Attachment 6

Chapter 8. Groundwater Hydrology, Stream Base Flow, and Water Supply and Demand

INTRODUCTION

This chapter addresses the feasibility and environmental impacts of meeting the water demands of the project with onsite wells. Feasibility is an issue because the project area is underlain by fractured bedrock, and the yields of wells drilled in fractured rock aquifers are more variable and difficult to measure than yields of wells in alluvial aquifers. The feasibility issue principally concerns water supply reliability. Specifically, it is a question of whether available well test information is sufficient to conclude that the wells will be able to supply maximum day demand and maximum seasonal demand during a drought. Reliability is related to environmental impacts because an unreliable supply would result in water delivery shortages that could lead to mortality of irrigated landscape vegetation or prompt the project to seek water from some other source on an emergency basis. With the mitigation measures proposed in this EIR, the supply would be reliable and these potential environmental impacts would be avoided.

The project applicant retained five technical consulting firms (Camp Dresser & McKee, Inc.; Balance Hydrologics; David Keith Todd Consulting Engineers; Geoconsultants Inc.; and Luhdorff & Scalmanini Consulting Engineers) to perform extensive preliminary studies of surface water and groundwater hydrology at the project site. These included geological and geophysical surveys, drilling of 51 boreholes and wells, aquifer tests at 43 wells, gaging of streamflow on several creeks, development of a long-term average water balance for the project site, measurement of surface water and groundwater quality, and preparation of detailed water demand estimates for the proposed project. The results of these studies were compiled into a Comprehensive Hydrological Study report released in March 1994 (Camp Dresser & McKee, Balance Hydrologics et al. 1994a), which was reviewed by a third-party consultant (Ogden Environmental and Energy Services 1994) and by local agencies. Three supplements to the report dealing with specific technical details and potential environmental impacts were prepared by Camp Dresser & McKee, Balance Hydrologics et al. (1994b, 1995a, 1995b). Two technical memoranda regarding the water system design have also been prepared recently (Luhdorff & Scalmanini Consulting Engineers 1995a, b). Finally, two technical studies have been prepared addressing the golf trail, including design features related to irrigation water supply and water quality protection (Rancho San Carlos Partnership 1994a, 1994b).

The analysis in this chapter draws principally on information presented in the Comprehensive Hydrological Study and its three supplements, which are available for review at the Monterey County Planning and Building Inspection Department. Unless otherwise noted, information presented in this chapter was obtained from those documents, which are collectively referred to as the Comprehensive Hydrological Study. Where supplements or technical memoranda provided revised or more complete information, they were used instead of the information in the original study. Additional information for this analysis was obtained from a site visit, discussions with members of the consulting team that prepared the hydrological study, discussions with local agency officials, and review of literature related to selected topics.

SETTING

Hydrogeology

Geology

Rancho San Carlos is underlain by several bedrock units, principally granitic basement rocks, continental and marine sandstones and conglomerates of the Chamisal Formation, and marine shales and sandstones of the Monterey Formation. Geophysical and borehole data indicate that these formations extend at least several thousand feet below the land surface, or greater than the depth of any proposed water supply wells.

Unconsolidated alluvial deposits less than 100 feet deep are present along some of the creek channels. Although these deposits store and transmit groundwater more readily than the bedrock units, their contribution to the overall groundwater resources at Rancho San Carlos is small because of their limited depth and areal extent.

The bedrock formations are all of Miocene age or older (greater than 5 million years old) and are distributed in a complex spatial pattern resulting from depositional contacts and faults. Five faults have been mapped within the boundaries of Rancho San Carlos. The faults were active during the Miocene epoch and offset all of the granitic and sedimentary bedrock units. *Investigation revealed no evidence of recent fault activity.* ~~None of the faults are presently active, however.~~ The nearest active fault is the Tularcitos Fault, which approximately follows the Carmel River valley upstream of the Narrows (near the lower end of Robinson Canyon Road). See Chapter 6, "Geology and Minerals", for additional information about the geology of the project site and region.

Flow Boundaries

The Comprehensive Hydrological Study concluded that there are no major barriers to groundwater flow within or near the project site and that the area can be considered as a single hydrogeologic unit for the purpose of estimating the overall availability of groundwater to supply the project. This conclusion was supported by the lack of significant discontinuities in groundwater levels across faults and the lack of consistent or large boundary effects in the drawdown patterns measured during aquifer tests.

In the absence of barriers, groundwater theoretically could flow freely between any two points within the rancho. In practice, the groundwater flow system naturally subdivides itself into functionally separate local flow systems corresponding approximately to the creek watersheds. Groundwater levels are relatively high beneath topographic ridges, not because recharge is greater on ridges but because recharge occurs at a higher elevation. Groundwater levels are relatively low along the creeks because seepage into the creeks prevents adjacent groundwater levels from rising substantially above the level of the creek. The flow boundaries along ridges and creeks are flexible divides that reflect the present balance between recharge, discharge, and aquifer characteristics. They are not flow barriers. Thus, a well located near a ridgetop could capture some groundwater from the local groundwater flow system in the neighboring watershed, and a well on one side of a creek could draw groundwater from the opposite side of the creek.

Although the area can be considered a single hydrogeologic unit because there appear to be no major internal barriers to groundwater flow, groundwater throughout the area may not be readily accessible to the proposed network of water supply wells because of the low permeability of the fractured bedrock. This issue is discussed in greater detail as it relates to water supply reliability in the "Impacts and Mitigation Measures" section, below. Also, the present number and locations of wells might not be large enough to reveal local discontinuities in the groundwater flow system associated with contacts between geologic formations or variations in fracture continuity.

Aquifer Characteristics

The transmissivity and storage coefficient (storativity) of the fractured bedrock aquifer system were measured by aquifer tests at 43 wells, of which 12 were tested more than once. Tests consisted of measuring drawdown during pumping at the pumping well and at six locations in a nearby observation well. Most tests lasted 24 hours, although 23 wells were pumped for 72 hours and five wells were pumped for 30 days. Details of the testing procedure and plots of the drawdown data are provided in Chapter 6~~, "Geology and Minerals",~~ and Appendix E of the Comprehensive Hydrological Study.

The hydraulic conductivity (permeability) of fractured bedrock is typically much lower and more variable than the hydraulic conductivity of alluvial aquifers. Measured hydraulic conductivities at the wells ranged from 0.02 to 13.60 gallons per day per square foot (gpd/ft^2), although most of the values were between 0.02 and 2.0 gpd/ft^2. This is a reasonably narrow range of values, given that hydraulic conductivities of naturally occurring geologic materials can range over 13 orders of magnitude (Freeze and Cherry 1979). The distribution of hydraulic conductivity was similar for all of the fractured bedrock formations. The geometric mean (average) hydraulic conductivity of the porphyritic granodiorite (0.44 gpd/ft^2) was 70% greater than the mean for all bedrock formations combined (0.26 gpd/ft^2), but the difference might not be statistically significant because of the fairly small number of wells sampled. The test results *may* ~~probably~~ slightly overestimate the average permeability of the bedrock because five boreholes with very low initial yields were not completed as wells and included in the testing program. *However, this bias would be somewhat offset by the tendency for tests with large drawdowns in unconfined aquifers to underestimate hydraulic conductivity.*

Hydraulic conductivity was found to decrease with depth below the land surface. Values decreased from greater than 1 gpd/ft^2 for most wells less than 400 feet deep to less than 0.1 gpd/ft^2 for most wells greater than 1,000 feet deep. The hydraulic conductivity (or transmissivity) was used in the Comprehensive Hydrological Study to calculate the radius of influence of pumping wells and subsurface outflow to offsite areas.

Aquifer storativity was estimated for the Comprehensive Hydrological Study by two methods. Analysis of test results at the two wells with suitable data indicated storativity values between 0.5% and 1.2%. This range includes the uncertainty created by effects of partial penetration of the wells. A larger estimate of storativity (3%) resulted from a comparison of the average water-level rise in wells during the recharge season (10 feet) with the estimated unit rate of groundwater recharge (0.29 foot per year). The Comprehensive Hydrological Study indicates that the larger storativity obtained from the recharge calculations could be representative of water table fluctuations in relatively porous weathered bedrock at shallow depths, whereas the smaller storativity obtained from the aquifer tests could represent storativity at greater depths. *Decreasing storativity with depth has been documented in other fractured rock systems (Bedinger et al. 1986) and could result from decreasing fracture porosity with depth. Also, seasonal storage responses would be expected to be larger than responses to short-term stresses such as well tests because the water-table response to pumping at depth is delayed by the low vertical permeability of the intervening depth interval. It should be noted, however, that the amplitude of seasonal hydrographs does not appear to correlate with depth to water.* ~~This implies that the storage response to short-term stresses, such as aquifer tests lasting a few days, is smaller than the response to long-term stresses, such as recharge occurring over a period of months. Although this type of delayed yield effect is common in deep, layered alluvial aquifer systems, the physical mechanism for causing those types of delays in fractured bedrock aquifers is not as obvious. Also, the seasonal amplitude of water table fluctuations does not correlate with depth to water, which would be expected if near-surface water tables were fluctuating within porous, weathered material.~~

Other factors could also account for the discrepancy between the storativity estimates. The average annual groundwater recharge rate could have been overestimated (as explained below). Also, the recharge rate during the relatively dry years included in the water-level record (1990-*1992* ~~1993~~) could have been substantially less than the average recharge rate used in the storativity calculation.

Aquifer storativity affects the radius of influence of a pumping well. More important, it is a crucial factor for determining the volume of groundwater storage beneath Rancho San Carlos. Assuming an average well depth of 800 feet (the "optimal" depth for future wells and approximately the yield-weighted average depth of the existing bedrock wells (842 feet), an average depth to water of 150 feet, and the smallest measured value of storativity (0.5%), the amount of groundwater in storage is 64,675 acre-feet (af). Because the storativity was calculated from the amount of water actually yielded to wells, the total storage amount represents usable storage. If average storativity is 1.0% and wells are drilled to a depth of 2,000 feet, the total amount of usable groundwater storage is 398,000 af. The ability of project wells to reach this storage is discussed in the section on "Water Supply Reliability".

The second supplement to the Comprehensive Hydrological Study addressed questions raised by local agencies related to anisotropy (permeability that varies with direction) and the assumption that the fractured bedrock aquifer can be treated as an equivalent porous medium. The drawdown pattern for a well pumping from a linear, vertical fracture system would theoretically create a concave-downward pattern on semilogarithmic drawdown plots. Although many of the drawdown plots presented in the Comprehensive Hydrological Study deflected downward, most of the deflections were abrupt and more likely indicative of boundary conditions or casing and borehole storage effects than fracture flow. Only the plot for well T-29 showed a continuous downward curvature. A carefully instrumented aquifer test in fractured bedrock in Maine found that drawdown patterns in the pumping well and nearby observation wells showed some evidence of fracture flow but that patterns in distant observation wells (greater than about 150 feet from the pumping well) conformed to theoretical drawdown patterns for porous media (Muff 1993). These results confirm that for the temporal and spatial scales of interest for this impact analysis, it is reasonable to assume that the fractured bedrock aquifer is equivalent to a porous medium.

Anisotropy creates an asymmetric cone of depression around a pumping well. Drawdown data for two well pairs at Rancho San Carlos were suitable for detecting the presence of anisotropy, but none was found. If anisotropy were present, the radius of influence of the pumping well could be underestimated in one direction and overestimated in another. However, anisotropy would not affect the estimated well yield.

Water Levels

Figure 8-1 is a map of groundwater levels at Rancho San Carlos in April 1993. The water-level contours were based on water levels measured at the wells and the constraint that water levels beneath creeks not exceed the elevation of the creekbed. Although the well data are somewhat

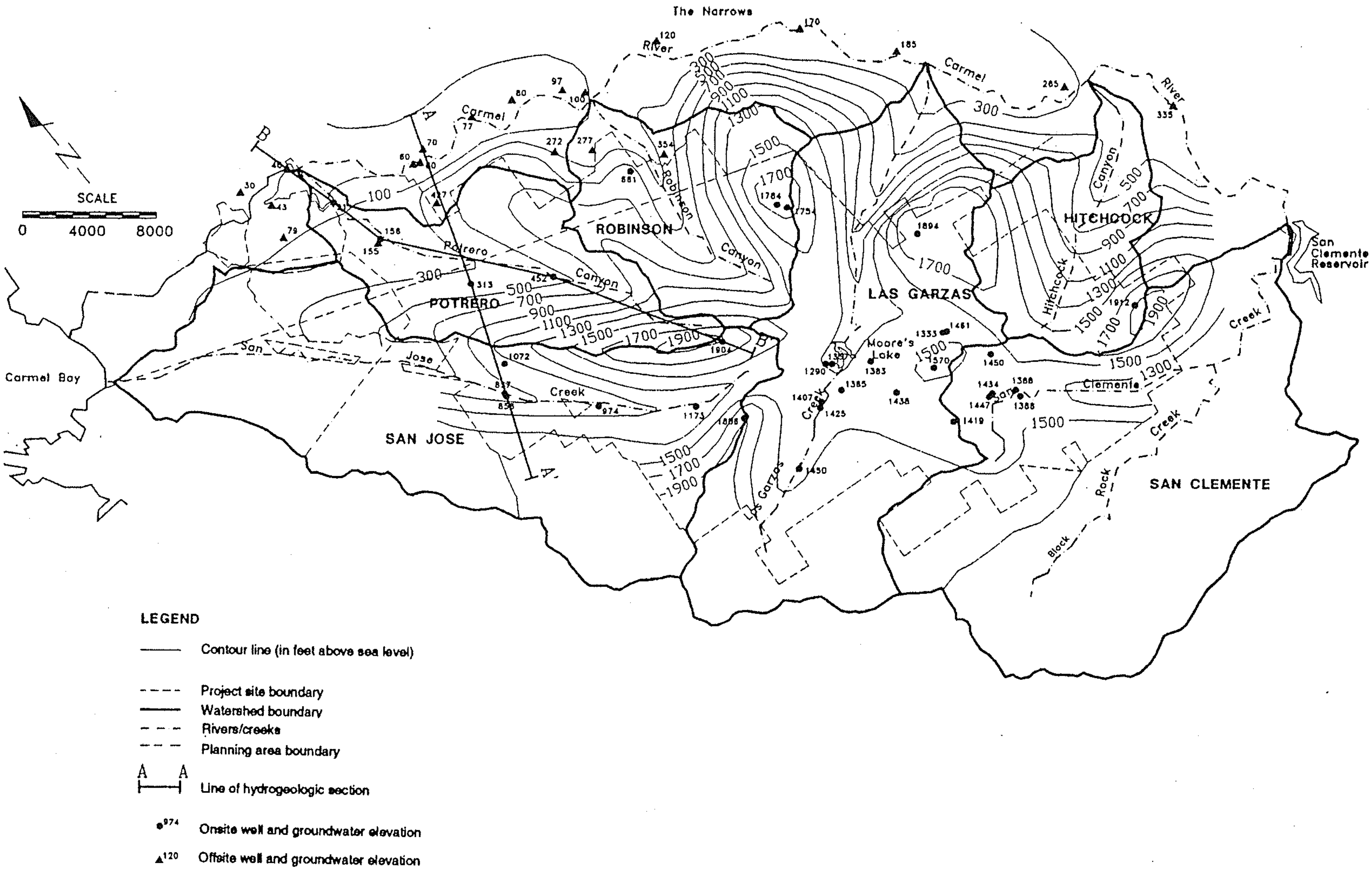

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Figure 8-1
Groundwater Elevations on Rancho San Carlos in April - May 1993

clustered, they indicate that water levels are generally higher beneath ridges and lower along the creeks. This pattern indicates that groundwater generally flows toward the nearest creek, whereupon much of the groundwater flow seeps into the creek and becomes streamflow.

The water-level data are also consistent with smooth, continuous contours that mimic the overlying land surface topography. The data do not indicate any local discontinuities in water levels such as might result from flow barriers along fault planes. Thus, the data support the conclusion that the fractured bedrock aquifer is effectively a single hydrogeologic unit throughout the area.

