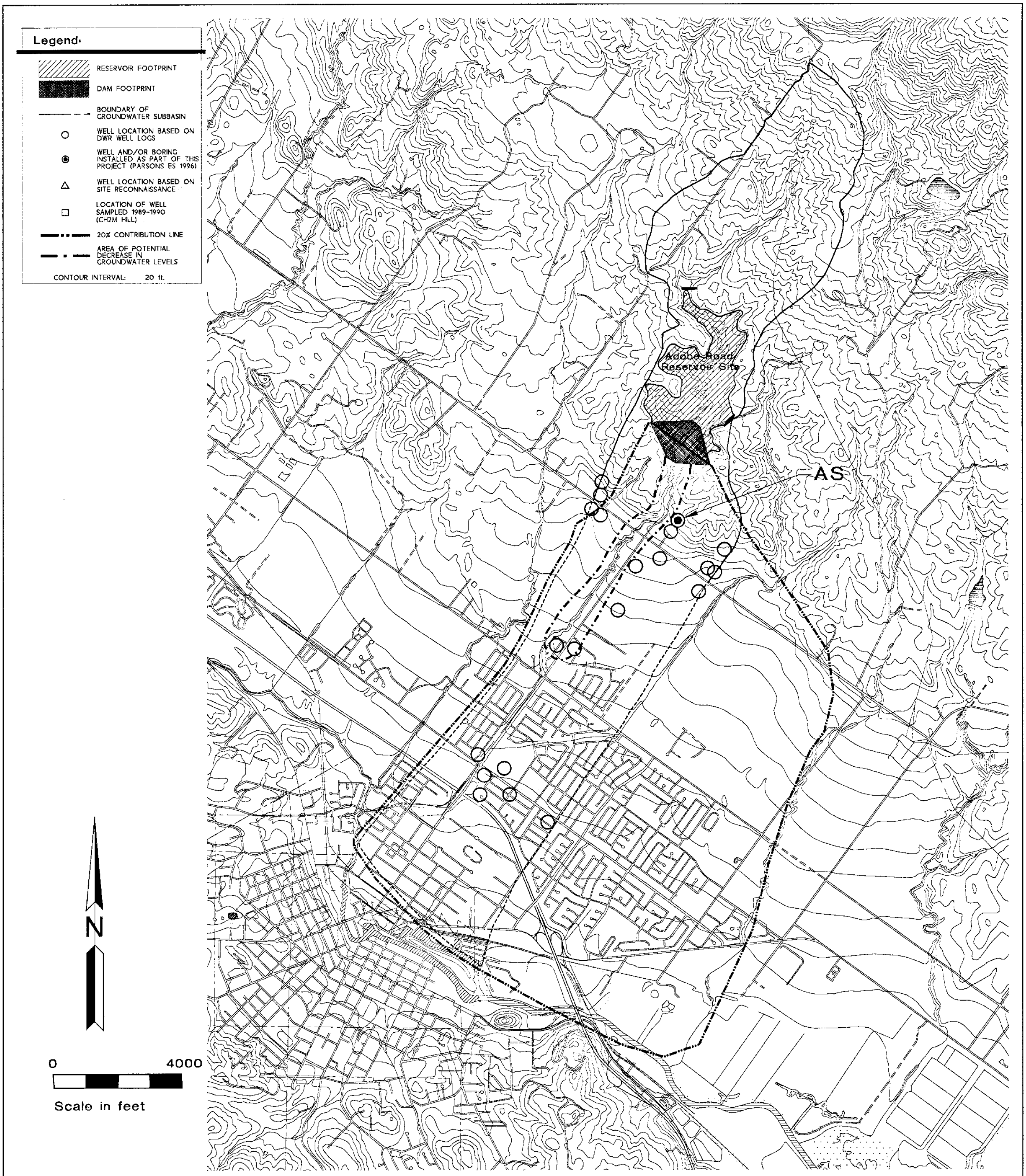
AREA OF POTENTIAL DECREASE IN GROUNDWATER LEVELS TOLAY RESERVOIR SITE

Figure 4.5-2



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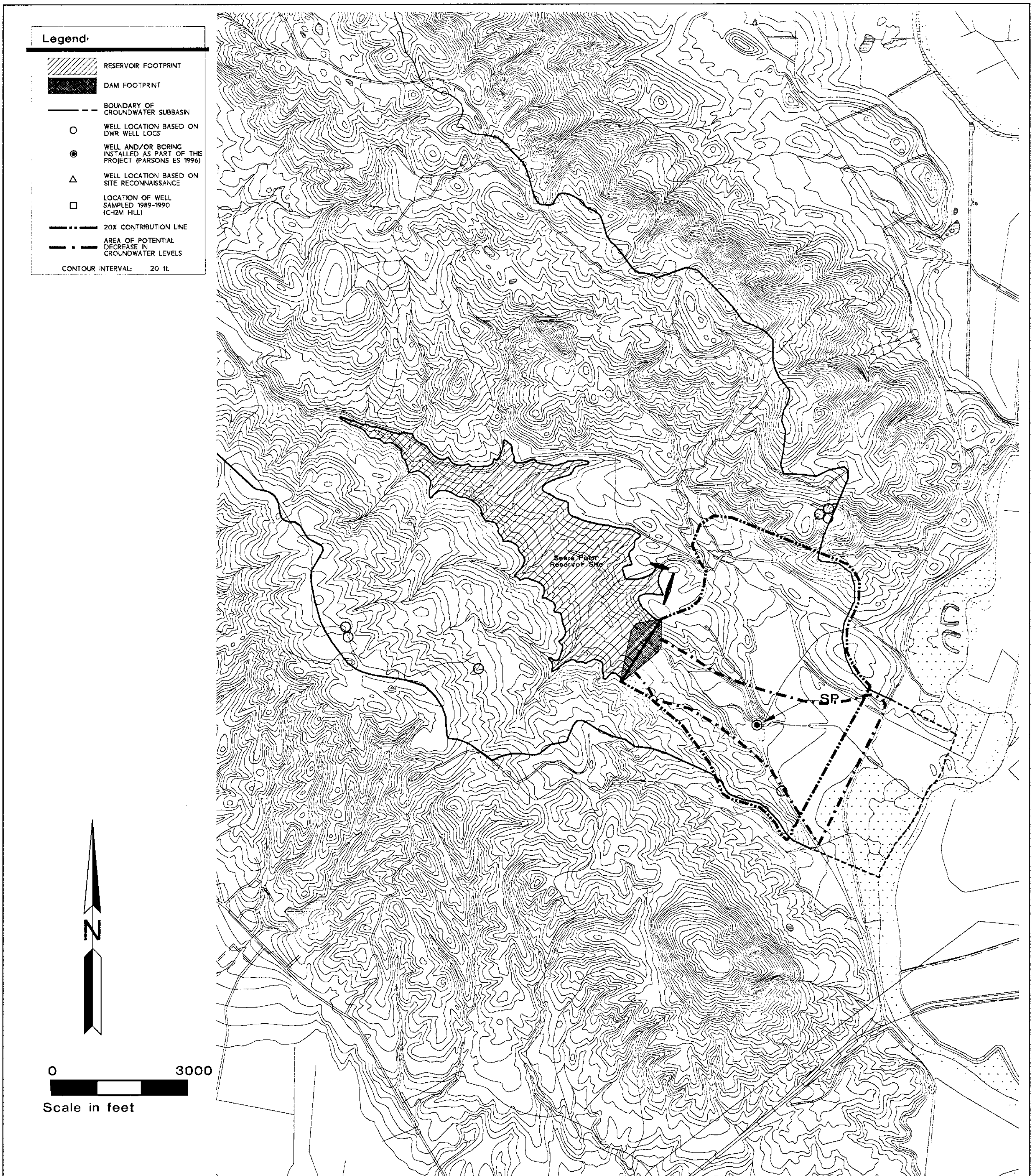
AREA OF POTENTIAL DECREASE IN GROUNDWATER LEVELS ADOBE ROAD RESERVOIR SITE