Vertical water-level gradients are present in some locations. At seven locations, pairs of wells were installed at different depths, allowing vertical water-level differences and gradients to be measured. Vertical water-level differences were detected at only two of the locations. The hydrographs for well pairs T-6 and T-9 indicated downward gradients of about 0.28 and 0.038 foot per foot, respectively. At well pairs T-18, T-26, and T-29, water levels in the shallow and deep wells were essentially the same. Well pairs T-11 and T-14 are located next to creeks. The water levels in the shallow and deep wells remained constantly at or near the ground surface, indicating that the water levels were *higher than the level of the creek and that groundwater probably discharges into the creek.* ~~constrained by seepage into the adjacent creek.~~ Under these conditions of groundwater discharge, small upward gradients are normally present.

The presence of springs and seeps on hillsides above the creeks indicates that in at least a few areas, the geometry of the bedrock fracture systems impedes downward movement of rainfall recharge sufficiently to cause the percolating water to flow horizontally and emerge on the hillside. In general, however, the data do not indicate the widespread presence of perched or vertically separate groundwater flow systems. This means that base flow in the creeks is not hydraulically separated from the adjacent aquifer and that water can move freely between the creek and the aquifer. This conclusion is also supported by water-level contour patterns and the presence of persistent dry-season base flow supported by groundwater discharge along some reaches of most creeks.

Hydrographs of water levels at 33 wells during 1990-1993 were presented in the Comprehensive Hydrological Study. At 12 wells, the period of record was too brief or water levels were too strongly affected by well development or pump tests to indicate the amount of natural seasonal water-level fluctuation. At four wells near creeks, the water level remained constantly at the level of the creek. The seasonal fluctuations in the remaining 17 wells ranged from 1 to 20 feet and averaged about 8 feet.

Water Balance

An average annual water balance for Rancho San Carlos was described in the Comprehensive Hydrological Study. The analysis treated the area (including the parts of the creek watersheds upstream of the rancho boundary) as a single, lumped hydrologic system. Rainfall was the inflow to the system, and interception, evapotranspiration, streamflow, phreatophyte use of groundwater, and subsurface outflow ~~(assumed equal to groundwater recharge)~~ were the outflows. Budgets were calculated annually for 1961-1990, but only the average annual budget was considered reliable.

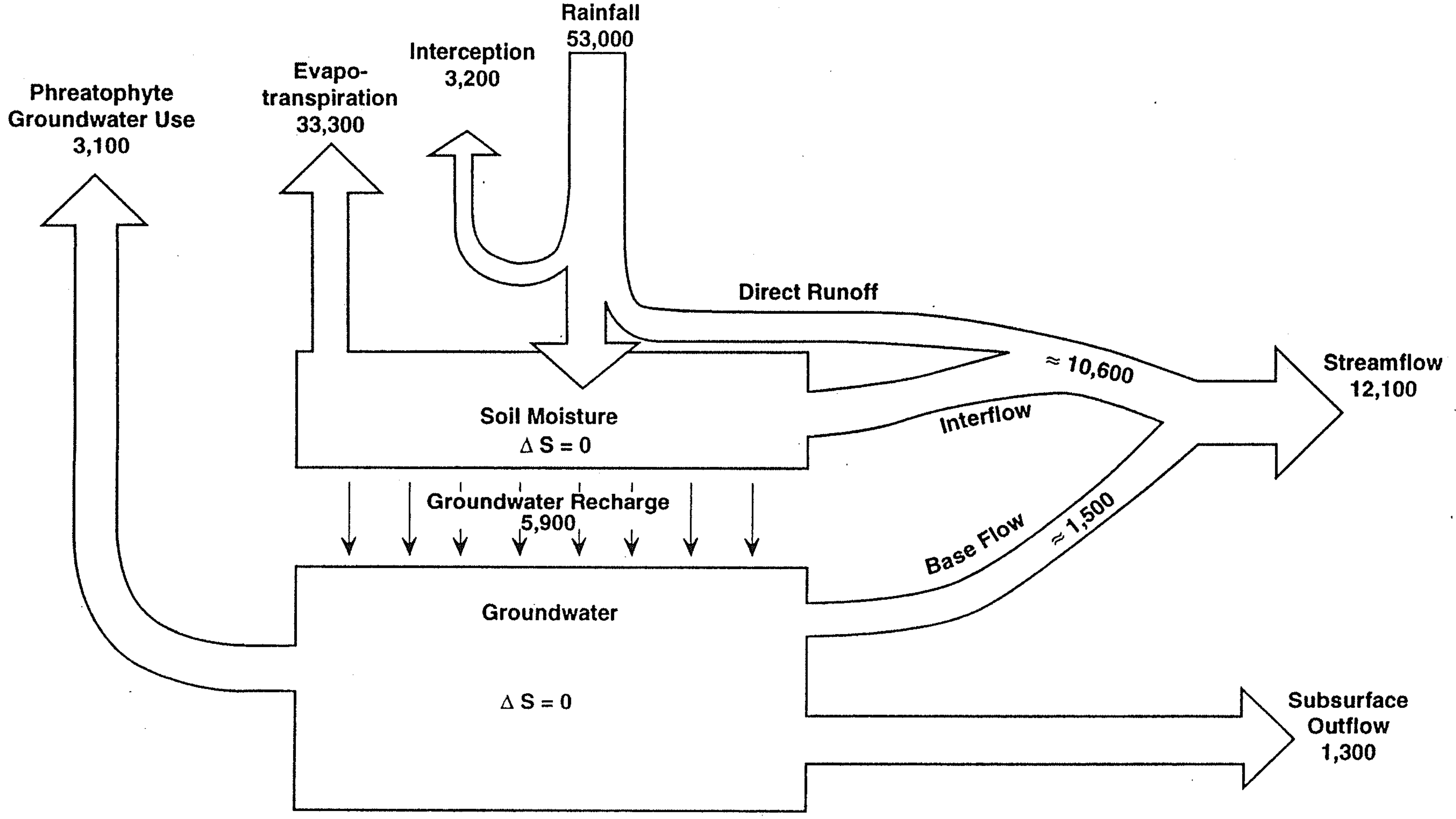
The purpose of the water balance was to determine whether average groundwater recharge and the overall groundwater budget were substantially larger than the estimated project water demand and thus capable of supporting the project on a long-term basis. The analysis concluded that average annual recharge is approximately 6,800 af/yr, which is much larger than the average annual project net water demand at buildout (400 af/yr).

The water balance was revised slightly for this environmental impact analysis. The purpose of the revisions was to facilitate the evaluation of impacts by representing more explicitly some of the physical processes in the hydrologic system. In particular, accurate partitioning of flows within the hydrologic system is important for estimating impacts. For example, direct runoff needs to be differentiated from base flow because groundwater pumping would affect the latter and not the former. The original water balance treated all streamflow equally as a single item in the balance. Similarly, subsurface groundwater outflow was not clearly differentiated from groundwater recharge in the water balance. In reality, these flows are governed by different processes, and groundwater pumping could affect one and not the other. Thus, the processes need to be estimated separately.

A conceptual diagram of the revised water balance is shown in Figure 8-2. The estimated flows in the budget reflect a balanced, long-term average budget under existing conditions. There is assumed to be no net long-term change in soil moisture or groundwater storage. Individual flows in the budget are discussed in the following paragraphs.

Rainfall and interception flows are the same as those in the original water balance (53,000 and 3,200 af/yr, respectively). Average annual rainfall was estimated using an isohyetal map developed from several rain gage records and is probably reasonably accurate. (An isohyete is a line on a map connecting points having equal amounts of annual precipitation.) Average annual interception was assumed to equal 6% of annual rainfall, based on data from studies in other areas. The accuracy of this assumption for the Rancho San Carlos area is unknown.

Total streamflow is the same as that in the original water balance (12,100 af/yr), but it is partitioned into direct runoff, interflow, and base flow. Total annual streamflow was estimated by a combination of gage records and regression and is probably reasonably accurate. Direct runoff consists principally of overland flow of rainwater that never enters the soil. Direct runoff occurs rapidly in response to rainfall and ceases within hours after rainfall stops. Interflow is streamflow generated from water that infiltrates into the soil but moves rapidly downslope to the creek through macropores. Interflow might persist for a few days following the cessation of rainfall. Base flow consists of groundwater discharge that occurs where groundwater levels adjacent to a creek channel are higher than the surface elevation of the creek. Because of the large volume of groundwater storage and the generally low hydraulic conductivity of the fractured bedrock aquifers, base flow is



Note: Values are in acre-feet per year.

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Figure 8-2
Conceptual Diagram of Average
Annual Water Balance for Rancho San Carlos,
Including Upstream Watershed Areas

relatively constant. It can persist all year in places, but it is typically highest in late spring after the recharge season and gradually recedes during the dry season.

Hydrographs of monthly stream discharge data reported in the Comprehensive Hydrological Study do not reveal distinct differences between periods of runoff and periods of base flow. A rough estimate of base flow can be obtained by assuming that all streamflow measured during May through October is base flow. During 1989-1993, the combined discharge during these months at gages on four of the six watersheds ranged from 24 af to more than 696 af. A reasonable average would be on the order of 300-500 af. Streamflow data were incomplete for some months and gages so actual base flow was larger by an unknown amount. Assuming groundwater discharge to streams is somewhat greater in winter than in summer and increasing the estimates for both seasons to account for ungaged watershed areas within Rancho San Carlos (18% of the total water balance area) result in an estimated average annual base flow of approximately 1,000-2,000 af/yr. Although this estimate is rough, it indicates that base flow is a relatively small fraction (less than 20%) of the total annual stream discharge.

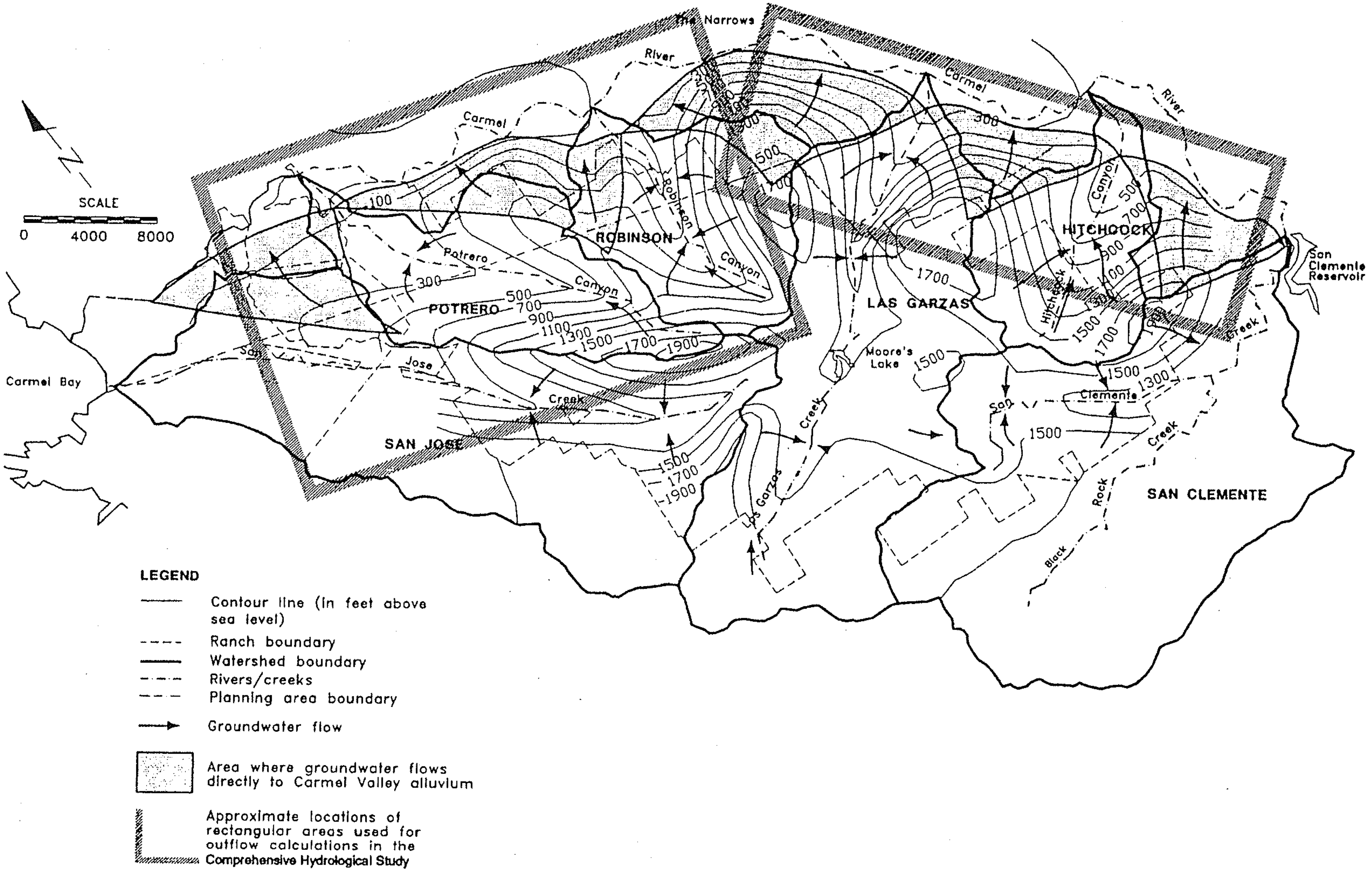
Evapotranspiration of soil moisture by plants is perhaps the most difficult flow to estimate because of large variations in root depths, "crop coefficients", soil type, and slope and aspect. For the revised water balance, this term was estimated as the residual in the water balance. Although evapotranspiration is one of the largest terms in the water balance, it would not be affected by groundwater pumping. It could be affected by the proposed changes in grazing management, but the effect would probably be beneficial. Thus, estimating this term by difference is reasonable and probably as accurate as other simple methods.

The revised estimate of average annual evapotranspiration is 33,300 af/yr, or 5,500 af/yr more than that in the original water balance. The increase is balanced by a decrease in groundwater recharge. This shift is considered reasonable because the root depth assumed in the original water balance (5 feet) may have been unrealistically small and consequently groundwater recharge would have been overestimated. An independent indication that groundwater recharge might have been overestimated in the original water balance is the discrepancy between the storativity estimate derived from well tests and the estimate derived from recharge and seasonal water-level fluctuations. A smaller recharge estimate would decrease the discrepancy. *It should be noted, however, that other assumptions in the original water balance might have tended to underestimate recharge. For example, native vegetation was assumed to transpire at the same rate as well-watered turf.*

Direct use of groundwater by phreatophytic vegetation was estimated for the original water balance by multiplying the area of riparian vegetation by the difference between potential evapotranspiration and available soil moisture. In other words, riparian vegetation was assumed to transpire at a rate equal to reference evapotranspiration (evapotranspiration by well-watered short-cropped grass), and any of the transpiration demand that could not be met by infiltrated rainfall was assumed to be met by groundwater. These assumptions introduce some errors, but the errors probably counteract each other. Not all of the vegetation types mapped as riparian are obligate phreatophytes. In other areas, for example, California bay and redwood trees commonly grow on hillsides where a shallow water table is not present. In other words, they can grow solely on rainfall if rainfall is adequate. Also, unlike the grasses used to define reference evapotranspiration, many of the species included in the riparian vegetation map units have physiological characteristics designed to minimize water loss, such as stomatal hairs and waxy cuticles on leaves. These factors indicate that the water demand for riparian vegetation may have been overestimated. On the other hand, the original water balance assumed all net rainfall (after interception losses) infiltrated into the soil and became available to plants. With direct runoff not estimated, available soil moisture was probably overestimated in some years, and the amount of evaporative demand met by groundwater was consequently underestimated. In the absence of additional information to resolve these uncertainties, the original estimate of phreatophyte use of groundwater (3,100 af/yr) was retained.