Figure 4.5-3



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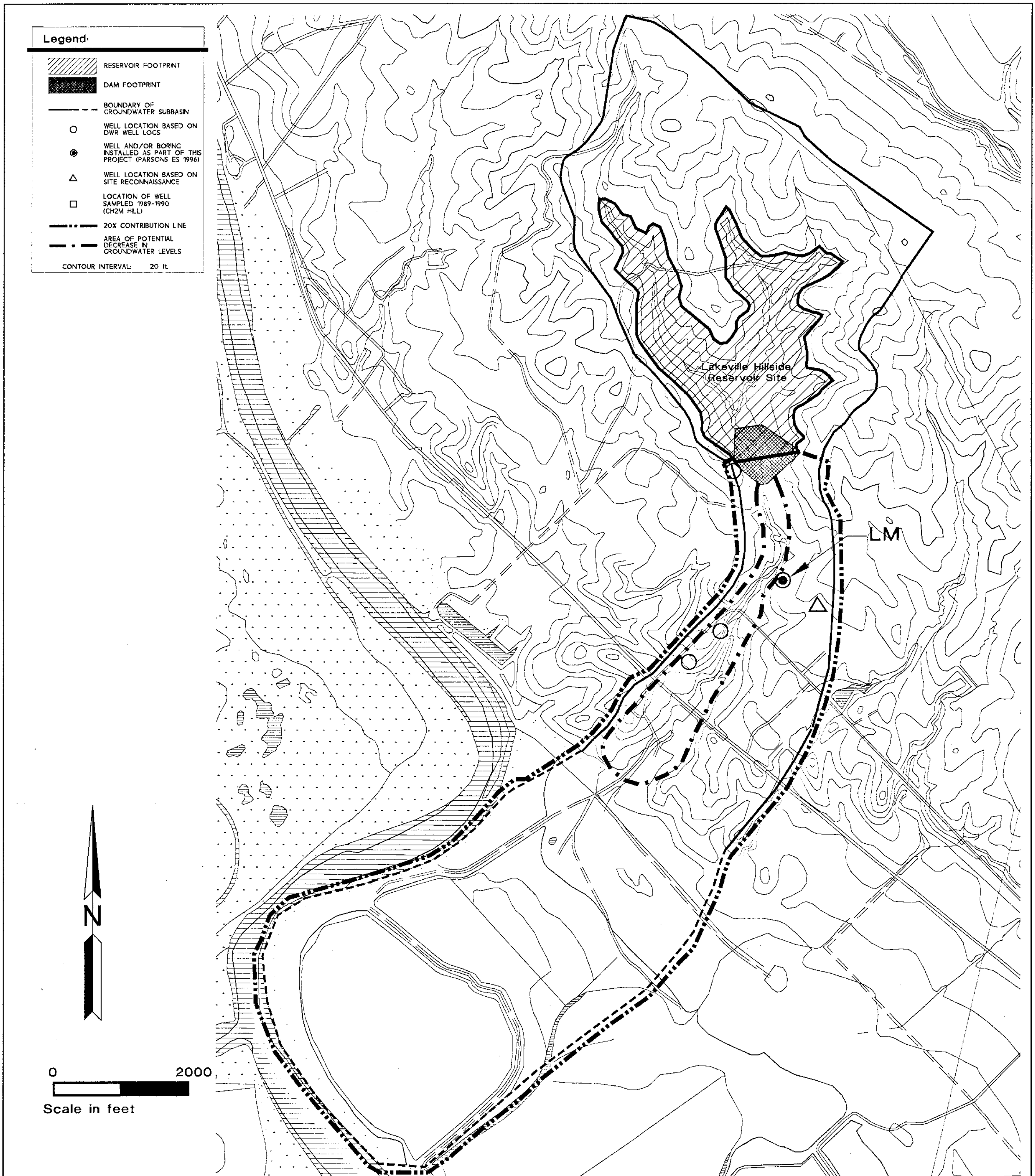
AREA OF POTENTIAL DECREASE IN GROUNDWATER LEVELS SEARS POINT RESERVOIR SITE

Figure 4.5-4



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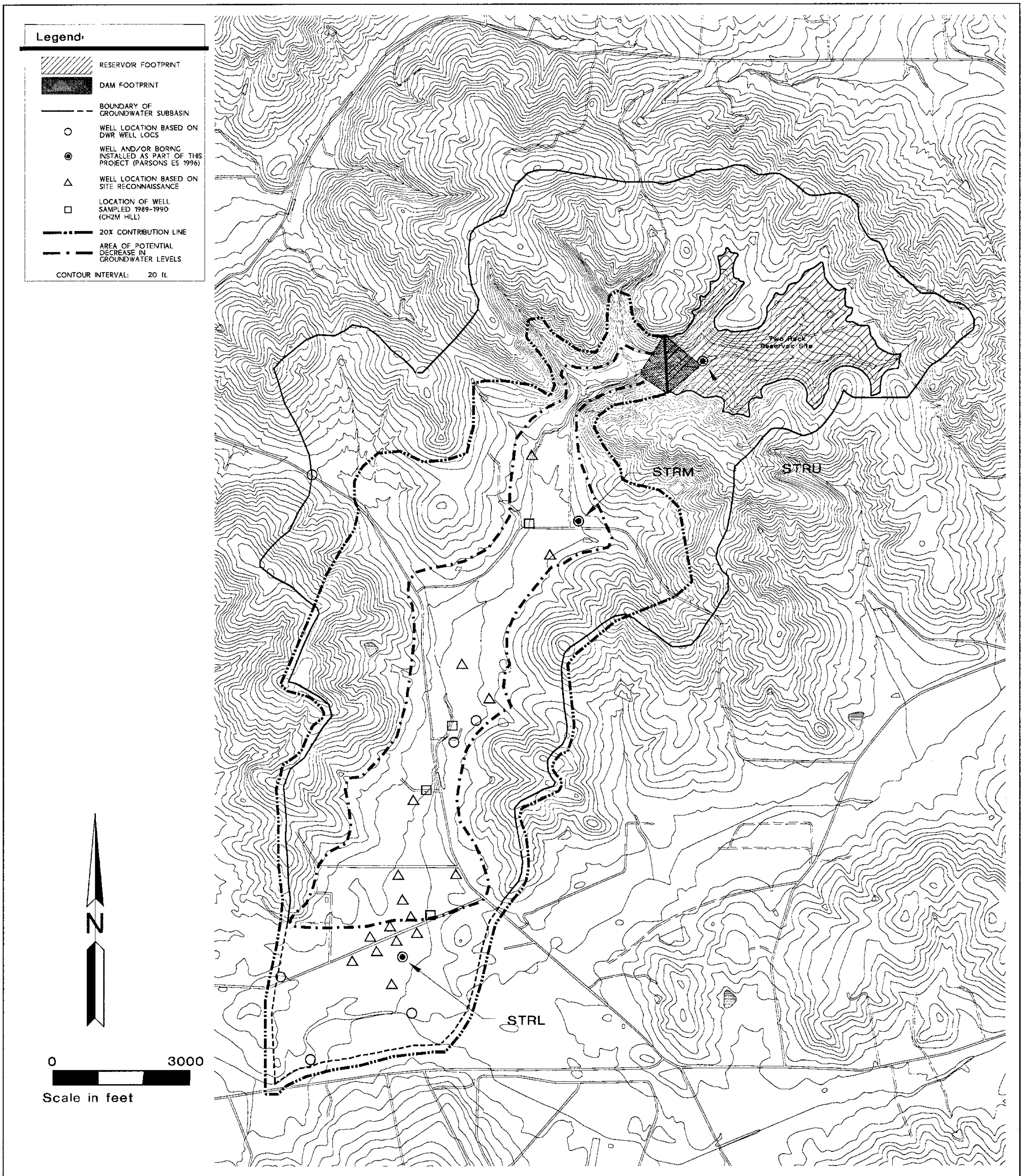
AREA OF POTENTIAL DECREASE IN GROUNDWATER LEVELS LAKEVILLE HILLSIDE RESERVOIR SITE

Figure 4.5-5



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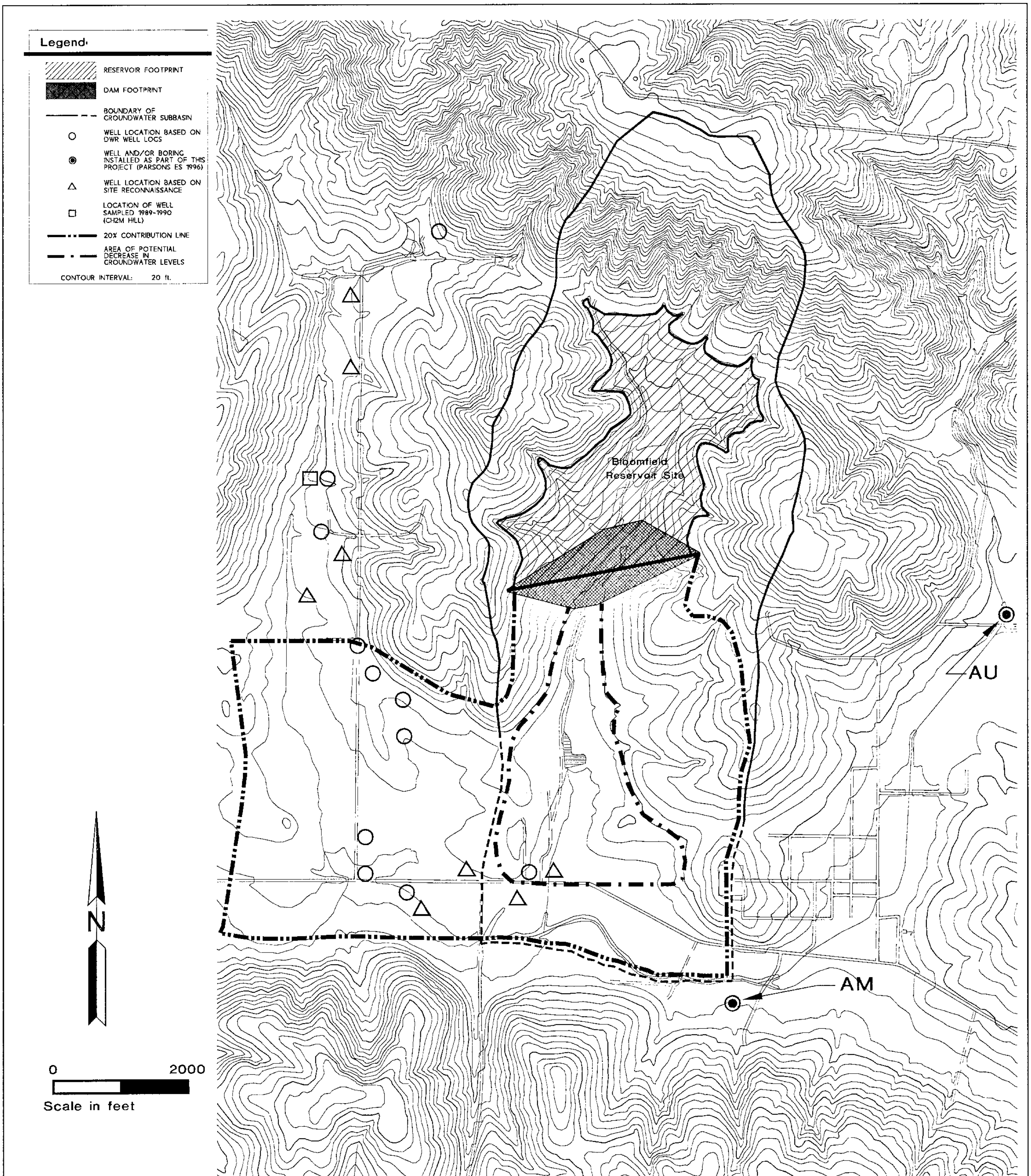
AREA OF POTENTIAL DECREASE IN GROUNDWATER LEVELS TWO ROCK RESERVOIR SITE