Subsurface groundwater outflow to the Carmel Valley was calculated for the original water balance by applying an unconfined groundwater flow equation to a simplified geometric representation of the flow system. The flow domain was conceptualized as two trapezoidal prisms, one upstream of the Narrows and one downstream of the Narrows. The approximate locations of the prisms are shown in Figure 8-3, and a diagram of the downstream prism is shown in Figure 8-4. Given the slope of the water table, the hydraulic conductivity of the fractured bedrock aquifer, and the length of the outflow boundary, subsurface outflow to the Carmel Valley was estimated to equal 2,200 af/yr. This estimate would be reasonably accurate if groundwater were forced to remain underground along the entire length of the assumed flow paths. However, the region of groundwater flow represented by the calculations includes Las Garzas Creek and Potrero, Robinson, and Hitchcock Canyons. The water-level contours (Figure 8-3) indicate that much of the groundwater assumed to exit as subsurface outflow actually flows locally toward the creeks and exits the watershed as base flow in the creeks. Flow lines drawn perpendicular to the contours indicate that flow from approximately two-thirds of the area included in the original prismatic flow tubes probably enters local creeks rather than the Carmel Valley alluvium. Direct subsurface outflow to the alluvium appears to occur in five triangular areas at the ends of the ridges separating the creek valleys (see Figure 8-3). Applying the same equation and hydraulic conductivity used in the original calculations to these revised flow areas results in an estimated average annual outflow of approximately 1,300 af/yr, or 60% of the original estimate.

An independent estimate of subsurface inflow to the Carmel Valley was developed during calibration of the Carmel Valley Simulation Model (CVSIM) used to simulate reservoir operations and groundwater flow for water resources planning studies. The model initially included no subsurface inflow. When the model was first calibrated in 1988, simulated drawdown in storage unit 3 (between the Narrows and Potrero Canyon) during the 1976-1977 drought was too large. The lack of drawdown in the measured data was assumed to have resulted from subsurface inflow. An inflow of 5.12 af per day (equivalent to 1,870 af/yr) to storage unit 3 improved the simulated water levels during the drought but resulted in water levels that were too high during normal conditions (Fuerst pers. comm.). Thus, this estimate of inflow is probably a high one. Even if the estimate is decreased somewhat to account for subsurface inflow from the north side of the Carmel Valley (where drainage areas are smaller and drier than on the Rancho San Carlos side), it would still be substantially larger



Source: Base map and water levels from Camp Dresser & McKee, Balance Hydrologics et al. 1994a.

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Figure 8-3
Groundwater Flow Directions and Groundwater Subareas Used for Outflow Calculations

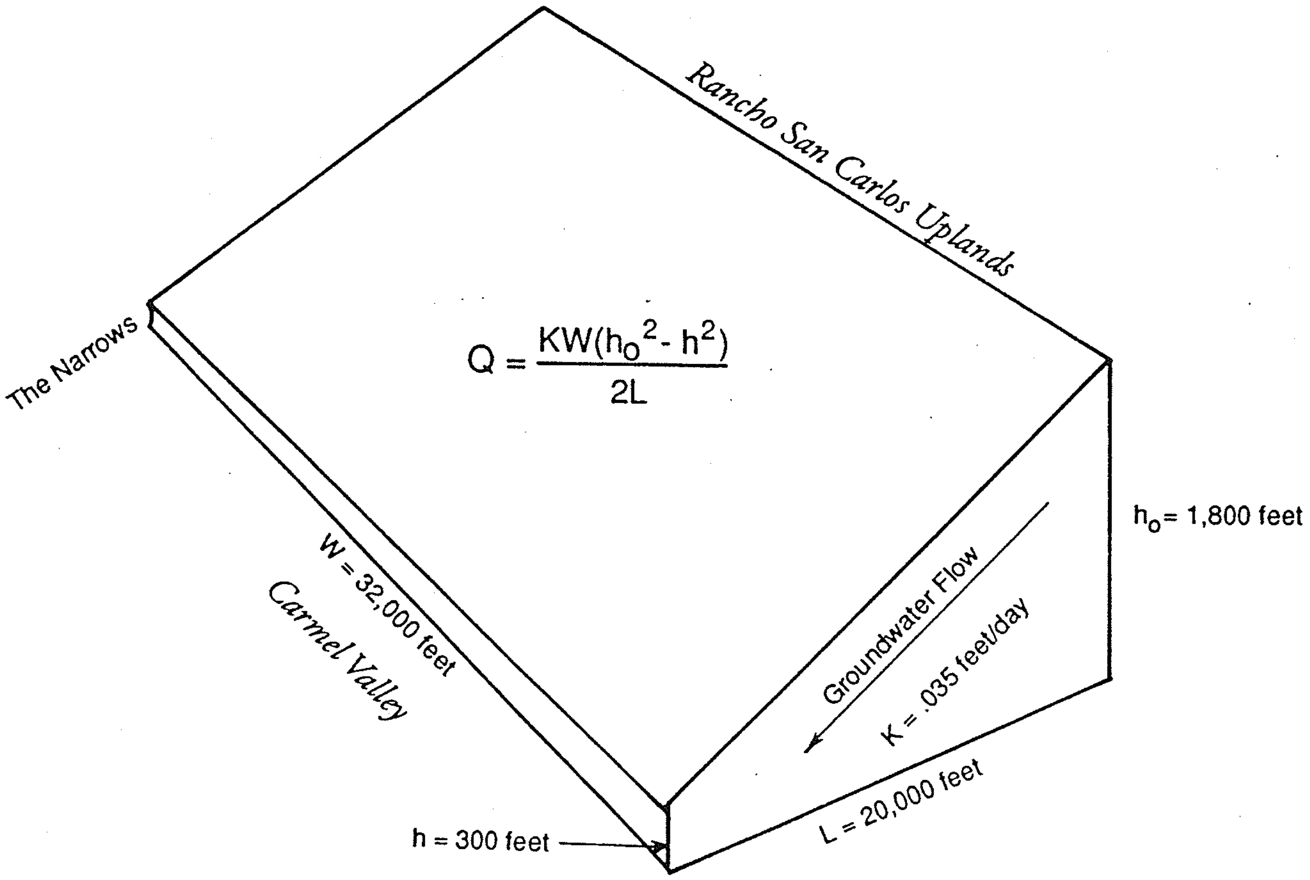

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Figure 8-4
Diagram of Trapezoidal Prism Method of Calculating Groundwater Outflow

than the estimate obtained in this study for subsurface inflow from the triangular subareas between Potrero Canyon, Robinson Canyon, and Las Garzas Creek (a total of 857 af/yr).

In addition to groundwater outflow to the Carmel Valley, there is groundwater outflow in the San Clemente and San Jose Creek watersheds. Rancho San Carlos is in the upper parts of these watersheds, where almost all groundwater outflow probably emerges as base flow in the creeks. The steep topography and the water-level contours on the Rancho San Carlos sides of those creeks indicate that groundwater flow is almost entirely toward the creeks rather than down the valley. There is no offsite alluvial groundwater basin in these watersheds for groundwater to flow toward directly, and only a very small fraction of total groundwater outflow might be through the fractured bedrock in the downvalley direction as subsurface flow beneath the creeks. Thus, groundwater outflow from these two watersheds was effectively accounted for in the estimates of base flow in the creeks.

The estimate of subsurface outflow included in the water budget shown in Figure 8-2 is somewhat inconsistent with the other terms in the budget. The other terms are only for Rancho San Carlos and upstream tributary areas and do not include areas between the Rancho San Carlos property boundary and the Carmel Valley. The groundwater outflow estimate, on the other hand, is for areas where groundwater flows directly to the Carmel Valley alluvium. These areas are located almost entirely between Rancho San Carlos and the Carmel Valley. The method used here to calculate subsurface outflow is appropriate for an analysis of project impacts, even though it creates an inconsistency in the water budget. Similarly, the streamflow estimate shown in the water budget does not include all surface runoff from the tributary creeks to the Carmel Valley. Runoff originating from rainfall and groundwater seepage between Rancho San Carlos and the Carmel Valley is not included.

Groundwater recharge from deep percolation can be estimated from the other terms in the groundwater part of the water balance. Assuming no net long-term change in groundwater storage, recharge must equal the sum of the groundwater outflow terms, or 5,900 af/yr.

The differences between the original and revised water balances are not considered large. The consequences of the differences, especially the smaller estimate of groundwater recharge and the explicit estimate of base flow, will become apparent in the "Impacts and Mitigation Measures" section. It will be shown that of the three groundwater outflow terms, base flow is most likely to be affected by groundwater pumping.

IMPACTS AND MITIGATION MEASURES

This section describes water demand for the proposed project and the adequacy and reliability of the proposed water supply wells. It describes the potential impacts of increased consumptive use of groundwater on groundwater levels, base flow in streams, phreatophytic vegetation, and subsurface outflow to offsite areas. Impacts of septic systems and use of reclaimed water for irrigation on groundwater quality are also discussed. Impacts on surface runoff during storms (including flood peaks) and surface water quality are discussed in Chapter 9, "Runoff, Flooding, and Water Quality".

In some cases, the evaluation of impacts presented in this chapter draws on hydrologic interpretation or impact analysis presented in the Comprehensive Hydrological Study and its supplements. In those cases, a review of the adequacy of those analyses for this EIR is presented, and modifications are made as necessary.

Significance Criteria

The State CEQA Guidelines (Governor's Office of Planning and Research 1986) provides several general significance criteria for environmental impacts associated with groundwater and related resources. A project will normally have a significant effect on the environment if it will:

- substantially degrade or deplete groundwater resources;
- interfere substantially with groundwater recharge;
- substantially degrade water quality;
- contaminate a public water supply; or
- substantially diminish habitat for fish, wildlife, or plants.

For this EIR, additional significance criteria were developed that refine the concepts in the general criteria to reflect the project design, local hydrologic system, and important local and regional resource issues. Thus, impacts are considered significant if any of the following thresholds apply:

- The yield of the groundwater system is not capable of supplying the net consumptive use demand of the project on a long-term average annual basis and during droughts.

- The water supply wells and water distribution network for the project is not capable of supplying water at a rate equal to maximum day demand.

- The project substantially decreases the availability of groundwater to existing users in adjoining offsite areas (by intercepting subsurface outflow and streamflow that would have recharged those areas), and the amount of the decrease exceeds a reasonable correlative share of groundwater yield.

- Water use for the project does not fall within the safe yield criterion imposed by the Monterey County Board of Supervisors in Resolution No. 93-115: "Determine within the accuracy of standard hydrogeologic practices, whether the level of development proposed by the applicant is consistent with safe yield of the proven water resources without adverse impacts on off-site water resources."

- The project lowers groundwater levels near creeks that support phreatophytic vegetation such that the total area of riparian vegetation on the Santa Lucia Preserve decreases by more than 5% below the 1994 baseline area on a long-term basis (either by direct mortality or impaired regeneration).

- Groundwater pumping for the project induces seepage that depletes pool volume and base flow in local creeks during summer by more than 10%, or to the point that resident fish populations are substantially decreased or substantially more vulnerable to severe impacts caused by natural fluctuations in flow and other environmental factors.

- Groundwater pumping for the project induces seepage that decreases the total area of wetlands on a long-term basis.

The significance thresholds related to the yield of the groundwater system and the capacity of the water distribution network address the reliability of the water supply system. Reliability is related to environmental impacts because an unreliable supply could prompt the project to pump groundwater in excess of safe yield, deplete stream base flow, or attempt to import water on an emergency basis from some other source that might be similarly drought-stricken.

The significance threshold for impacts on riparian vegetation is based on professional judgment and is considered reasonable in light of the widespread historical decreases in riparian habitat area in California and the relatively high habitat value of riparian areas. Further discussion of this significance threshold and the value of riparian habitat is presented in the section on "Impacts on Riparian Vegetation and Wetlands" and in Chapter 11, "Biological Resources".

The significance threshold for decreases in stream base flow is based on professional judgment. Resident fish populations are generally limited by the availability of habitat in summer. Given the small flows and short lengths of *protected* base flow reaches under existing conditions, a decrease of 10% is considered a reasonable upper limit of acceptable decline. Wildlife management agencies generally prefer no decrease in summer flows. *A map of the locations of protected base flow (as defined later in this chapter in mitigation measure "Monitor Base Flow in Creeks and Provide Supplemental Water if Necessary") is shown in Figure 8-4a.*

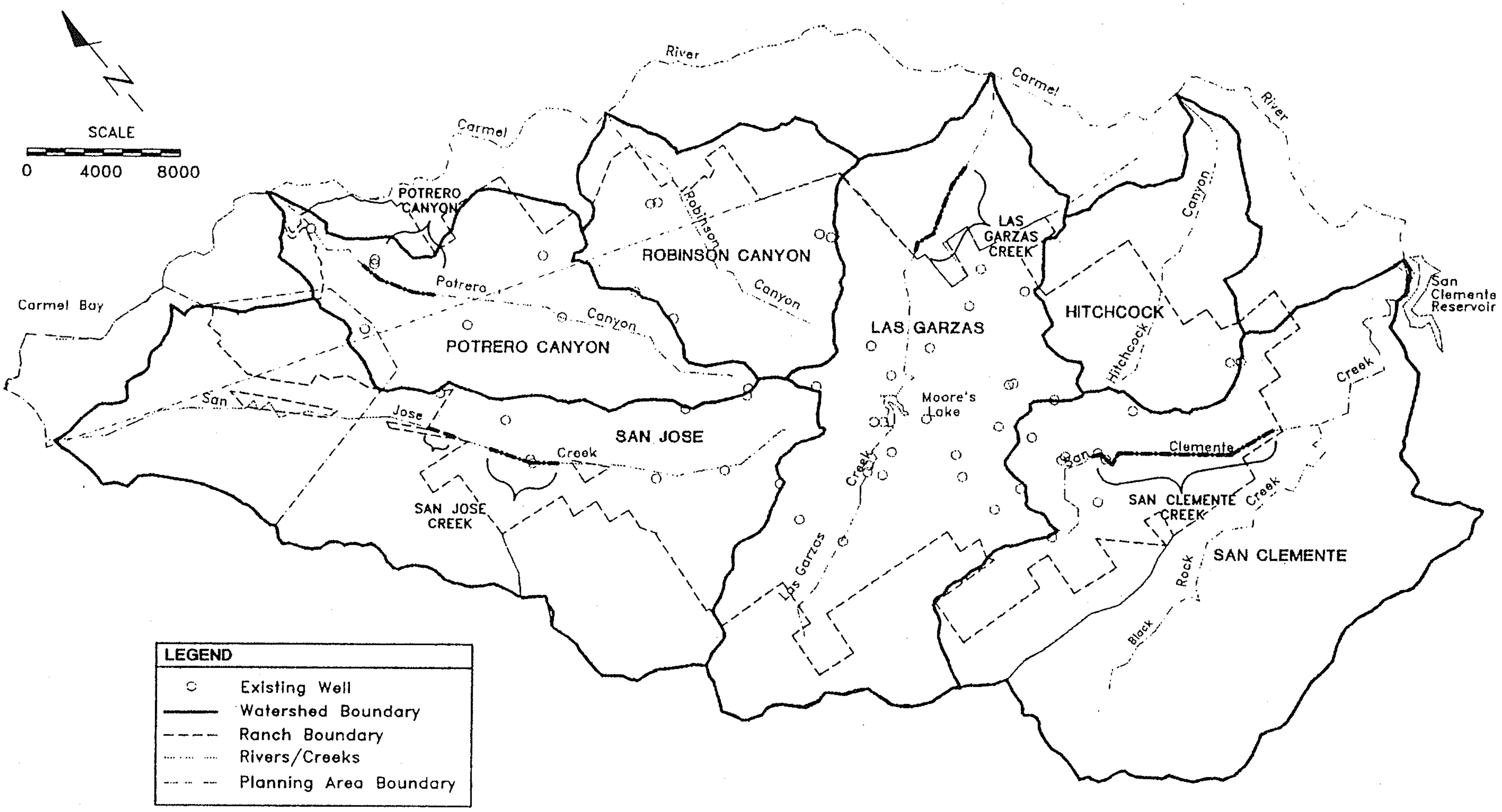

Figure 8-4a
Location of Protected Base Flow Reaches

A distinction is made in this environmental impact analysis between impacts on groundwater resources and related natural resources and impacts on other groundwater users, such as well owners in the Carmel Valley. Evaluation of impacts of groundwater pumping on groundwater and related resources is relatively straightforward, and the groundwater-related significance criteria listed in the State CEQA Guidelines suggest that these are the principal types of impacts CEQA is intended to address. Evaluation of impacts on other groundwater users is more difficult because it raises issues related to water rights and because reasonable thresholds of significance are difficult to define. Under California law, groundwater rights are generally not quantified, and it is not the role of an EIR to quantify or prioritize those rights. Impacts on other water users is clearly an important issue to residents and local agencies in the Carmel Valley and Monterey Peninsula region, however, and a discussion of the physical impacts on groundwater conditions and water supply is certainly appropriate under CEQA. Determining the significance of those impacts ultimately is somewhat subjective and relies on professional judgment. The legal concept of correlative groundwater rights is useful in this analysis because it reflects the reality that groundwater users commonly adversely affect one another and, up to a point, accept these effects as an inevitable consequence of using the resource. Although this analysis draws on legal concepts, it should not be misconstrued as a legal determination of water rights.