Figure 4.5-6



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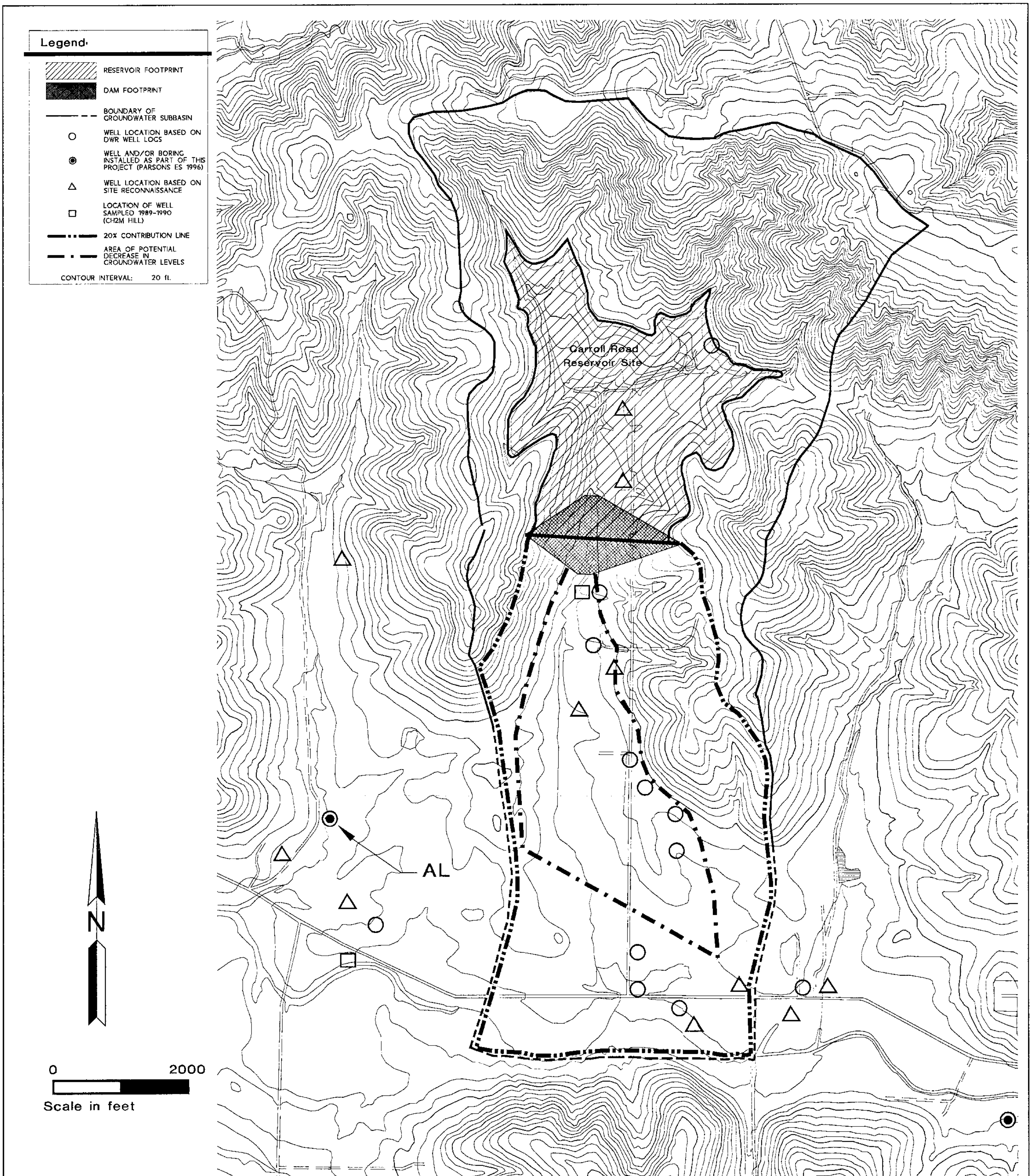
AREA OF POTENTIAL DECREASE IN GROUNDWATER LEVELS BLOOMFIELD RESERVOIR SITE

Figure 4.5-7



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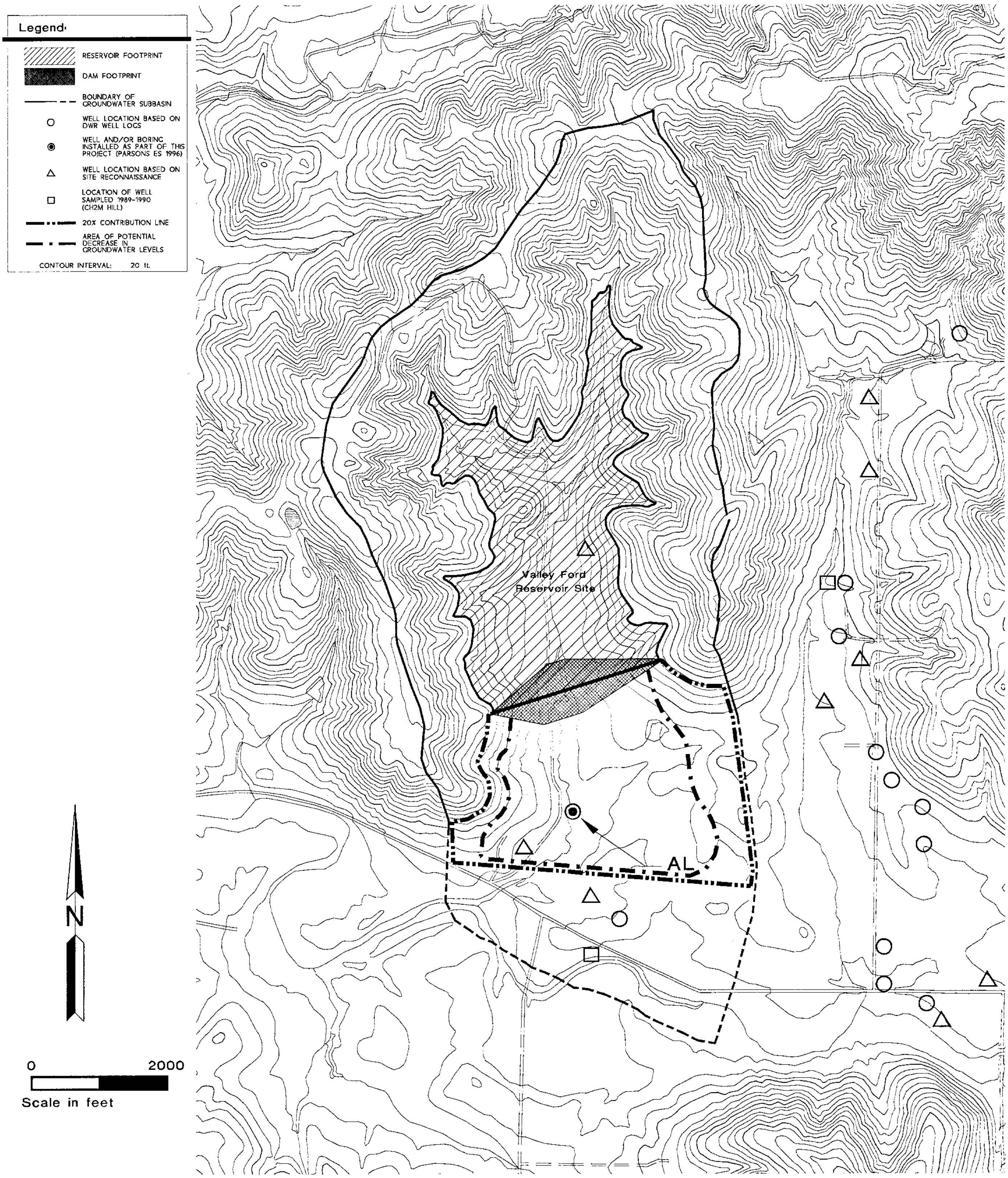
AREA OF POTENTIAL DECREASE IN GROUNDWATER LEVELS CARROLL ROAD RESERVOIR SITE