Applicant's Proposed Mitigation Measures

Many features of the project design were selected to increase water supply reliability or minimize hydrologic impacts. In particular, some details of the water system design and proposed programs for testing new wells and monitoring water levels have been presented in technical memoranda prepared after the project description was developed for this EIR (Luhdorff & Scalmanini Consulting Engineers 1995a, b). These features are described in the following discussions of individual impacts. If they are considered essential for mitigating impacts, they are reiterated in this document as mitigation measures to ensure that they will be included in the project design and implemented.

Water Supply Reliability

The water supply system for the project would be considered unreliable if it were unable to meet the water demand on a long-term average annual basis, during moderately severe droughts, or during short-term peak demand periods. Potential environmental consequences of such a shortfall include mortality of irrigated landscape vegetation if extreme water conservation measures are imposed during droughts and depletion of offsite water supplies if water were imported to the site to eliminate the shortfall. The project applicant intends to avoid these potential impacts by developing a reliable water supply. The mitigation measures proposed in this EIR serve to ensure that the supply is reliable.

Evaluating the reliability of the proposed water supply system requires a thorough understanding of the anticipated water demands and the proposed wells and water distribution network. These subjects are discussed below before evaluation of the impacts.

For the purpose of discussion, reliability can be divided into short-term and long-term issues. Short-term reliability is principally an issue of delivery rate and whether the wells and distribution system are able to extract and deliver groundwater at a rate equal to the maximum day demand. Water storage tanks included in the distribution system will meet even shorter-term peak demands, such as fire flows and hourly demand peaks within the maximum demand day. Long-term reliability is principally a function of the groundwater budget and whether the project demand can be met under various climatic conditions without causing groundwater overdraft.

Water Demand

An itemized water demand estimate for the project was prepared for the Comprehensive Hydrological Study using water demand factors for each proposed type of water use. Most of the water demand factors were developed by local water resources agencies from metered water use records. In any case, all of the factors used for this project were reviewed and approved by local agencies, including the Monterey Peninsula Water Management District (MPWMD), Monterey County Water Resources Agency (MCWRA), and Monterey County Division of Environmental Health (Bilse pers. comm.). The water demand factors appear reasonable and possibly generous in some cases. Of particular interest are the assumed demand factors for the golf trail and the market rate homes, because together they represent 77% of the overall net water demand for the project. The assumed irrigation rate for the golf trail is 31 inches per year (slightly higher on tees and greens and lower on fairways), or 78% of the estimated water demand for turf (39 inches at the golf trail site). The remaining 8 inches of water demand is assumed to be supplied by effective rainfall, which is reasonable at a location where average annual rainfall is about 30 inches.

The water demand factor assumed for market rate homes was 0.75 af/yr per home, as recommended by the MPWMD (Bilse pers. comm.). This factor appears to be ample, given that the largest measured water use rates in nearby areas with large single-family homes (i.e., Pebble Beach, Del Monte Forest, and Rancho Fiesta) were slightly less than 0.50 af/yr per home.

The annual groundwater demand for the GMPAP part of the project is summarized by watershed in Table 8-1. The table lists gross water demand, return flows, and net water demand. The net annual water demand is of greatest importance to long-term impacts on the groundwater system, because return flows become groundwater recharge. The only differences between this table and the tables in the Comprehensive Hydrological Study are the inclusion of the golf trail demand with the combined development permit demand and a decrease in the estimated golf trail demand to reflect a revised estimate of irrigated area (71 acres versus 90 acres) (Wilcoxon pers. comm.). The

Table 8-1. Estimated Average Annual Groundwater Demand for the GMPAP Part of the Santa Lucia Preserve Project, by Watershed

Watershed and Demand Item	Gross Groundwater Demand (af/yr)	Return Flow (af/yr)	Net Groundwater Demand (af/yr)
Hitchcock Canyon			
Market rate homes (10.5 units)	7.88	3.94	3.94
Subtotal	7.88	3.94	3.94
Las Garzas Creek			
Existing uses	17.24	6.88	10.36
Market rate homes (103 units) [a]	77.25	22.13	55.12
Inclusionary housing [b]	7.44	1.15	6.29
Visitor rooms	47.31	3.03	44.28
Neighborhood commercial	4.51	0.18	4.33
Recreational	21.67	3.30	18.37
Services/Operations	2.20	0.26	1.94
Golf *trail* ~~course~~ and facilities[c]	106.94	0.36	106.58
Reclaimed water supply[d]	-78.75	NA	-78.75
Stormwater supply[e]	-24.0	NA	-24.0
Subtotal	181.81	37.29	144.52
Potrero Canyon			
Market rate homes (34 units)	25.50	12.75	12.75
Subtotal	25.50	12.75	12.75
Robinson Creek			
Market rate homes (8.5 units)	6.38	3.19	3.19
Subtotal	6.38	3.19	3.19
San Clemente Creek			
Market rate homes (59 units)	44.25	15.23	29.02
Golf *trail* course[c]	103.69	0	103.69
Stormwater supply[e]	-34	NA	-34
Subtotal	113.94	22.12	98.71
San Jose Creek			
Market rate homes (24 units)	18.00	9.00	9.00
Subtotal	18.00	9.00	9.00
Total	353.51	81.40	272.11

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[a] 55 market rate homes in the Las Garzas watershed and 23 in the San Clemente watershed will be sewered; return flow rate is 0.075 af/yr (versus 0.375 af/yr for homes with septic systems).

[b] All of the 44 inclusionary housing units in the Las Garzas watershed will be sewered; return flow rate is 0.0169 af/yr (versus 0.0845 af/yr for units with septic systems).

[c] Half of the golf *trail* ~~course~~ irrigation demand (103.69 af/yr) is for turf in the Las Garzas watershed. The clubhouse will also be in the Las Garzas watershed (3.25 af/yr). The remaining irrigation demand will be in the San Clemente watershed. Return flow is for clubhouse landscape irrigation only. Golf *trail* ~~course~~ irrigation is assumed to *have zero return flow to groundwater.* ~~be 100% efficient.~~

[d] The reclaimed water supply is for a treatment plant capacity of 70,300 gpd (49 gpm) operating continuously at full capacity with seasonal storage of reclaimed water to match the seasonal irrigation demand.

[e] In an average year, 58 af of diffuse stormwater runoff from the golf *trail* ~~course~~ will be collected and stored in ponds for use during the irrigation season (Camp Dresser & McKee and Luhdorff & Scalmanini Consulting Engineers 1994).

NA = not available.

estimated gross annual water demand is 354 af and the net demand is 272 af. Return flows consist of deep percolation of septic system leachate and excess applied irrigated water.

The annual irrigation water demand for the golf trail will be 207 af/yr, ranging from a peak of 28.8+ af in July to as little as 5.7+ af in December. This includes 184 af/yr for irrigation of 71 acres of turf and 23 af/yr evaporative losses from storage facilities for the golf trail. Golf trail turf acreages and associated water demands were developed based on the following irrigation requirements.

	Acres	Percent Use
Greens	2.5+	3.6
Tees	3.5+	4.2
Fairways	35.0+	43.5
Aprons	8.5+	9.4
Close rough	21.5+	25.0

Three sources of supply are proposed for the golf trail: reclaimed domestic wastewater, diffuse stormwater runoff from the golf trail irrigated turf areas, and pumpage from wells. The use of reclaimed domestic wastewater and diffuse stormwater runoff will reduce the demand on groundwater as an irrigation water supply.

- **Reclaimed Domestic Wastewater**. The wastewater treatment facility on Lot 261 will generate up to a maximum of 70,000 gallons per day of irrigation quality water. This represents 79 af/yr or 39% of the estimated irrigation water demand.
- **Recycled Golf Trail Irrigation and Rainfall**. In order to mitigate potential water quality degradation, the drainage system for the golf trail has been designed to capture all irrigation and stormwater runoff from those turf areas subject to intensive turf management techniques. This water will be recycled and returned to the irrigation supply system. Up to 28% (58 af/yr) of the estimated irrigation water demand will be met from this source.
- **Wells**. Additional demand beyond that capable of being supplied by the two sources described above will be met by pumping from wells *(70 af/yr)*.

Potable water for the clubhouse will be provided by the Santa Lucia Preserve County Service Area as a part of the same domestic water supply system proposed for all improvements with the preserve.

Water from the three sources described above is to be collected, mixed, and stored in *four* ~~three~~ new ponds capable of *storing 58* ~~38~~ af adjacent to the golf trail. The irrigation system will be supplied from these storage ponds.

Storage facilities are proposed to meet peak summertime demands for the golf trail and reduce the need for peak groundwater pumping capacity. Although short-term (maximum day) peaks may be as high as 421 gpm, these peak demands will be met from storage and will not require source capacity equivalent to the peak demands. The required peak groundwater pumping capacity to serve the golf trail will be approximately 152 gpm.

A computerized irrigation system linked to an onsite weather station will automatically control daily water usage to achieve efficient water replacement within the turf root zone. Surface runoff and deep percolation (below the root zone) of irrigation water will be negligible during the irrigation season.

Reclaimed water used for irrigation of the golf trail is included in the water demand table as a negative demand. This supply corresponds to the revised wastewater treatment plant capacity of 70,300 gallons per day (= 49 gpm = 79 af/yr) (Camp Dresser & McKee and Luhdorff and Scalmanini Consulting Engineers 1994).

Stormwater runoff collected from the golf *trail* ~~course~~ and stored in ponds for use during the irrigation season is also shown in the water demand table as a negative demand. In an average year, this source of water would supply 58 af of water for irrigation.

In addition to the residences and facilities included in the water demand table, the project applicant expects to build another 67 residential units to achieve complete buildout of the project. This would result in an additional 45.0 and 22.5 af/yr of gross and net annual water demand, respectively.

The ~~instantaneous~~ combined pumping capacity of the water supply wells is also an important factor affecting water supply reliability because *Title 22 of the California Administrative Code requires that water supply systems be able* ~~the wells need to be able~~ to meet the gross water demand on the day of the year with the highest demand rate. Two methods have been used to estimate the *maximum day demand.* ~~required pumping capacity of the well network.~~ Following customary engineering practice for residential developments, the maximum day demand was assumed in the Comprehensive Hydrological Study to equal twice the average daily demand. This resulted in pumping capacity estimates of 353 gpm for the combined development permit (excluding the golf trail) and 750 gpm at buildout. A subsequent analysis (Luhdorff & Scalmanini Consulting Engineers 1995b) used *the minimum source capacity curves published in Title 22* ~~the California Administrative Code Title 22 requirements~~, which *indicated a required* ~~specify a~~ pumping capacity of 1 gpm per service connection to meet maximum day demand. Including all residences and facilities at buildout and supplemental irrigation requirements at the golf trail (152 gpm in addition to the reclaimed water supply), this method resulted in a pumping capacity requirement of 584 gpm. Applying this same method to the homes and facilities included in the combined development permit as presently defined (i.e., everything except 58 market rate *homes* and ~~nine~~ *2 gpm for* inclusionary home*s* *not within the GMPAP*), results in a pumping capacity requirement of *524* ~~526~~ gpm.

Water Supply Wells and Distribution Network

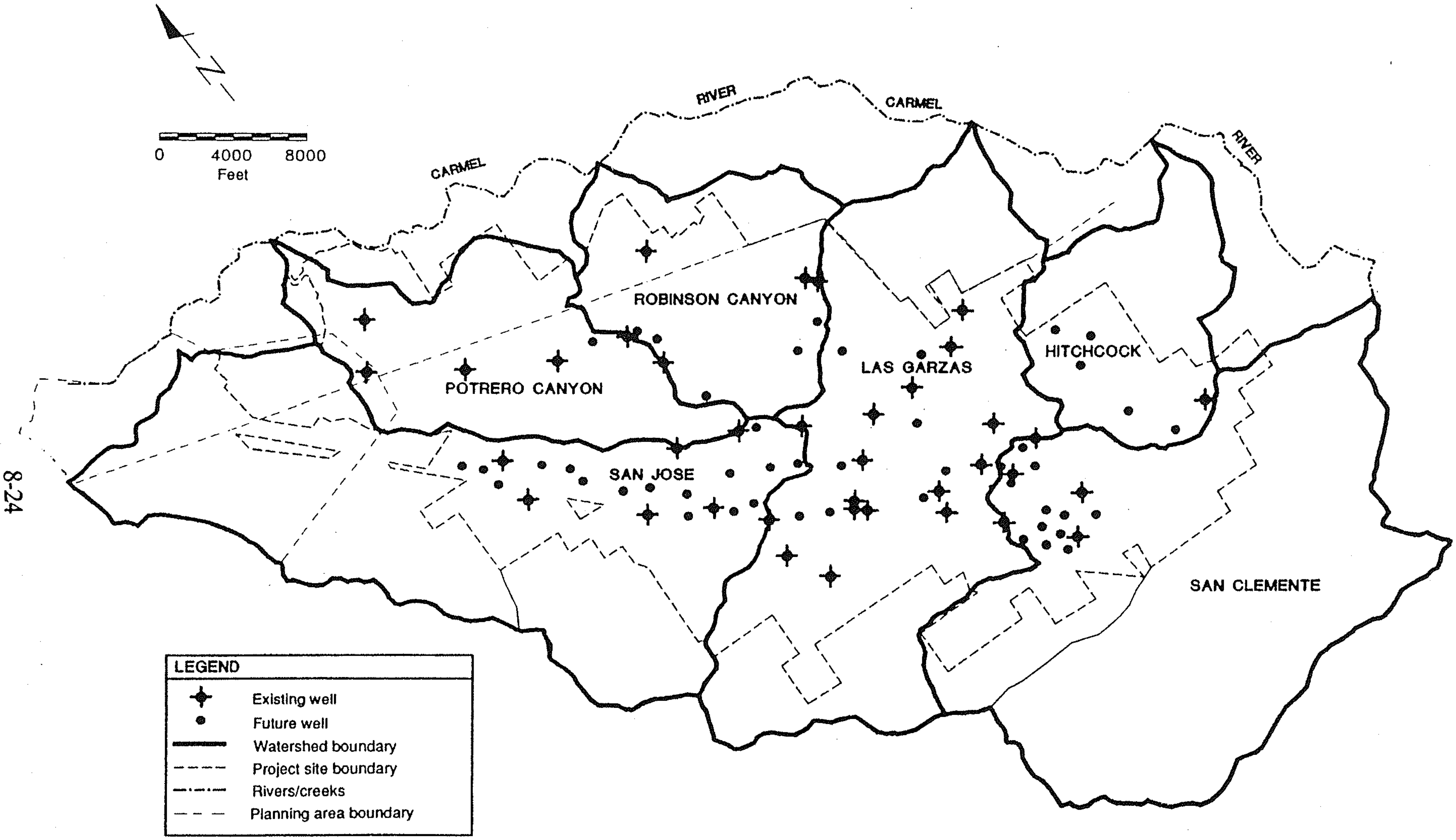
Thirty-seven existing wells are proposed for inclusion in the water supply system for Rancho San Carlos. The combined yield of these wells is sufficient to meet the water demand during the early phase of project completion. The project applicant plans to drill additional wells to meet the higher water demand levels during the later phases of project completion. Figure 8-5 shows the locations of the existing wells and tentative locations for future wells. Table 8-2 lists the estimated 24-hour yield of each well as stated in the Comprehensive Hydrological Study. The 24-hour yield, or demonstrated pumping capacity, is the amount of water a well can produce in 1 day without exceeding the available drawdown. Available drawdown was defined as equal to two-thirds of the vertical distance between the static water level and the top of the well screen.

Well yields in fractured bedrock aquifers tend to be highly variable, as illustrated by the yields of the Rancho San Carlos wells. The estimated yields range from 1 to 50 gpm, although wells expected to produce less than 1 gpm were not included in the program. The highest yield (65 gpm) was at well E-3, which is screened in alluvium rather than bedrock. The yields do not appear to correlate significantly with location or with bedrock formation type. Consequently, the average yield of future wells drilled for the water supply system would probably be approximately the same as the average for the wells that have already been drilled and tested.

A sufficient number of wells will be included in the water supply system so that collectively they will be able to meet the maximum day demand without operating more than 12 hours per day. The normal operating mode for wells will be 12 hours of pumping followed by 12 hours of recovery, with additional capacity obtained by turning on additional wells. This means that the sustained yield of the wells in actual operation will be one-half the 24-hour yield. The total 24-hour yield cited in the Comprehensive Hydrological Study was 527 gpm. The actual effective pumping rate would be 264 gpm, which equals about 53% of the maximum day demand rate (500 gpm).

The water distribution system *for well water* will be entirely interconnected, so that each well could potentially deliver water to any service connection in the system. Because of the large topographic relief encompassed by the distribution system, it will be divided into 23 interconnected pressure zones with flow and pressure maintained by pumping stations and pressure regulators.

Construction of the water distribution system will proceed in phases corresponding to the phasing of overall project construction. At any time during the development process, the amount of on-line well yield and storage tank capacity will be adequate to serve the on-line water demand.



Source: Camp Dresser & McKee, et al. 1995.

Jones & Stokes Associates, Inc.

Figure 8-5
Locations of Existing and Proposed Future Water Supply Wells

Table 8-2. Locations and Yields of Existing Water Supply Wells

			Estimated Yield (gpm)		
Well Number	Watershed	Test Duration	Comprehensive Hydrogeologic Study	Adjusted Estimates	Reason for Adjustment or Uncertainty
E-3	Las Garzas	4 hours	65	65?	Test too short
E-4	San Jose	2 hours	3	3?	Test too short; results dominated by casing storage effect
S-1	Las Garzas	72 hours	5	3	Fall '94 pumping rate adjusted for available drawdown
S-3	Las Garzas	6 hours	2	2	Fall '94 pumping rate adjusted for available drawdown
S-4	Las Garzas	73 hours	5	5?	Large change in pumping rate during test
S-6	San Jose	4 hours	1	0?	Test too short; results dominated by casing storage effects
T-3	Robinson	72 hours	30	11	Boundary effect; adjusted for late-time T
T-4	Potrero	74 hours	8	5?	Variable pumping rate; adjusted for late-time T
T-6A	Las Garzas	29 hours	8	8	
T-7	San Clemente	24 hours	6	6	
T-8	Potrero	72 hours	15	15	
T-9	Las Garzas	72 hours	50	50	
T-10	Las Garzas	72 hours	25	25	
T-11	Potrero	30 days	35	35	
T-12	San Jose	24 hours	10	9?	Variable pumping rate; adjusted for rate during first 450 minutes
T-14	San Jose	30 days	10	10?	Highly variable pumping rate
T-17	Robinson	30 days	4	4	
T-18	Potrero	30 days	45	26	Boundary effect; adjusted for late-time T
T-20	Las Garzas	24 hours	2	2?	Highly variable pumping rate; casing storage effect
T-21	Robinson	72 hours	10	10	
T-24	Las Garzas	72 hours	5	0	Sudden and complete loss of yield after 2.0 days
T-25	Las Garzas	72 hours	17	17	
T-26	San Clemente	30 days	15	9	Boundary effect; adjusted for late-time T
T-29	Hitchcock	72 hours	30	5	Boundary effect; adjusted for late-time T
R-1	San Clemente	72 hours	21	27	Boundary effect; adjusted for late-time T
R-3	Las Garzas	72 hours	5	1?	Boundary effect; adjusted for late-time T
R-5	Las Garzas	72 hours	3	1	Boundary effect; adjusted for late-time T
R-6	San Jose	72 hours	12	12	
R-9	Potrero	72 hours	4	4	
R-10	Las Garzas	72 hours	8	7?	Erratic drawdown; adjusted for projected 24-hour drawdown
R-11	Potrero	72 hours	8	4	Boundary effect; adjusted for late-time T
R-13	San Jose	18 hours	8	8?	Test too short; large casing storage effect
R-14	Robinson	72 hours	6	6	
R-15	San Clemente	72 hours	5	5	
R-27	Las Garzas	50 hours	4	2?	Variable pumping rate; adjusted to reflect available drawdown
R-33	Las Garzas	30 hours	6	6	
R-42	Las Garzas	72 hours	31	31	
	Total		527	439	

Notes: ? = uncertain test results.

To adjust for late-time T, transmissivity (T) was calculated from data after a break in the drawdown slope. The yield, or specific capacity, was multiplied by the ratio of the revised T to the original T.

The total number of additional wells that will be needed for the project is not known at this time because it depends on the yields actually achieved by wells drilled in the future and on the required system source capacity, which will be determined by measurements of actual water use during the early phases of project development. A conservative estimate of the number of wells can be calculated from the demand and well yield estimates. As described earlier, the estimated source capacity requirement ranges from 524 gpm for facilities included in the combined development permit to 750 gpm at buildout. Assuming the adjusted well yields shown in Table 8-2 and assuming 12-hour-per-day well operation, the 37 existing wells can supply 220 gpm. The remaining demand to be met by additional wells is therefore 304-530 gpm. Assuming that all additional wells would be drilled in bedrock, would have the same average yield as the existing wells (10.4 gpm, using the adjusted yields), and would be operated a maximum of 12 hours per day, approximately 58-102 additional wells will be needed. The number of drill holes might exceed this estimate because some of the holes (approximately 10%) might not yield enough water to be worth completing as wells. These holes would be plugged according to state and county well abandonment regulations.

The actual ultimate number of wells included in the water supply system (assuming the above estimate is reasonably accurate) is inconsequential to this analysis, because the significant environmental impacts associated with water use for the project result from the amount of water consumed, not from the number of wells used to withdraw the water from the ground. As demonstrated by the lack of significant environmental impacts caused by installation of the first 37 wells, constructing wells using current standard drilling methods is not considered a source of significant environmental impact. Mitigation measures described later in this chapter will ensure that new wells are drilled away from sensitive environmental resources such as base flow reaches in creeks.

~~The applicant estimates that 50 additional wells will need to be drilled to meet the maximum day water demand after complete buildout of the project. The locations of future wells will be selected so that groundwater pumpage is distributed among the watersheds in approximately the same proportions as groundwater recharge.~~

Impact: Water Supply Shortage Because of Overestimated Well Yields

If the proposed network of water supply wells failed to supply their expected yield after demand was already on line, a water supply emergency could result. Many of the possible operational responses to the emergency could result in environmental impacts. For example, severe water rationing could result in mortality of irrigated landscape vegetation, increased groundwater pumping could result in overdraft or excessive streamflow depletion, and attempts to import water from offsite areas could affect other users and the environment in those areas.

The wells need to be capable of supplying water for 1 day at a rate equal to the maximum day demand in the middle of the high demand season. Fire flow requirements and hourly demand fluctuations within the maximum demand day would be met by storage in above-ground tanks and would not rely on the pumping rates of the wells. This is consistent with the proposed design of the water supply distribution system, which includes tank storage equal to four times the maximum day demand (excluding golf trail demand) plus fire flow requirements.

Evaluation of maximum day and month reliability of the wells and distribution system was based on a careful review of the well yield analysis presented in the Comprehensive Hydrological Study. The results of the review are presented in this section to substantiate the evaluation of environmental impacts.

The 24-hour well yields used in the Comprehensive Hydrological Study to quantify the available water supply for the project were based on actual pumping tests of up to 30 days in duration. Yield was calculated by multiplying the 24-hour specific capacity (in gallons per minute per foot of drawdown) by the amount of available drawdown (in feet). The drawdown plots and calculations were documented in Appendix E of the Comprehensive Hydrological Study.

In spite of the thorough testing program, it remains uncertain whether the yields stated in the Comprehensive Hydrological Study could be achieved reliably on the maximum demand day. The reasons for the uncertainty include the conceptual appropriateness of using the measured 24-hour yield to represent the maximum demand day yield and irregularities or ambiguities in test results. The latter include effects caused by variable pumping rates, casing storage, and apparent flow boundaries. Each of these is explained below.

Appropriateness of 24-Hour Yields. The pumping tests used to estimate the yields began from static conditions in which water levels in the wells had been allowed to recover to a stable level over a long period of time. In contrast, the maximum demand day will occur in summer, and most or all of the supply wells will have been pumping on a cyclic basis for several months prior to the maximum day. The aquifer in the immediate vicinity of each well will have undergone some cumulative seasonal drawdown as a result of the prior pumpage, and the wells might not produce at as high a rate as when they start with a fully recharged aquifer. The effect of prior pumping on water levels is illustrated by comparing the drawdowns after 24 hours with the drawdowns after 30 days at the five locations where 30-day tests were performed. The additional drawdown during the 29 days ranged from 13% to 81% of the available drawdown. In some cases, the increment was larger than would occur in practice because the pumping rate during the test was greater than the 24-hour yield rate. Nevertheless, drawdown caused by prior pumping can substantially decrease the amount of available drawdown actually available on the peak demand day. In many cases, the rate of drawdown increased (relative to the theoretical straight line rate) as the test progressed. These apparent boundary effects, discussed below, further indicate the potentially important effects of prolonged pumping that are not always reflected in the 24-hour yields.

Variable Pumping Rates. If the pumping rate does not remain constant during a well test, the drawdowns will depart from theoretical drawdown curves and complicate the calculation of specific capacity. The pumping rate varied during many of the tests. In most cases, the variation was small enough or early enough that the test results could be reasonably interpreted using the average pumping rate. At wells T-4, T-12, T-14, T-20, and R-27, however, variations in the pumping rate were large, frequent, or occurred near the middle of the test, and the drawdown patterns were highly irregular. The yields estimated from these wells are consequently somewhat uncertain.

Casing Storage. In low-yielding wells, the volume of water standing in the well casing prior to a pumping test can contribute a significant fraction of the well yield during the early part of the test. Formulas are available for calculating the critical time (Tc) at which this effect becomes negligible, and the calculated critical time for each well was shown on the drawdown plots presented in the Comprehensive Hydrological Study. For most of the tests, enough data were collected after Tc that the results were presumably free of any errors resulting from casing storage. For some of the shorter tests, however, the test ended either before Tc or too soon after Tc to determine the true aquifer response. These include the tests of wells E-4, S-6, T-20, and R-13. Because casing storage increases the apparent yield of a well, it is possible that the yields of these wells were overestimated.

Apparent Flow Boundaries. In a large number of the well tests, the rate of drawdown departed from the theoretical straight-line trend and shifted either gradually or abruptly to a more rapid rate. This pattern raises serious questions about the use of short-term tests to measure the reliable well yield in the middle of the peak demand season. Data from the 3-day and 30-day tests demonstrate that tests lasting 24 hours or less can underestimate the long-term drawdown rate and consequently overestimate the well yield. In the tests of wells T-3, T-9, T-10, T-18, and T-24, for example, an increase in drawdown rate occurred between 1 and 3 days after the start of the test and would not have been detected with a 24-hour test. At well T-26, an increase in drawdown rate occurred after 3.5 days of pumping and would not have been detected with even a 3-day pumping test. At well T-29, the increase in drawdown rate was gradual rather than abrupt. In only one case (well T-21) did the rate of drawdown decrease with time and indicate a higher yield than was indicated by the short-term test.

Several possible causes account for the changes in the measured rate of drawdown. These include the "casing storage" effect of the gravel pack surrounding the casing, the presence of a steeply sloping water table in the general vicinity of the well, and limited areal extent of the local fracture system tapped by the well. For the purpose of estimating the reliable yield of the wells, it does not matter whether one or all of these causes contribute to the effect. The empirical fact remains that in many cases the measured yield of the well decreases as the duration of the pumping test increases.

Cyclic pumping will not prevent the drawdowns from reaching the apparent boundary effects. As explained in the Comprehensive Hydrological Study, the long-term drawdown rate associated with cyclic pumping (for example, 12 hours on followed by 12 hours off) is the same as the drawdown rate that would result if the well were pumped continuously at half the pumping rate. In other words, cyclic pumping does not allow the drawdown to remain perpetually in the first phase following static conditions. Furthermore, the time at which a boundary is encountered depends on the rate at which the cone of depression expands, which is a function of transmissivity and storage coefficient but not a function of pumping rate. So the boundary would be encountered at the same elapsed time even if cyclic pumping effectively cuts in half the pumping rate.

An obvious consequence of the pattern of decreasing yields is that the yields of wells tested for 24 hours or less were probably overestimated in some cases. The wells in this category are wells E-3, E-4, S-3, S-6, T-7, T-12, T-20, and R-13, and their combined yield was reported as 97 gpm, or 18% of the total yield of all wells. These wells were tested for periods ranging from 2 to 24 hours.

At some of the wells with observed increases in drawdown rate, the transmissivity and well yield were calculated from data after the increase. This results in a yield estimate that is appropriately conservative for conditions of long-term continuous or cyclic pumping. These include wells T-8, T-9, T-10, T-14, T-25, R-6, and R-10. At other wells, however, the transmissivity and well yield were calculated from data prior to the increase in drawdown rate, and the results might consequently overestimate the long-term yield. These include wells S-1, T-3, T-4, T-18, T-26, R-5, and R-11. At well R-1, the rate of drawdown decreased, and the long-term yield might have been underestimated. Adjusted estimates of yield for these wells are shown in Table 8-2. The yields were adjusted by multiplying the 24-hour specific capacity by the ratio of transmissivity calculated from late-time data to the transmissivity calculated from early-time data.

In several cases (wells T-24, T-29, and R-3), the change in the rate of drawdown was irregular or drastic enough that an adjustment was already included in the yields reported in the Comprehensive Hydrological Study. However, the adjusted value might still be overly optimistic. For example, the water level in well T-24 suddenly plummeted from 75 feet to 210 feet (available drawdown is 200 feet) during the third day of the pumping test, yet the reported adjusted yield of 5 gpm is only slightly less than the test pumping rate (8 gpm). In a few other cases (wells T-12, R-10, and R-15), a projected rather than actual drawdown after 24 hours might have been more appropriate for calculating specific capacity because variations in pumping rate or other factors caused irregular water levels 24 hours into the test.

Finally, the concentration of aluminum in water produced from wells T-6A and R-11 exceeds the maximum concentration allowed under California primary drinking water standards. The Monterey County Division of Environmental Health has indicated that it does not permit treatment as a means of meeting primary drinking water standards. The project applicant plans to retest the water quality of those wells because the high aluminum might have resulted from incomplete well development. If the wells still fail to meet the drinking water standard, the project applicant proposes to use the wells for landscape irrigation by installing nonpotable water distribution lines from those wells to nearby residences and community facilities. Thus, it is appropriate to retain these wells in the water supply table.

The combined yield of the proposed water supply wells after making the above adjustments is 439 gpm, or 17% less than the yield stated in the Combined Hydrological Study. This does not include the probable decreases in estimated yields that would result from longer tests at wells that were tested for 24 hours or less.

Operating Features That Enhance Reliability. The risk of water supply shortages is greatly decreased by two aspects of the planned well operating criteria. First, the wells will be operated only 12 hours per day, or effectively at half of the reported 24-hour yield rate. In other words, the wells would only be relied upon to provide 264 gpm, rather than the 527 gpm of combined yield reported in the Comprehensive Hydrological Study. Second, the available drawdown used in the yield calculations was only two-thirds of the maximum drawdown that could occur before adversely affecting well operation. Together, these criteria create a safety factor of about 3. That is, if wells were pumped continuously at a drawdown equal to the maximum drawdown, the yield would be about three times the yield credited to the wells under the planned operating criteria. These operating criteria create a substantial safety factor that is probably sufficient to compensate for any overestimates of well yields.