Figure 4.5-8



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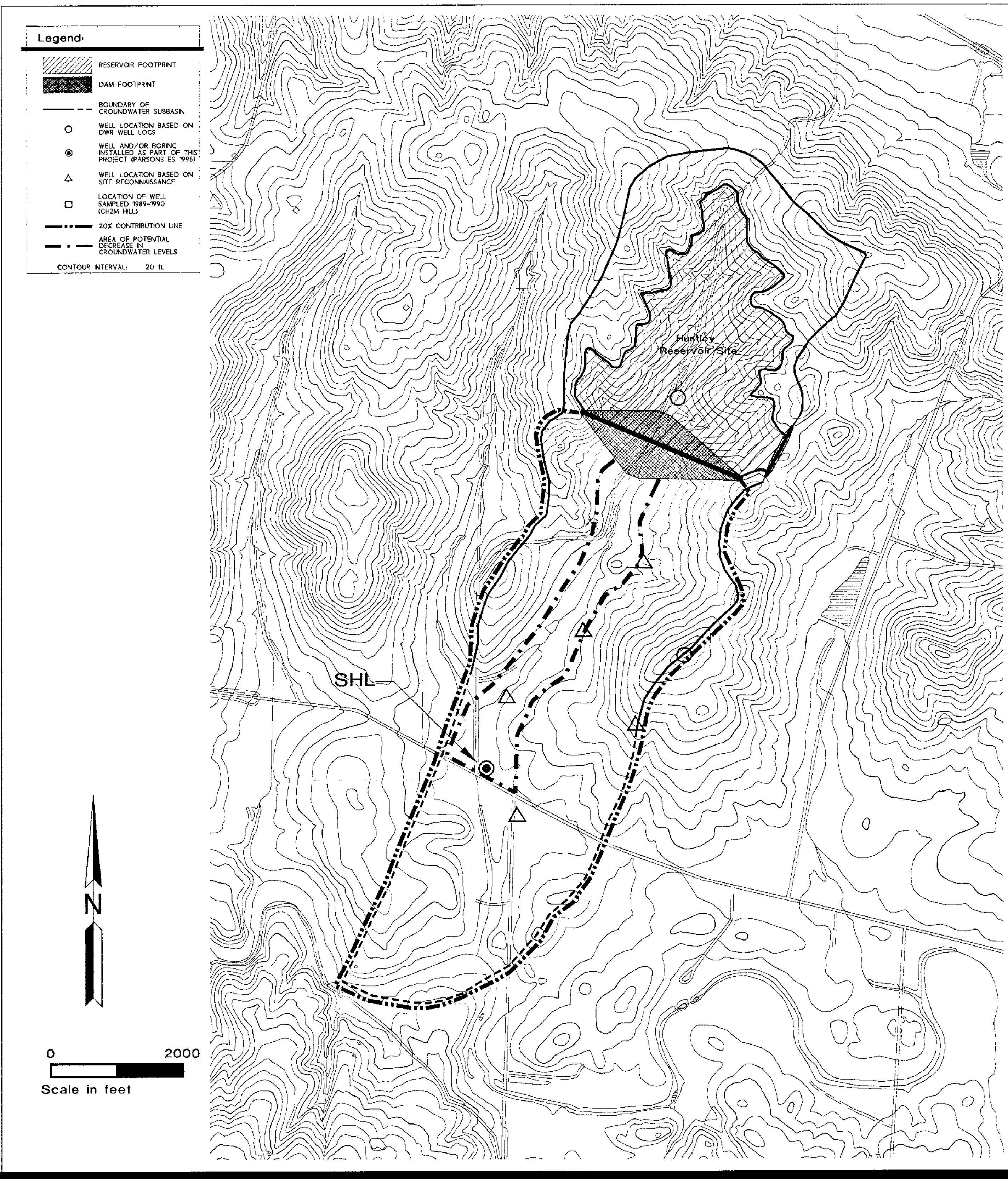
AREA OF POTENTIAL DECREASE IN GROUNDWATER LEVELS VALLEY FORD RESERVOIR SITE

Figure 4.5-9



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AREA OF POTENTIAL DECREASE IN GROUNDWATER LEVELS HUNTLEY RESERVOIR SITE

Figure 4.5-10

There are seven wells identified in the Tolay Creek watershed. Six of these wells are located upgradient of the reservoir on steep slopes near the boundary of the watershed and are screened in the Franciscan Complex or in Sonoma Volcanics. These wells will not be affected by the reservoir. One well located downgradient of the reservoir sites is outside the 20 percent contribution zone and will receive significantly less than 20 percent contribution from any of the reservoirs proposed for this watershed. This well is screened in the alluvial deposits. It is possible that other wells, not documented in this report, are present within the subbasin that may be affected by the Project. However, based on information obtained from site reconnaissance and California State Department of Water Resources well logs it appears that no existing wells will be affected by these three reservoir configurations (Figures 4.5-2 and 4.5-4).

Maximum average groundwater flow travel time at all reservoir sites was estimated at 3 feet per year, but a conservative groundwater flow rate assumption of 30 feet per year was used. The documented well nearest the Tolay and Sears Point reservoir sites will not receive a contribution of reclaimed water for at least 130 years.

Alternatives 1, 4, and 5 do not have a storage reservoir component.

Mitigation: *Alternatives 2B, 2D, and 3.*

2.3.12. Provide replacement water supply for affected wells.

Alternatives 1, 2A, 2C, 4, and 5. No mitigation is needed.

After Mitigation: *Less than Significant after Mitigation; Alternatives 2B, 2D, and 3.*

With provision of an alternate water supply, where needed, this impact will no longer be significant. This mitigation measure has secondary growth-inducing impacts discussed in Chapter 5.3.

Table 4.5-7

Groundwater Impacts by Component - Storage Reservoirs, Criteria 2 to Criteria 5

Evaluation Criteria	Point of Significance	Impact	Type of Impact[1]	Level of Significance[2]
5.5.2. Will the storage reservoir component degrade groundwater quality at future drinking water wells, resulting in a public health hazard?	Greater than 0 parcels		O&M	
• Tolay Extended		16		⊙
• Adobe Road		20[3]		⊙
• Tolay Confined		16		⊙

Table 4.5-7

Groundwater Impacts by Component - Storage Reservoirs, Criteria 2 to Criteria 5

Evaluation Criteria	Point of Significance	Impact	Type of Impact[1]	Level of Significance[2]
• Lakeville Hillside		10		⊙
• Sears Point		10		⊙
• Two Rock		40		⊙
• Bloomfield		20		⊙
• Carroll Road		8		⊙
• Valley Ford		3		⊙
• Huntley		20		⊙
5.5.3. Will the storage reservoir component cause groundwater mounding or increase groundwater levels that cause surface water discharge in a non-stream environment?	Groundwater raised to within 6 feet of the surface		O&M	
• Bloomfield, Carroll Road, Valley Ford, Huntley		Within 6 feet of the surface or shallower[3]		⊙
• All other reservoirs		Groundwater would be more than 6 feet from the surface		❍
5.5.4. Will the storage reservoir component lower groundwater levels at existing wells?	Greater than 0 wells		O&M	
• Tolay and Sears Point		0		==
• Adobe Road		2		⊙
• Lakeville Hillside		2		⊙
• Two Rock		15		⊙
• Bloomfield		2		⊙
• Carroll Road		9		⊙
• Valley Ford		1		⊙
• Huntley		3		⊙
5.5.5. Will the storage reservoir component lower groundwater levels in areas that could have been developed for future water supply?	Greater than 0 parcels		O&M	
• Tolay Extended		10		⊙
• Adobe Road		5[4]		⊙

Table 4.5-7

Groundwater Impacts by Component - Storage Reservoirs, Criteria 2 to Criteria 5

Evaluation Criteria	Point of Significance	Impact	Type of Impact[1]	Level of Significance[2]
• Tolay Confined		10		⊙
• Lakeville Hillside		7		⊙
• Sears Point		7		⊙
• Two Rock		20		⊙
• Bloomfield		5		⊙
• Carroll Road		4		⊙
• Valley Ford		3		⊙
• Huntley		7		⊙

Source: Parsons Engineering Science, Inc., 1996

Notes: 1. Type of Impact:
O&M Operation and Maintenance

2. Level of Significance:
== No impact
❍ Less than significant impact; no mitigation proposed
⊙ Significant impact before mitigation; less than significant impact after mitigation

3. 20 parcels are located east of Adobe Road, approximately 1,000 parcels are located west of Adobe Road where future development would be on municipal water.