The foregoing review of the well yield analysis demonstrates that the wells may not be able to supply the reported yields throughout the peak demand season *without violating the proposed operating criteria and encroaching on the safety factor*. Without accurate estimates of reliable well yields, water demand might accidentally be allowed to exceed the available water supply capacity at some time during the project construction period. The potential for a water shortfall during the peak demand season is considered a significant impact. To avoid this impact and reduce it to a less-than-significant level, the following mitigation measure should be implemented.

Additional Mitigation Measure *12*: Maintain a Water Supply Equal to or Greater than Connected Water Demand at All Times. A water supply shortage could occur if new wells are not drilled and connected to the water supply system during the 20-year project construction period at a rate such that pumping capacity always exceeds maximum day demand. In addition, shortages could develop in subsequent years if well yields decline as a result of mineral deposits in the well. The Comprehensive Hydrological Study clearly states that additional wells will need to be drilled to meet the ultimate project water demand and indicates tentative locations for additional wells. However, the Comprehensive Hydrological Study does not indicate when the wells will be drilled, although it is logically understood that additional wells would be drilled and equipped as demand increases.

It is recognized that the overall operation of a municipal water system such as planned for Rancho San Carlos will be governed by a Water Supply Permit, ultimately issued by the State Department of Health Services (DHS) under Section 4011(a) of the State Health and Safety Code (when the total number of connected water services reaches at least 200). It is further recognized that, as part of administering the Water Supply Permit, DHS is mandated by the provisions of Section 4039 of the Health and Safety Code to annually inspect and evaluate the water system for conformance with its permit. Standards for evaluation include sufficient source capacity and storage volume to meet maximum day demand, maximum hour demand, and fireflow demand. Specifications for source capacity and system storage volume are included in the California Waterworks Standards (22 CCR 16).

The methodologies for determination of well yields, as documented in the Comprehensive Hydrological Study, conform to those specified in the Title 22 Waterworks Standards. As noted above, an analysis of projected water demand on the ranch also used the Title 22 Waterworks Standards as a basis for water demand projections (Luhdorff & Scalmanini Consulting Engineers

1995b). These standards specify the source capacity, in gallons per minute (gpm), based on the maximum monthly temperature at the site. The maximum average monthly air temperature in Monterey was 62.4°F for the 1951-1980 period. In consultation with the DHS, the project applicant selected the 60°F curve in the Title 22 Waterworks Standards for calculating the necessary source capacity. This resulted in a requirement of 1 gpm per service connection, which exceeds the maximum day pumping rate requirements estimated from water demand factors in the Comprehensive Hydrological Study (0.93 gpm per service connection for market-rate homes and 0.21 gpm per service connection for inclusionary housing). Thus, the Title 22 Waterworks Standards, which the project will be required to meet, are relatively conservative and should ensure that the source capacity exceeds demand at all times.

In light of the mandated annual inspection of the water system, complemented by conformance with Title 22 Waterworks Standards, specific operating criteria and/or conditions for adding source capacity as a mitigation measure are potentially redundant or in conflict with the mandated provisions of the Health and Safety Code and California Administrative Code. It is expected that conformance with its Water Supply Permit will accomplish this mitigation measure to maintain a water supply equal to or greater than connected water demand at all times.

However, as part of generally accepted practice in water system operation, *the applicant shall monitor* the operating time and pumping water level of all active water supply wells ~~shall be monitored~~ at least weekly during the maximum demand season (June-August) and monthly during the balance of the year. These data shall be reviewed annually to define source capacity versus system demand and to determine whether additional well capacity is needed. The following conditions should be considered indicators that the overall pumping capacity of the well system cannot meet demand within the criteria established by the ranch and that source capacity needs to be increased by adding additional wells or rehabilitating existing wells (if yield has declined because of mineralization or clogging):

- the average operating time during the maximum demand season exceeded 12 hours per day for more than 10% of the active wells,
- more than 10% of the water production during the maximum demand season was from wells operating more than 12 hours per day on average, and
- the average annual operating time throughout the year exceeded 8 hours per day for the active wells.

If a need for additional capacity is indicated by the above criteria, *the applicant shall rehabilitate* existing wells *and/or drill, test, and connect new wells* ~~will be rehabilitated and/or new wells drilled, tested, and connected~~ to the water supply system until the total system yield is sufficient to meet the system yield objective. The yield objective will ensure that the total connected source capacity (with wells operating a maximum of 12 hours per day) equals or exceeds the maximum day water demand for all connected water users at all times. The number of wells required will depend on the actual yields achieved in the new wells and the amount of additional overall yield needed. The yields of new or rehabilitated wells will be measured in conformance with the Title 22 Waterworks Standards (using 72-hour pumping tests similar to those performed for the Comprehensive Hydrological Study). *The yield shall be calculated by multiplying the 24-hour specific capacity by the available drawdown. If the apparent transmissivity decreases between the first 24 hours of the test and the end of the test, the 24-hour specific capacity shall be adjusted by multiplying the ratio of late-time transmissivity to early-time transmissivity. Available drawdown is defined here as two-thirds of the vertical distance from the static water level to the top of the well screen.*

In any year in which a need for additional capacity is identified, the additional capacity will be provided in accordance with the annual review of the Water Supply Permit *by DHS*, which is expected to limit new connections to the water supply system if total system capacity is insufficient to meet demand.

Monitoring of well operating times and pumping water levels during the maximum-season and the requirement to meet the system yield objective will continue as long as the *base flow monitoring program described in mitigation measure "Monitor Base Flow in Creeks and Provide Supplemental Water if Necessary".*~~water supply system remains in operation.~~

Monitoring of operating times and pumping water levels will not incur substantial additional expense and is within the scope of activities considered reasonable and prudent for water system operation and management. The proposed water system design (Luhdorff & Scalmanini Consulting Engineers 1995b) includes telemetered monitoring and control of all wells from a central control station. Operating time and water level are among the variables that will be automatically monitored.

To improve coordination among county agencies involved in overseeing implementation of the project, the applicant shall submit a brief annual report to the Monterey County Division of Environmental Health documenting basic water system operations information monitored under this mitigation measure or developed for the annual review of the water supply permit, including:

- *the operating times and water levels of wells supplying the water system,*
- *daily systemwide water deliveries and monthly delivery summaries by pressure zone,*
- *the results of any well yield tests performed during the year, and*
- *an analysis of whether and how much additional source capacity is needed to meet projected demand for the coming year.*

Impact: Potential Groundwater Overdraft if Water Demand Exceeds Groundwater Supply

If the average annual consumptive use of groundwater by the project exceeds the sustainable yield of the groundwater basin, groundwater overdraft and steadily declining water levels will result.

The long-term and drought reliability of the water supply for the project depend primarily on the groundwater balance, the usable groundwater storage capacity, and the ability of the well network to reach groundwater throughout the ranch. Each of these factors was carefully reviewed and is discussed below. The conclusion reached through this analysis is that the impact is less than significant and no mitigation is required.

Groundwater Balance. The water balance calculations described in the "Setting" section indicated that average annual groundwater recharge is on the order of 5,900 af/yr. Although this estimate is approximate, it is much larger than the average annual consumptive use of groundwater by the project (272 af/yr for the GMPAP part and 295 af/yr at buildout). Thus, it can be safely concluded that recharge is adequate to supply the increase in consumptive use of groundwater.

Conservation of mass dictates that if groundwater storage does not change in the long run, the increase in consumptive use of groundwater for the project must be matched by a corresponding change elsewhere in the water balance. In this case, the change would probably consist of one or more of the following changes in individual flows in the water balance:

- an increase in groundwater recharge resulting from implementation of the Cattle Grazing Plan,
- a decrease in subsurface outflow,
- a decrease in groundwater use by phreatophytes, and
- a decrease in streamflow.

Each of these changes could be associated with environmental impacts, and the changes are discussed individually later in this chapter. However, it is clear that the combination of these changes could provide enough water to meet the consumptive use demand of the project without causing long-term groundwater overdraft.

Usable Groundwater Storage Capacity. Groundwater storage capacity is essential to sustain the project during droughts. Although the average annual groundwater recharge is adequate to supply the project in the long term, recharge during droughts might be less than the project demand. During these periods, the project will have to rely on groundwater storage. Early studies by Blaney et al. (1963) of rainfall recharge in the Coast Ranges near Lompoc demonstrated that rainfall recharge is limited by a threshold level of soil moisture. Deep percolation to the water table is negligible until the soil moisture deficit accumulated in the root zone during the dry season has been fully replenished. A conservative assumption is that there is no groundwater recharge during droughts and that the consumptive water demand must be supplied entirely from groundwater storage. The smallest estimate of usable groundwater storage in the depth interval penetrated by most of the water supply wells is 64,675 af, as described in the section on "Aquifer Characteristics". This volume is sufficient to supply the project demand at buildout for 219 years. Even if the distribution of wells (Figure 8-5) allows access to only about half of the total Rancho San Carlos area during periods of prolonged pumping, the amount of accessible groundwater would still greatly exceed the project's water demand. Thus, there clearly is ample storage to sustain the project during droughts.

Ability of the Well Network to Reach Groundwater. The average annual groundwater recharge and the volume of groundwater storage were calculated for a study area that includes all of Rancho San Carlos and parts of the creek watersheds upstream of the rancho. The total amounts of recharge and storage would not be available to the project unless the project wells are able to draw water from all parts of the study area. However, the total amounts of recharge and storage greatly exceed the amounts needed to ensure a reliable and sustainable water supply for the project. Average annual recharge is 20 times greater than the project's net water demand at buildout, and usable storage is 22 times greater than the amount needed to supply the project throughout a 10-year drought. Thus, the project would theoretically be reliable with access to only 5% of the total aquifer area, which the locations of existing and proposed future wells would clearly provide.

The principal reason for spreading the wells out over a large area is to avoid well interference effects (overlapping cones of depression), which would decrease the well yields. The Comprehensive Hydrological Study described the radius of influence of a pumping well for pumping cycles lasting 0.5-3.0 days. For an average well with a hydraulic conductivity of 0.26 gpd/ft^2, a saturated thickness of 650 feet, and a storativity of 0.01, this radius would be 50-123 feet. The radius of influence would continue to expand as the pumping cycles repeated themselves, however. Cyclic pumping creates drawdown equivalent to the drawdown created by continuous pumping at a lower rate. As long as pumping is effectively continuous, the radius of influence increases at a rate that is independent of the pumping rate. Thus, over a 6-month dry season, the radius of influence of the same well would increase to 960 *feet, assuming it does not reach a source of recharge such as a stream at a closer distance*. Overall, the distribution of the wells appears broad enough to provide adequate and reliable access to groundwater recharge and storage.

Mitigation Measure: No mitigation measures are required.

Impacts on Groundwater Recharge

Several aspects of the project would affect groundwater recharge, including impervious surfaces, septic systems, irrigation, and range management.

Impervious surfaces include roads, rooftops, driveways, and parking lots. Infiltration of rainfall through these surfaces is negligible, and runoff from these areas is typically concentrated in rills and rivulets where infiltration is small relative to the total flow rate. Thus, groundwater recharge from infiltrated rainfall is essentially eliminated in impervious areas. Because the development density for the project is extremely low, however, impervious surfaces would occupy only a small fraction of the total project area. The amount of impervious surface estimated in the drainage initial study (Bestor Engineers 1994) is 173 acres, or only 0.75% of the total project area. Because rainfall infiltration contributes almost all of the groundwater recharge at the site and is strongly dependent on total land area, groundwater recharge would decrease by approximately the same percentage as the percentage of impervious area. This impact is considered too small to substantially decrease groundwater availability, because the estimated available yield greatly exceeds the project water demand. Additional information regarding the effects of impervious surfaces on surface runoff is presented in Chapter 9, "Runoff, Flooding, and Water Quality".

Deep percolation of septic system leachate and applied irrigation water are sources of groundwater recharge. These sources were accounted for as return flows in the consumptive water demand estimates and are not treated here as separate effects.

Impact: Increased Groundwater Recharge through Implementation of the Cattle Grazing Plan

The Cattle Grazing Plan (Sage Associates 1994a) was included in the project design partly because of its hydrologic effects, which would be very beneficial. Numerous studies since the 1940s have documented the effects of grazing on rainfall infiltration and runoff and demonstrated that decreased grazing intensity is associated with increased rainfall infiltration, decreased runoff, and decreased erosion.

The additional water that would infiltrate into the soil would greatly increase the opportunity for groundwater recharge that would offset the effects of groundwater pumping for the project. Some of the additional water that infiltrates into the soil would be transpired by vegetation, but only a small fraction of it would need to percolate to the water table to offset the project water demand. Average annual rainfall on the 8,000 acres of grazed land is approximately 25 inches, so the average annual volume of rainfall on that area is 16,700 af. This is 57 times more water than the project's average annual net water use. Thus, infiltration would have to increase by less than 2% of gross rainfall to increase groundwater recharge by an amount equal to the project water demand. Deep percolation of infiltrated rainfall from the soil zone to the water table would have to increase by less than 5%. The grazing studies reviewed for this EIR are described below, and the results of the studies indicate that an increase of this magnitude or greater is very likely. Therefore, the Cattle Grazing Plan would have a substantial beneficial impact on the groundwater balance that would probably more than offset the long-term effects of project water use on groundwater levels, subsurface outflow, stream base flow, and phreatophytic vegetation.

A key variable in all of the grazing studies was grazing intensity, as measured by the number of animal units per acre. An animal unit equals 1,000 pounds of grazing animal, which could consist, for example, of two steers, a cow-calf pair, one bull, or a number of sheep. Some of the earlier studies (Rhoades et al. 1964, Ravzi and Hanson 1966, Wood and Blackburn 1981) measured the effects of continuous grazing at various intensities. The results of these studies are summarized in Figures 8-6 and 8-7, which show that infiltration is inversely correlated with animal density and runoff is directly correlated with animal density. Most of the studies measured infiltration and runoff during short periods of relatively intense rainfall generated using rainfall simulators. One study (shown in Figure 8-9) found that the relationships were also evident in annual runoff, however. More recent studies (McCalla et al. 1984, Warren et al. 1986, Pluhar et al. 1987, and Takar et al. 1990) have focused on the effects of grazing systems involving rotational grazing at various intensities and frequencies. The results were less consistent but generally indicated that heavy grazing with high animal densities resulted in significantly decreased infiltration regardless of whether it occurred on an intermittent or continuous basis.

Specific factors found to contribute significantly to the changes in infiltration and runoff included soil compaction by trampling, percent vegetative cover, and total above-ground biomass, all of which were directly or inversely correlated with grazing intensity. Range condition was also found to correlate with runoff rates during experiments with intense (4 inches in 30 minutes) simulated rainfall (Knight 1993). Only 2% of the rainfall became runoff on ranges in good condition, whereas 14% and 73% became runoff on ranges in fair and poor condition, respectively.

The effect of potentially greatest significance to this project is the seasonal shift in rainfall runoff, which would manifest itself as a flattening of the flow duration curve. Increasing the infiltration rate decreases the direct runoff rate during rainstorms. Much of the infiltrated water becomes groundwater recharge that later emerges as base flow in nearby creeks. Thus, the effect of grazing management has the double benefit of decreasing floodflows while increasing summer base flow. This is illustrated by observed effects in several small watersheds in the interior Coast Ranges west of Colusa in northern California, where decreased animal densities and rotational grazing were implemented beginning in the early 1990s. The timing and duration of grazing were managed to favor perennial rather than annual grasses, similar to the proposed management objective of the Rancho San Carlos Cattle Grazing Plan. Beginning in 1993, small creeks in the affected watersheds began flowing year round, which had not ever occurred during the previous several decades of intense grazing. Runoff during storms simultaneously decreased. On January 6, 1995, after the first several days of a major storm event, the creeks were barely starting to flow and stock pond impoundments on the creeks were still almost empty. Similar creeks on neighboring ranches were flowing in torrents and the impoundments were spilling (Gilgerd pers. comm.).

Similar changes can be expected at Rancho San Carlos as a result of implementing the Cattle Grazing Plan. Historical grazing intensity was substantially higher than the future intensity proposed under the Cattle Grazing Plan. Prior to 1991, approximately 850 cow-calf pairs were grazed year round and as many as 250 yearlings were brought in from spring to summer (Froke pers. comm.). The corresponding total annual grazing amount was about 892 animal unit-years (au-yr) (assuming 1 animal unit per cow-calf pair and 0.5 animal unit per yearling). The cattle were free to roam throughout the rancho and were sometimes found in remote locations. However, most of the rancho

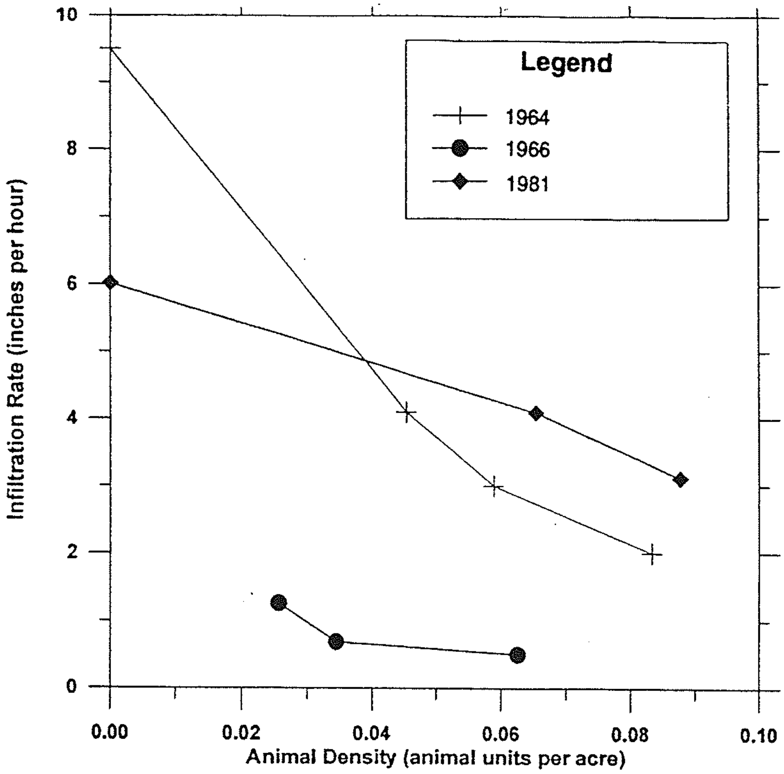


Figure 8-6
Effect of Grazing Intensity on Rainfall Infiltration Rate

Sources: Rhoades et al. 1964, Rauzi and Hanson 1966, Wood and Blackburn 1981.

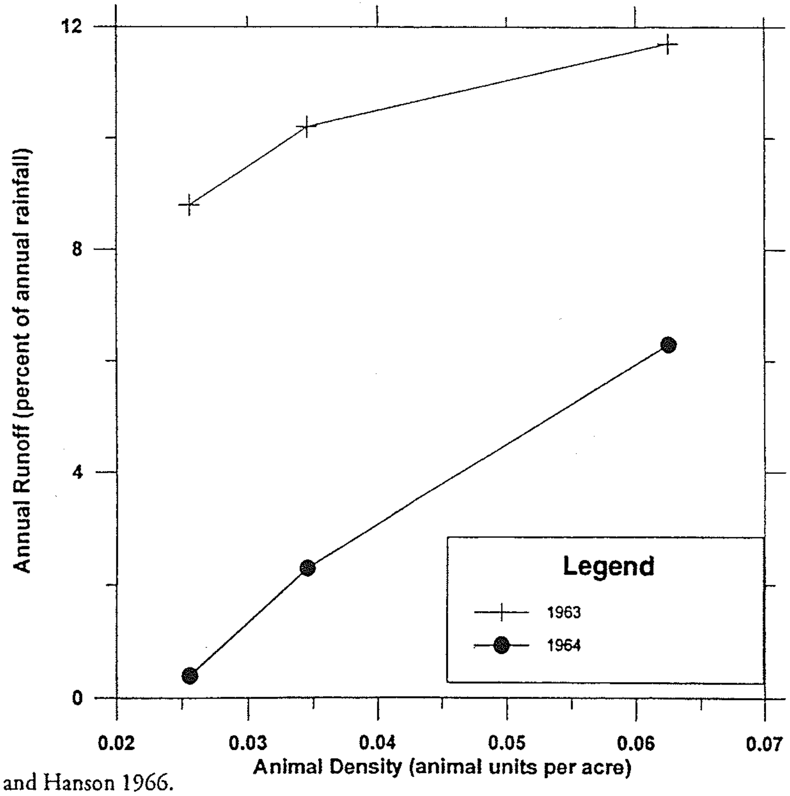


Figure 8-7
Effect of Grazing Intensity on Annual Rainfall Runoff

Source: Rauzi and Hanson 1966.

has steep slopes or is covered with chaparral, redwood forests, and other types of vegetation not particularly attractive to cattle. The most desirable vegetation types for grazing are oak savannahs, ruderal grassland, and coastal terrace prairie, which together occupy 5,100 acres. Cattle also used riparian corridors adjacent to the grassy areas and local open areas within the oak woodlands. It is reasonable to assume that most of the grazing was concentrated on approximately 8,000 acres, or 40% of the rancho area. Evidence of overgrazing, erosion, and vegetation trampling prior to 1991 also indicates that grazing was concentrated in selected areas. The Cattle Grazing Plan indicated that about 6,000 acres are suitable for grazing, and this estimate excluded riparian areas and steep slopes that might have been grazed historically. Assuming historical grazing effectively occurred on 8,000 acres, the grazing intensity was approximately 0.112 au-yr per acre (au-yr/ac).

The Cattle Grazing Plan calls for grazing 500 steers on 2,800 acres for 100 days per year, which corresponds to a grazing intensity of *0.023* ~~0.024~~ au-yr/ac, or one-fifth of the historical rate. Frequent rotation of the herd through a large number of relatively small pastures would also help to ensure grazing uniformity and prevent localized overgrazing. The remaining 5,100 acres formerly grazed would not be grazed at all due to sensitive habitat constraints. The data in ~~8-6~~ indicate that a decrease in grazing intensity from 0.112 to 0.023 au-yr/ac could increase infiltration rates by a factor of 2 to 3, and a decrease to 0.0 au-yr/ac would increase infiltration rates by an even larger factor. The increase in annual infiltration would be smaller because low-intensity rainfall would tend to infiltrate in any case, but the effect would nevertheless be substantial.

Mitigation Measure: No mitigation measures are required.

Impacts on Groundwater Levels

Pumping at project wells will cause groundwater levels to be lower than they would be in the absence of pumping. As described below, the declines are expected to be too small or transient to cause direct adverse impacts on the groundwater system, but they could be large enough to indirectly cause significant adverse impacts on base flow in creeks, subsurface outflow, and riparian vegetation. The water-level impacts described in this section are used in later sections to evaluate impacts on each of those resources. For purposes of discussion, water-level impacts can be divided into localized, short-term cones of depression around individual wells and seasonal and long-term water-level changes over a much broader area.

Impact: Localized Local and Short-Term Water-Level Drawdowns near Pumping Wells

The cone of depression that forms around a pumping well can be described in terms of the maximum drawdown near the well and the radius of influence, which is the farthest distance from the well at which drawdown would theoretically occur. For an average bedrock well (650 feet of saturated thickness, pumping at a rate of 13 gpm in an area with a hydraulic conductivity of 0.26

gpd/ft^2 and storativity of 1%), the drawdown after a 12-hour pumping cycle would decrease from 28 feet at a distance of 10 feet from the well to zero at a radial distances greater than about 100 feet. Drawdown would accumulate during successive pumping cycles, however. The cone of depression created by a well pumping 50% of the time (e.g., 12 hours on followed by 12 hours off) is similar to the cone created by a well pumping continuously at half the rate. If the wells are designed to operate 12 hours per day on the maximum demand day, the average operating time during the peak demand season (May through October) would be approximately 8 hours per day. After 6 months of pumping 8 hours per day, the drawdown created by an average well would decrease from 27 feet near the well to zero at radial distances greater than about 960 feet.

The depth of the cone of depression is directly proportional to pumping rate, whereas the radius of influence is proportional to the duration of pumping and is independent of pumping rate. Under cyclic pumping conditions, the drawdown created by pumping during the "on" cycle continues to propagate outward during the "off" cycle. If hydraulic conductivity is not uniform in all directions (i.e., the aquifer is anisotropic), the cone of depression will spread farther in some directions than others. However, limited test data did not reveal any indications of anisotropy.

The localized, short-term drawdowns around pumping wells would not cause any adverse impact on the groundwater system itself, such as subsidence or water quality degradation. However, indirect impacts of the drawdowns on stream base flow and riparian vegetation are considered potentially significant, as discussed later in this chapter.

Mitigation Measure: No mitigation measures are required for direct impacts. See "Impacts on Base Flow in Creeks" and "Impacts on Riparian Vegetation and Wetlands" for mitigation measures for indirect impacts.

Impact: Long-Term Decreases in Groundwater Levels

Pumping at project wells would result in lower groundwater levels than would be present without the project. The amount of decline is difficult to quantify with available information. Although the decline is not expected to be large, it could cause adverse impacts on base flow in streams, subsurface outflow, and phreatophyte transpiration, which are discussed later in this chapter.

Over prolonged periods of pumping, such as during the dry season or a multiyear drought, the cones of depression from neighboring wells will tend to coalesce, forming a broader area of more uniform drawdown. The cone of depression calculations and the distribution of wells on the rancho (Figure 8-5) suggest that wells might noticeably affect regional water levels in about half of the total rancho area. The average water-level decline in this area after 1 year (in the absence of rainfall recharge but including return flows) can be estimated by dividing the annual consumptive use of groundwater (272 af for the GMPAP development and 295 af at buildout) by the affected area (9,950 acres) and the aquifer storativity (0.01). This results in an annual water-level decline of 2.7-3.0 feet. This change is moderately small compared to natural seasonal water-level fluctuations that typically average about 8 feet. It is also similar to the estimate (2 feet) developed in the Comprehensive Hydrological Study using gross pumpage (400 af/yr) and the total rancho area (19,900 acres).

Groundwater levels would not continue to progressively decline in the long term. Seasonal water-level declines during the dry season would become larger, but in most years water levels would recover to near existing levels the following winter. During droughts, there may be net water-level declines over periods of several years, but these levels would recover during wet periods. Groundwater levels would not progressively decline because each additional increment of decline would tend to intercept an additional amount of groundwater that would have left the groundwater system by some other path (subsurface outflow, stream base flow, or phreatophyte transpiration). Thus, water levels would cease declining when the intercepted outflow balances the net consumptive use of the project. Under this new balance, water levels will be lower on average than under existing conditions. The amount of decline is difficult to estimate, but it would be largest under ridges and least near creeks.

If the Cattle Grazing Plan results in increased groundwater recharge, as expected, average water levels would decline less than they would without the plan and might actually rise.

The long-term lowering of groundwater levels throughout much of Rancho San Carlos would not cause any adverse impact on the groundwater system, such as subsidence or water quality degradation. However, indirect impacts on stream base flow and riparian vegetation are considered potentially significant, as discussed later in this chapter.

Mitigation Measure: No mitigation measures are required for impacts on the groundwater system. Refer to "Impacts on Base Flow in Creeks" and "Impacts on Riparian Vegetation and Wetlands" for mitigation measures for indirect impacts on those resources.

Impacts on Base Flow in Creeks

Base flow in creeks is sustained by gradual draining of groundwater from beneath the surrounding watershed drainage area. Discharge to creeks is the path of least resistance for most groundwater outflow. The groundwater contour map (Figure 8-3) confirms that flow from most of the rancho area is toward the nearest creek rather than toward an offsite area.

Figure 8-8 shows the profile of groundwater levels along hydrogeologic section A-A' across Potrero Canyon (see Figure 8-1 for section location) and illustrates how the creeks serve to drain the groundwater mounds that form beneath the intervening ridges. This draining action prevents nearby groundwater levels from rising substantially above the level of the creek. Figure 8-9 shows the profile of groundwater levels along the length of Potrero Canyon (section B-B') and also illustrates how the groundwater level coincides with the level of the creekbed along the reach *where* ~~of persistent~~ base flow *was observed in August 1991*. Toward the upper end of the creek, the groundwater level rises