4. Refer to *Hydrogeology of Storage/Reuse Areas and Potential Impacts to Groundwater* (Parsons Engineering Science, Inc. 1996a).

Impact: 5.5.2. Will the storage reservoir component degrade groundwater quality at future drinking water wells, resulting in a public health hazard?

Analysis: *Significant; Alternatives 2 and 3.*

As discussed in impact 5.5-1, above, operation of storage reservoirs could degrade groundwater quality in the vicinity of the reservoir. Groundwater at all the reservoir sites travels slowly and impacts will not occur for many years into the future. For the purposes of this analysis, the area of potential future groundwater impacts is defined by the 20 percent or greater contribution zone. Impacts range from 3-40 developable parcels at the various reservoir sites.

No Impact; Alternatives 1, 4, and 5.

These alternatives do not have a storage reservoir component.

Mitigation: *Alternatives 2 and 3.*

2.3.12. Provide replacement water supply for affected wells.

Alternatives 1, 4, and 5. No mitigation is needed.

After Mitigation: *Less than Significant after Mitigation; Alternatives 2 and 3.*

With provision of an alternate water supply, where needed, this impact will no longer be significant. This mitigation measure has secondary growth-inducing impacts discussed in Chapter 5.3.

Impact: 5.5.3. Will the storage reservoir component cause groundwater mounding or increase groundwater levels that cause surface water discharge in a non-stream environment?

Analysis: As indicated in the Methodology section, a two-dimensional analytical model was used to evaluate potential groundwater mounding impacts at reservoir sites. The results of that evaluation indicate that there will be a moderate rise of groundwater within the vicinity of some of the reservoirs (Parsons Engineering Science, Inc. 1996a).

Construction of reservoirs will result in a maximum increase in groundwater levels of 18 feet under the reservoir footprint at Adobe Road. The potential impact of groundwater mounding is related to existing groundwater levels. Modest increases in areas where the groundwater occurs at depth will not result in near surface groundwater. However, slight mounding in areas with shallow groundwater could affect leachfield operations.

Significant; Alternatives 3B, 3C, 3D, and 3E.

Groundwater mounding calculations that assumed unconfined conditions (Parsons Engineering Science, Inc. 1996a) indicate that after reservoir construction at Carroll Road, Bloomfield, and Huntley, groundwater could rise to within 6 feet or less of the ground surface downgradient of the dam. The groundwater level at Valley Ford will be about 6 feet below the ground surface. Although listed as a significant impact, semi-confined groundwater conditions in the Americano Creek area will probably reduce the magnitude of groundwater mounding and adverse impacts are not likely to occur.

Less than Significant; Alternatives 2 and 3A.

Reservoir construction at all other reservoirs will not cause groundwater to rise to within 6 feet of the ground surface.

No Impact; Alternatives 1, 4, and 5.

These alternatives do not have a storage reservoir component.

Mitigation: *Alternatives 3B, 3C, 3D, and 3E.*

2.5.9. Implement a septic system monitoring and replacement program.

Alternatives 1, 2, 3A, 4 and 5. No mitigation is proposed.

After Mitigation: *Less than Significant after Mitigation; Alternatives 3B, 3C, 3D, and 3E.*

Monitoring of septic systems and replacement of affected systems with non-conventional systems, will reduce this impact to insignificant.

Impact: 5.5.4. Will the storage reservoir component lower groundwater levels at existing wells?

Analysis: *Significant; Alternatives 2B, 2D, and 3.*

Surface water that enters the subsurface as interflow at a given reservoir site would be intercepted by the proposed dam. Therefore, the dam will intercept most upstream interflow. The water that will contribute to streamflow downstream of a proposed dam will be minimal and will be derived from "dam seepage". Consequently, wells screened in alluvial deposits or in weathered bedrock could lose groundwater interflow inputs and groundwater levels could decline.

Water supply wells are located downgradient of reservoirs in each subbasin. At the Sears Point, Two Rock, Bloomfield, and Carroll Road reservoir sites, downgradient wells are screened in alluvial deposits. These wells could be subject to groundwater level decreases following dam construction. Downgradient wells at Adobe Road, Lakeville Hillside, Valley Ford, and Huntley reservoir sites may be screened entirely or partially within alluvial deposits and could be adversely affected be groundwater level declines.

No Impact; Alternatives 1, 2A, 2C, 4, and 5.

No wells have been documented in the Tolay Creek watershed that could be affected by project-related decrease in groundwater levels.

Alternatives 1, 4, and 5 do not have a storage reservoir component.

Mitigation: *Alternatives 2B, 2D and 3.*

2.3.13. Monitor groundwater levels and provide replacement water supply.

Alternatives 1, 2A, 2C, 2D, 4, and 5. No mitigation is needed.

After Mitigation: *Less than Significant after Mitigation; Alternatives 2B, 2D, and 3.*

With provision of an alternate water supply, where needed, this impact will no longer be significant. This mitigation measure may have secondary growth-inducing impacts discussed in Chapter 5.3.

Impact: 5.5.5. Will the storage reservoir component lower groundwater levels in areas that could have been developed for future water supply?

Analysis: *Significant; Alternatives 2 and 3.*

As discussed in impact 5.5-4, above, operation of storage reservoirs could result in groundwater depletion immediately downgradient of the dam. The areas that could be subject to groundwater depletion in the vicinity of the reservoir sites are shown in Figures 4.5-2 through 4.5-10.

No Impact; Alternatives 1, 4 and 5.

These alternatives do not have a storage reservoir component.

Mitigation: *Alternatives 2 and 3.*

2.3.13. Monitor groundwater levels and provide replacement water supply.

Alternatives 1, 4 and 5. No mitigation is needed.

After Mitigation: *Less than Significant after Mitigation; Alternatives 2 and 3.*

With provision of an alternate water supply, where needed, this impact will no longer be significant. This mitigation measure may have secondary growth-inducing impacts discussed in Chapter 5.3.

Pump Station Component

Impact: 5.6.1-5. Will the pump station component impact groundwater based on evaluation criteria 1-5?

Analysis: *No Impact; All Alternatives.*

Pump stations will not interact with groundwater or cause an increase or decrease in recharge.

Alternatives 1 and 5 do not have a pump station component.

Mitigation: No mitigation is needed.

Agricultural Irrigation Component

Table 4.5-8

Groundwater Impacts by Component - Agricultural Irrigation

Evaluation Criteria	Point of Significance	Impact	Type of Impact	Level of Significance
5.7.1. Will the agricultural irrigation component degrade groundwater quality at existing drinking water wells, resulting in a public health hazard?	a. Nitrate levels in groundwater greater than 10 mg/L b. Greater than 0 wells in 20% contribution zone c. Less than 6 months travel time from reservoir to well d. Less than 500 feet from reservoir to well	<10 mg/L These points of significance are not applicable for irrigation	O&M, O&M-CP	◑
5.7.2. Will the agricultural irrigation component degrade groundwater quality at future drinking water wells, resulting in a public health hazard?	Greater than 0 parcels	0 parcels	O&M, O&M-CP	==
5.7.3. Will the agricultural irrigation component cause groundwater mounding or increase groundwater levels that cause surface water discharge in a non-stream environment?	Groundwater that is raised to within 6 feet of the surface	None within 6 feet of the ground surface	O&M, O&M-CP	◑
5.7.4. Will the agricultural irrigation component lower groundwater levels at existing wells?	Greater than 0 wells	0	O&M	==
5.7.5. Will the agricultural irrigation component lower groundwater levels in areas that could have been developed for future water supply?	Greater than 0 parcels	0	O&M	==

Source: Parsons Engineering Science, Inc., 1996

Notes:	1. Type of Impact:		2. Level of Significance:
O&M	Operation and Maintenance	==	No impact
O&M-CP	Operation and Maintenance - Contingency Plan	◑	Less than significant impact; no mitigation proposed

Impact: **5.7.1. Will the agricultural irrigation component degrade groundwater quality at existing drinking water wells, resulting in public health hazards?**

Analysis: *Less than Significant; Alternatives 2 and 3.*

Nitrate is the only constituent of concern because nitrate is present in reclaimed water at levels that exceed the MCL for drinking water. Nitrate levels in reclaimed water, applied in accordance with the proposed irrigation management plan, are below the nitrate requirements of crops. Therefore, nitrate in reclaimed water will be almost entirely taken up by the plants and will not migrate beyond the root zone. Although small amounts of nitrate do migrate through the root zone to enter the groundwater, the total input of nitrate to the groundwater will not be expected to measurably elevate nitrate levels in groundwater (Questa Engineering Corporation 1995b, Parsons Engineering Science, Inc. 1996b).

Agricultural irrigation could result in minor increases in salinity of groundwater, which is measured as total dissolved solids (TDS), but these will not be of public health concern. The City's reclaimed water is low in salinity, with an average TDS of 444 mg/L. This is below both the secondary MCL of 500 mg/L for TDS and the level of 3,000 mg/L at which water becomes unsuitable for municipal or domestic water supply. Existing TDS in groundwater at project monitoring wells ranged from about 300 mg/L to 1,000 mg/L. Based on the quality of reclaimed water, the potential for changes in salinity is minor, and will not be expected to impair beneficial uses of groundwater.

Application of reclaimed water in portions of the bay flats that are underlain by Reyes soils could result in the transport of salts and metals to shallow groundwater if programmed over-irrigation is implemented. Reyes soils are naturally acidic, with pH generally less than 4.0, and have shallow groundwater conditions (groundwater levels less than five feet below the ground surface). Metals that are not normally soluble may become soluble in acidic environments. Irrigation in previously unirrigated areas could result in flushing of metals and salts from the soil to the shallow groundwater. Shallow groundwater in the bay flats is brackish and is not considered to be potable. Therefore no significant health-related groundwater quality impacts will result. However, the movement of salts and metals from the soil to the groundwater and potentially to plants could adversely affect agricultural production within the bay flats irrigation area. Measures 2.2.1 and 2.2.3 included as part of the Project, provide for management of irrigation in the bay flats so as to avoid these potential adverse affects.

Accidental runoff or ponding from agricultural irrigation will be a temporary event that would not significantly alter groundwater quality.

No Impact; Alternatives 1, 4, and 5.

These alternatives do not have an agricultural component.

Mitigation: No additional mitigation is proposed.

Impact: 5.7.2. Will the agricultural irrigation component degrade groundwater quality at future drinking water wells, resulting in a public health hazard?

Analysis: *No Impact; All Alternatives.*

Although minor changes in groundwater quality may occur as described in Impact 5.7.1, no wells, either existing or future, will experience a change in quality sufficient to exceed standards or create a public health hazard.

Accidental runoff or ponding from agricultural irrigation will not impact future groundwater quality.

Alternatives 1, 4 and 5 do not have an agricultural irrigation component.

Mitigation: No mitigation is needed.

Impact: 5.7.3. Will the agricultural irrigation component cause groundwater mounding or increased groundwater levels cause surface water discharge in a non-stream environment?

Analysis: *Less than Significant; Alternatives 2 and 3.*

A water balance evaluation of potential impacts of reclaimed water application in Americano, Stemple, and Tolay creeks (Questa Engineering Corporation 1995a) indicates that most of the water that infiltrates past the root zone moves laterally along horizontal zones of preferential flow and discharges to ephemeral streams. Subsurface flow is influenced by shallow zones of relatively high permeability alluvium and/or surficial weathered material that is underlain by unweathered rock with lower permeability. Low permeability zones inhibit deep infiltration and most of the precipitation and irrigation water that infiltrates into the soil enters the “shallow groundwater return flow” regime (also referred to as interflow) and becomes surface water. In West County and the Tolay area this is expected to result in measurable discharges to local streams. Little, if any, of the irrigated water will infiltrate into the regional groundwater system and groundwater mounding will not result.

Subsurface conditions in the West Sebastopol area are similar to those in the Americano Creek watershed (i.e., horizontal beds of Wilson Grove Formation overlain by thin deposits of alluvium along stream valleys). Subsurface conditions in the Lakeville agricultural irrigation area are similar to those in the Tolay Creek watershed (i.e., Petaluma Formation bedrock). Because of these similar subsurface conditions at these sites it is assumed that infiltrating water will follow horizontal pathways; significant amounts of irrigation water will not enter the regional groundwater system and groundwater mounding will not occur. In the Lakeville and Sebastopol areas, irrigation is not expected to discharge to surface water because of the irrigation management practices that are adopted as part of the Project, as specified in Section 2.2, and the wide dispersal of irrigation sites.

Subsurface conditions at East Rohnert Park, North Petaluma (Petaluma, North and Adobe Road) and bay flats agricultural irrigation areas are not analogous to those of the West County and/or the Tolay Creek watershed. Potential groundwater contributions in these agricultural irrigation areas were evaluated using a two-dimensional analytical model (WinFlow, Environmental Simulation 1995). Model results indicate that regional groundwater levels will rise less than five feet in the East Rohnert Park and North Petaluma areas. Given the conservative assumptions used in the modeling, increases in groundwater levels in the vicinity of these irrigation areas will probably be negligible (Parsons Engineering Science, Inc. 1996a).

The bay flats area is underlain by fine-grained, very low permeability deposits. Questa Engineering Corporation (1995a) found that the bay flats area along the lower Petaluma River and adjacent to San Pablo Bay does not drain and discharge naturally to local streams or the bay. These near-tidal areas require surface water drainage systems and groundwater pumping to maintain the water table at depths of about five feet below the ground surface. The addition of any irrigation water will contribute to a rise in the existing shallow groundwater level and will require increased pumping. Drainage conditions throughout much of the bay flats, particularly in the Reyes soils, preclude the use of standard, permitted septic systems. Therefore, groundwater mounding will not affect leachfield operations.

Reclaimed water that enters the shallow through-flow will travel through the shallow unsaturated zone where leachfields are located (approximately upper five feet). Because irrigation will occur during the dry summer season when minimal amounts of perched water are present, it is unlikely that leachfields will be adversely affected by the reclaimed water.

No impacts will result in irrigation areas that are currently being irrigated with other water sources or in areas where drip irrigation systems are in use.

Accidental ponding or runoff from agricultural irrigation will not be sufficient in quantity or duration to cause groundwater mounding.

No Impact; Alternatives 1, 4, and 5.

These alternatives do not have an agricultural irrigation component.

Mitigation: No additional mitigation is proposed.

Impact: **5.7.4. Will the agricultural irrigation component lower groundwater levels at existing wells?**

Analysis: *No Impact; All Alternatives.*

Application of reclaimed water for agricultural irrigation will not result in decreased groundwater levels because no surface or subsurface flow into the groundwater will be intercepted or blocked by Project facilities. Accidental ponding or runoff will not decrease groundwater levels.

Alternatives 1, 4, and 5 do not have an agricultural irrigation component.

Mitigation: No mitigation is needed.

Impact: **5.7.5. Will the agricultural irrigation component lower groundwater levels in areas that could have been developed for future water supply?**

Analysis: *No Impact; All Alternatives.*

Agricultural irrigation will not result in decreased groundwater levels because no pumping or other extraction is proposed. Accidental ponding or runoff will not affect future groundwater levels.

Alternatives 1, 4, and 5 do not have an agricultural irrigation component.

Mitigation: No mitigation is needed.

Geysers Steamfield Component

Impact: **5.8.1-5. Will the geysers steamfield component impact groundwater based on evaluation criteria 1 through 5?**

Analysis: *No Impact; All Alternatives.*

Injection of reclaimed water into deep wells at the geysers steamfield will not result in adverse groundwater impacts because of the poor quality and high temperature of existing water in the steamfield and because this water is not used for drinking water.

Injection of reclaimed water at the geysers steamfield will affect a groundwater sink several thousands of feet below the ground surface. According to the Bureau of Land Management, which manages the geothermal resource, Federal requirements will protect the upper 3,000 feet from any leakage and there is no known groundwater resource in the geysers area (Renee Snyder, Bureau of Land Management, Clear Lake Resource Area Manager, Letter 6/17/96).

Alternatives 1, 2, 3, and 5 do not have a geysers steamfield component.

Mitigation: No mitigation is needed.

Discharge Component

Impact: 4.9.1-5. Will the discharge component impact groundwater based on evaluation criteria 1 through 5?

Analysis: *No Impact; All Alternatives.*

Shallow groundwater conditions in the Santa Rosa Plain indicate that streams and rivers are discharge points for groundwater. During the winter months when groundwater levels are high, the prevailing hydrologic conditions will result in gaining streams (i.e. the groundwater would discharge into streams). Reclaimed water discharged into the Laguna or Russian River will not enter groundwater because the water table slopes toward the stream so that the hydraulic gradient of the aquifer is toward the stream (Fetter 1994). Discharge does not occur from May 15 to September 30, during the dry months.

Direct discharge will not result in decreased groundwater levels because no pumping or other extraction is proposed.

Mitigation: No mitigation is needed.

CUMULATIVE IMPACTS

There are five impacts -- either less than significant or significant -- identified in the Groundwater section:

Impact: 5.1 and 2C. Will the Project plus the cumulative projects degrade groundwater quality at drinking water wells, resulting in a public health hazards?

Analysis: Alternatives 2 and 3. Data on existing groundwater quality indicate there are existing high nitrate levels in some aquifers, especially near the Two Rock and Lakeville Hillside reservoirs. These nitrate levels were taken into consideration in the analysis of impacts. No further information on cumulative projects or trends in nitrate concentrations in groundwater have been identified. The impact of the Long-Term Project has been identified as significant, and cumulative impacts do not warrant changing either the finding or significance or the proposed mitigation.

Impact: 5.3.C. Will the Project and cumulative projects cause groundwater mounding or increase groundwater levels that cause surface water discharge in a non-stream environment?

Analysis: Alternatives 3B, 3C, 3D, 3E. No cumulative projects which could cause groundwater mounding have been identified within the aquifer serving the affected area downgradient of these reservoirs.

Impact: **5.4 and 5C. Will the Project and cumulative projects lower groundwater levels at existing and future wells?**

Analysis: No cumulative projects which could cause groundwater drawdown have been identified within the aquifer serving the affected area downgradient of these reservoirs.

SUMMARY OF SIGNIFICANT IMPACTS AND MITIGATION MEASURES

Table 4.5-9

Summary of Significant Impacts and Mitigation Measures -- Groundwater

Evaluation Criteria	Level of Significance	Mitigation Measure
Storage Reservoir		
5.5.1. The storage reservoir component may degrade groundwater quality at existing wells, resulting in public health hazards.	Alt.2 - ⦿ Alt 3 - ⦿	2.3.12. Provide replacement water supply for affected wells.
5.5.2. The storage reservoir component may degrade groundwater quality at future drinking water wells, resulting in a public health hazard.	Alt.2 - ⦿ Alt 3 - ⦿	2.3.12. Provide replacement water supply for affected wells.
5.5.3. The storage reservoir component may cause groundwater mounding or increase groundwater levels that cause surface discharge in a non-stream environment.	Alt 3B - ⦿ Alt 3C - ⦿ Alt 3D - ⦿ Alt 3E - ⦿	2.5.9. Implement a septic system monitoring and replacement program.
5.5.4. The storage reservoir component may lower groundwater levels at existing wells.	Alt 2B - ⦿ Alt 2D - ⦿ Alt 3 - ⦿	2.3.13. Monitor groundwater levels and provide replacement water supply.
5.5.5. The storage reservoir component may lower groundwater levels in areas that could have been developed for future water supply.	Alt 2 - ⦿ Alt 3 - ⦿	2.3.13. Monitor groundwater levels and provide replacement water supply.

Source: Parsons Engineering Science, Inc., 1996

Notes:

⦿ Significant impact before mitigation; less than significant impact after mitigation

SUMMARY OF IMPACTS BY ALTERNATIVE

Table 4.5-10

Summary of Impacts by Alternative -Groundwater

Component	Alt 1	Alt 2A	Alt 2B	Alt 2C	Alt 2D	Alt 3A	Alt 3B	Alt 3C	Alt 3D	Alt 3E	Alt 4	Alt 5A	Alt 5B
No Action (No Project) Alternative	==	--	--	--	--	--	--	--	--	--	--	--	--
Headworks Expansion	--	==	==	==	==	==	==	==	==	==	==	==	==
Urban Irrigation	--	❍	❍	❍	❍	❍	❍	❍	❍	❍	--	--	--
Pipelines	--	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	--
Storage Reservoirs	--	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	--	--	--
Pump Stations	--	==	==	==	==	==	==	==	==	==	==	--	--
Agricultural Irrigation	--	❍	❍	❍	❍	❍	❍	❍	❍	❍	--	--	--
Geysers Steamfield	--	--	--	--	--	--	--	--	--	--	==	--	--
Discharge	--	==	==	==	==	==	==	==	==	==	==	==	==

Source: Parsons Engineering Science, Inc., 1996

Notes: Level of Significance Codes

-- Not applicable

== No impact

❍ Less than significant impact; no mitigation proposed

⊙ Significant impact; less than significant after mitigation

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