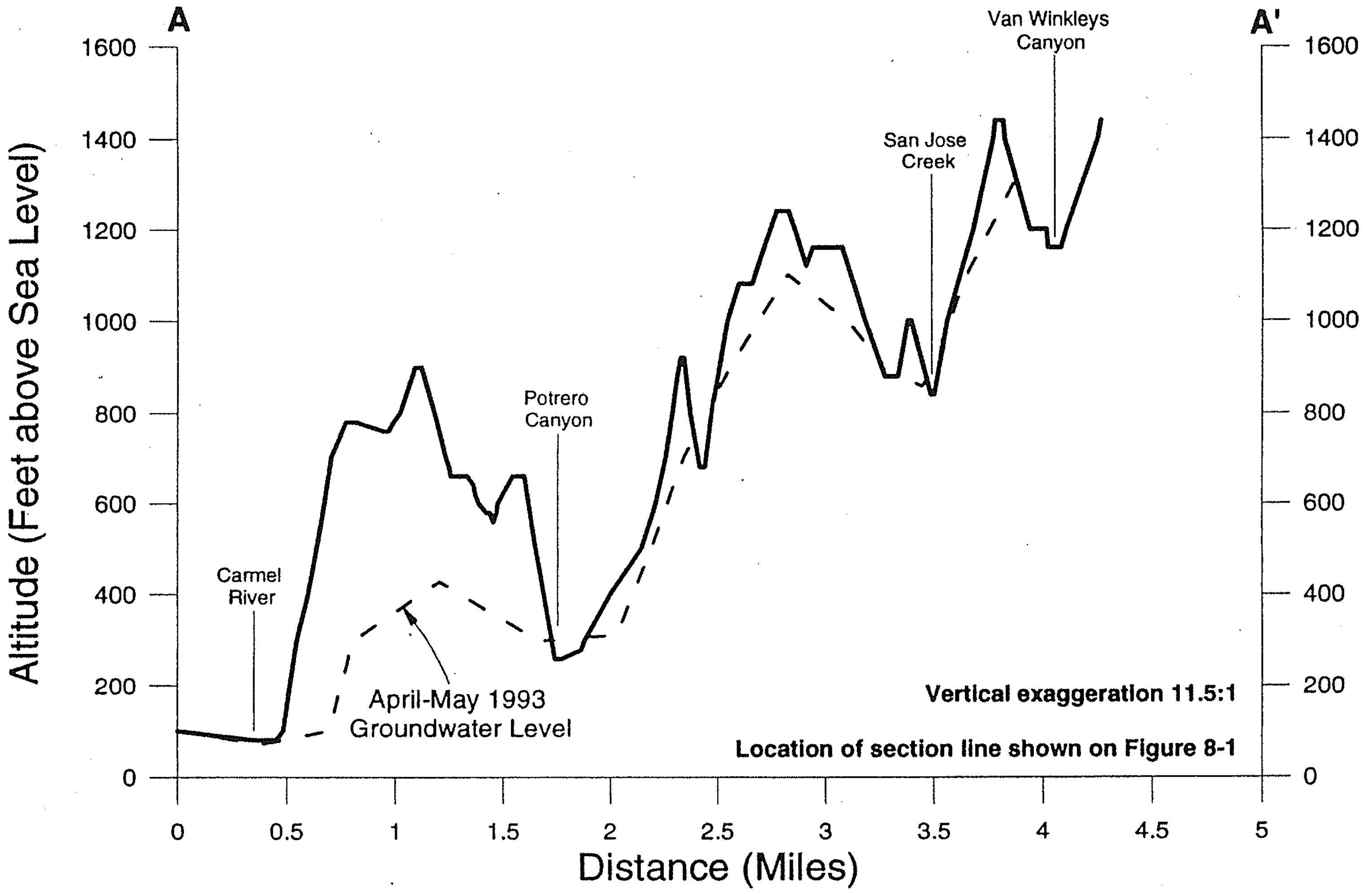


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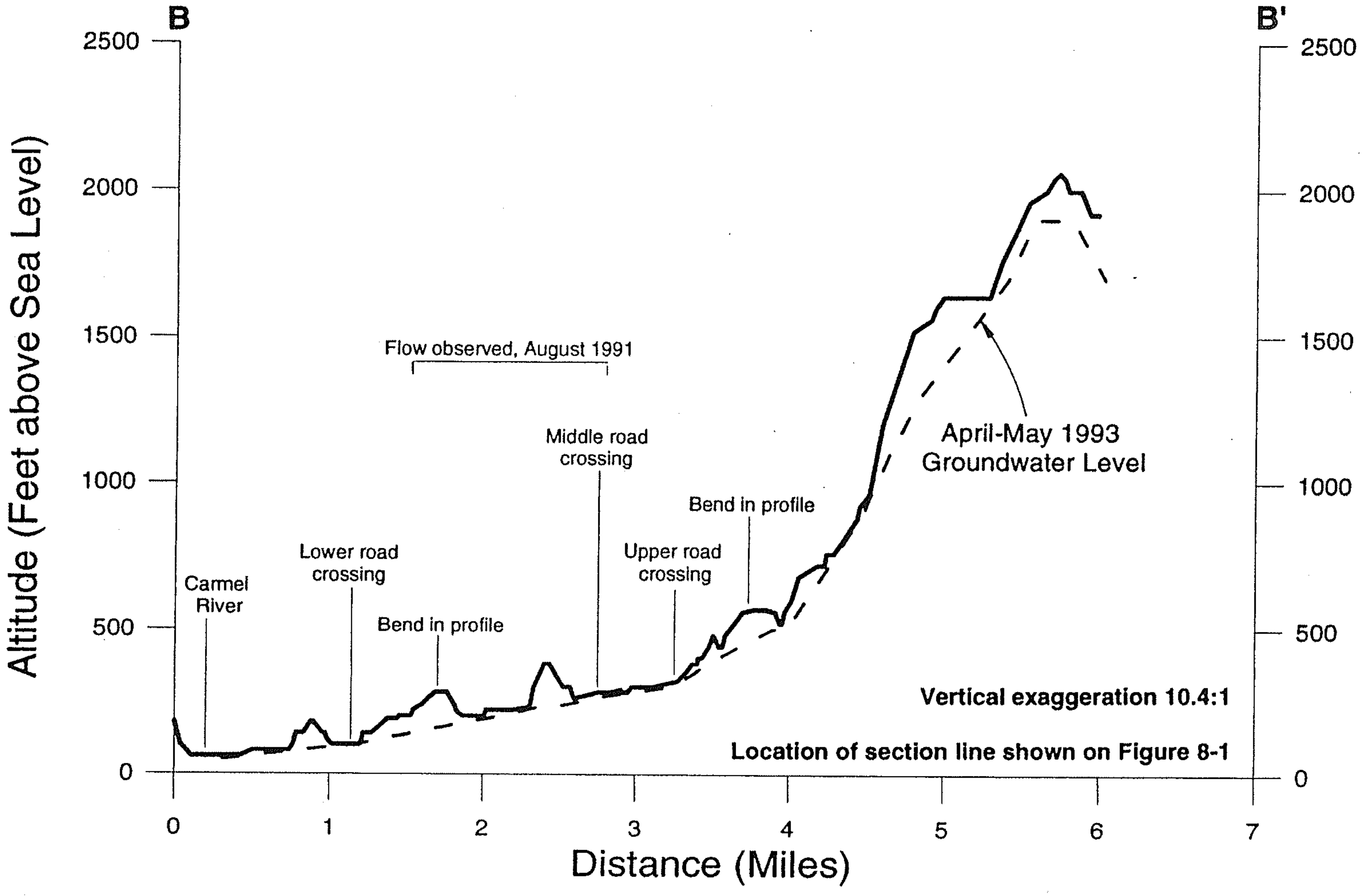
Figure 8-8
Profile of Land Surface Altitudes and Groundwater Levels
along Hydrogeologic Section A-A' across Potrero Canyon



Vertical exaggeration 10.4:1

Location of section line shown on Figure 8-1

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Figure 8-9
Profile of Land Surface Altitudes and Groundwater Levels along Hydrogeologic Section B-B' along the Length of Potrero Canyon

more gradually than the level of the creekbed, creating an unsaturated zone beneath the creekbed and an absence of base flow in the creek. The groundwater level also drops below the creekbed where the creek enters the Carmel Valley. The regional water table in the Carmel Valley is lower than the level of the Potrero Canyon creekbed. Base flow in the creek percolates entirely into the alluvium and becomes groundwater recharge. Figure 8-9 indicates the reach of Potrero Canyon where live flow was observed in August 1991. The groundwater profile shown on the figure is for April-May 1993, when water levels were probably higher than in 1991 and the *reach with live* base flow ~~reach~~ was probably longer.

Base flow is greatest during wet years, when recharge is relatively large and groundwater levels away from the creek are relatively high. Thus, during wet periods, the slope of the water table toward the creek increases and the rate of seepage into the creek consequently also increases. Because of the size of the watersheds and the relatively low permeability of the fractured bedrock aquifer, the seepage process is gradual and base flow fluctuates less than direct rainfall runoff.

The total volume of groundwater stored in areas of high water levels beneath the ridges is large enough to sustain small amounts of base flow in the creeks for periods of months or even years. For example, pools and reaches of continuous or partially continuous flow were surveyed in San Jose and Las Garzas Creeks and Potrero Canyon in August 1991. Flows of 9-14 gpm were found at all observed sites along a 2-mile reach of San Jose Creek above Van Winkley's Creek (Balance Hydrologics 1991c). Largely continuous flows of up to 15 cfs were found along a 1.6-mile reach of Potrero Canyon beginning near the upper road crossing (Balance Hydrologics 1991b). Pools and short segments of flow of up to 2.3 gpm were found along Las Garzas Creek beginning at about the 600-foot elevation and extending about 1.7 miles downstream, where the water eventually percolated into the Carmel Valley alluvium (Balance Hydrologics 1991a).

Although the large volume of groundwater storage provides a moderately steady supply of water for base flow, base flow during the dry season does vary from year to year depending on the amount of rainfall received during the preceding winter. Streamflow records during 1989-1993 for the gages on Las Garzas, San Clemente, and San Jose Creeks and Potrero Canyon indicate that base flow during summer and fall 1993 was higher *than* during 1989-1992 because of substantially greater rainfall in 1993. Total discharge for the four gages combined during May-October ranged from about 24 af in 1989 to more than 700 af in 1993, and the variations generally matched rainfall variations. These flows should be considered approximate because the streamflow record includes months with missing or estimated data. The year-to-year variations in base flow are confirmed by a comparison of the August 1991 flow conditions in Las Garzas Creek with flow conditions observed the previous October. October 1990 was the end of the dry season in the fourth consecutive year of below-normal rainfall and runoff. The length of the wetted reach was about 0.5 mile shorter than in August 1991, the flow was smaller by up to 2 gpm, and the overall wetted area was substantially smaller (Balance Hydrologics 1990).

Pumping at project wells could affect base flow in creeks by intercepting groundwater that would have discharged into the creeks or by inducing seepage out of the creeks. For discussion purposes, these impacts will be separated into localized short-term impacts near pumping wells and regional long-term impacts caused by changes in the groundwater balance.

The impact discussion in this section is directed toward impacts on aquatic organisms dependent on base flow in the creeks. Decreased base flow can also affect the water supply in downstream areas such as the Carmel Valley. This impact is discussed in the section "Impacts on Subsurface Outflow". The water-level declines that affect base flow could also affect riparian vegetation. This impact is described in the section "Impacts on Riparian Vegetation and Wetlands".

Impact: Induced Seepage Losses from Creeks and Substantial Depletion of Dry-Season Base Flow

The potential for wells near creeks to induce seepage losses was tested during three of the 30-day pumping tests described earlier in the "Aquifer Characteristics" section. All of the wells were within 250 feet of a creek reach with *continuous live* ~~sustained summer base~~ flow, and the tests were performed in summer. Streamflow was gaged near the pumping well and at a control point upstream of the pumping well before, during, and after the tests. At two locations (wells T-14 and T-26), the Comprehensive Hydrological Study concluded that there was no observable depletion of streamflow caused by the well. In contrast, streamflow at the third location (well T-11) appeared to be diminished by an amount approximately equal to the well discharge. Water quality measurements of the creek and well did not detect an obvious contribution of creek water to the well discharge. Also, the rate of drawdown at the wells did not noticeably decrease, which would be expected if the cone of depression had intercepted a surface water body such as a stream.

These tests appear to indicate that pumping at wells near creeks does not drastically deplete streamflow, at least in most locations. However, whether the effect of pumping could have been accurately detected at wells T-26 and T-14 is questionable for the following reasons:

- Summer base flow was fairly high during the test because of above-average rainfall during the preceding winter (1993). The pumping rate at the wells (5-15 gpm) was less than 7% of the streamflow rate at the start of the test (229 gpm). Thus, the effect of the pumping could have been too small to measure using stage-discharge relations in natural channels.

- ~~Even with a perfectly known stage-discharge curve, the water-level recorder used to monitor changes in flow might not have been precise enough to detect changes caused by pumping. For example, the 15-gpm depletion in flow reportedly detected at well T-11 corresponded to a change in water level at the staff gage of less than 0.02 feet.~~

- Streamflow decreased substantially due to natural base flow recession during the course of the test, possibly masking the effects of the pumping. Streamflow at the control stations decreased by 157 gpm (55%) at the control gage for well T-14 and by 198 gpm

(94%) at the control gage for well T-26. These changes are large compared to both the original flow rate and the well pumping rates.

Further evidence of a hydraulic connection between certain wells and nearby creeks is apparent in the water-level hydrographs presented in Appendix F of the Comprehensive Hydrological Study. Wells that have a close hydraulic connection to a nearby creek exhibit different seasonal drawdown and recovery patterns than wells that are relatively isolated from creeks. Seasonal water-level fluctuations at isolated wells reflect seasonal variations in rainfall recharge, and the water-level fluctuations follow a smooth, sinusoidal pattern created by alternating wet and dry seasons. The hydrograph for well S-4, which is not located near a creek, illustrates this pattern. In contrast, water levels in wells near creeks often recover abruptly when streamflow commences in winter, and the recovery ceases equally abruptly at a water level close to that of the creek level. Wells S-1, T-20, T-26, E-5, and S-2 are near creeks and their hydrographs demonstrate this pattern (note that the latter two wells would not be part of the water supply system, however). Still other wells are located near creeks and their water levels remain at the level of the creek all or most of the time, which probably indicates that groundwater at the well is discharging into the creek. The hydrographs for wells S-3, T-11, and T-14 illustrate this pattern. If the hydraulic connection between a well and a creek is such that flow in the creek can affect the water level in the well, then pumping at the well can affect flow in the creek.

The combined pumping rate of project wells in summer also substantially exceeds the combined base flow rate of springs and creeks on Rancho San Carlos. The combined flow rate of springs and base flow in creeks at Rancho San Carlos during summer was estimated in the Comprehensive Hydrological Study to be 70-100 gpm in normal years and 40-60 gpm in dry years. In comparison, the effective combined pumping rate of the project water supply wells at buildout (operating as planned in 12-hour pumping cycles) is approximately 247 gpm, or two to six times larger than the total base flow rate. Some of the dry season pumping effects will be absorbed by local groundwater storage declines near the well, but wells close to base flow reaches will probably deplete base flow. The effects of pumping on base flow cannot be deferred entirely from summer to winter, as explained later in this chapter under "Impact: Decreased Long-Term or Drought-Period Base Flow in Creeks".

The biological resources dependent on base flow in the creeks are relatively scarce and include special-status species (steelhead and red-legged frogs). Aquatic habitat availability is at a minimum during the dry season and thus could limit the populations of these dependent organisms. A more complete discussion of biological resources can be found in Chapter 10, "Fisheries", and Chapter 11, "Biological Resources".

The Cattle Grazing Plan is expected to result in increased groundwater recharge and increased base flow that will fully mitigate most of the potential impact of groundwater pumping. However, given the uncertainty regarding both the magnitude of the effect of grazing and the results of the 30-day stream-aquifer tests, the evidence in the hydrographs of hydraulic connection between wells and streams, the large magnitude of project pumpage relative to base flow, and the high value of the biological resources at risk, the potential effect of groundwater pumping on base flow and aquatic organisms is considered significant. To reduce this impact to a less-than-significant level, the following mitigation measures should be implemented.

Additional Mitigation Measure *13*: Monitor Groundwater Levels. The project applicant shall monitor groundwater levels in all of the project water supply wells at least *monthly* ~~quarterly~~. Wellhead (measuring point) elevations shall be surveyed at all wells so that water levels can be reported as elevation above sea level. The applicant *shall produce an annual report containing the results of the precipitation, streamflow, and groundwater production monitoring and* shall plot water-level hydrographs and evaluate the data for trends at least every 3 years. All data, hydrography, and interpretive reports shall be available to local agencies and the public. This monitoring program shall continue *at least as long as the base flow monitoring program described in the mitigation measure "Monitor Base Flow in Creeks and Supply Supplemental Water if Necessary" in Chapter 8, "Groundwater Hydrology, Stream Base Flow, and Water Supply and Demand"*. ~~in perpetuity.~~

The most recent description of the water system design (Luhdorff & Scalmanini Consulting Engineers 1995b) indicates that all wells would be connected by telemetry to a central control office and that static and pumping water levels would be monitored and included in the telemetered data. This mitigation measure is included simply to ensure that the monitoring is implemented and the results made available to interested parties.

Applicant's Proposed/Additional Mitigation Measure *14*: Delay Pumping at Wells near *Protected* Base Flow Reaches. Existing wells located within 1,000 feet of a protected base flow reach (as defined later in this chapter under "Additional Mitigation Measure: Monitor Base Flow in Creeks and Provide Supplemental Water if Necessary") shall be used only when the combined capacity of other wells connected to the water supply system is insufficient to meet project demand. The radius of influence after 6 months of pumping at an average well in a location with average aquifer characteristics is approximately 1,000 feet. This measure will largely avoid the relatively large but localized impacts caused by drawdown in the immediate vicinity of wells close to the creeks. It will not prevent long-term effects associated with regional water-level declines (described below), but it will maximize the extent to which those declines are absorbed by storage depletions away from the creeks during the dry season and the extent to which impacts on streamflow are deferred until the wet season.

This mitigation measure is similar to mitigation measure HYD-1 in the Mitigation and Monitoring Plan (Denise Duffy & Associates 1994), which requires that the direct effects of pumping shall be limited to small distances (i.e., from less than 50 feet to about 250 feet) for planned pumping cycles. This mitigation measure described above also addresses the cumulative drawdown after numerous pumping cycles during the dry season.

Applicant's Proposed/Additional Mitigation Measure *15*: Drill New Wells Away from Base Flow Reaches. New wells shall be located at least 1,000 feet away from protected base flow reaches (as defined later in this chapter under "Additional Mitigation Measure: Monitor Base Flow in Creeks and Provide Supplemental Water if Necessary"). This mitigation measure will further protect these reaches from flow depletions caused by relatively large seasonal drawdowns around project supply wells.

This mitigation measure is similar to mitigation measure HYD-2 in the Mitigation and Monitoring Plan (Denise Duffy & Associates 1994), which requires that future water supply wells be located sufficiently distant from streams or where the water table is sufficiently far below the streambed to avoid direct water-level impacts that could induce infiltration. As described below, it is probably not possible to avoid induced infiltration entirely. This mitigation measure described above also is designed to minimize it in a realistic and feasible manner.

This mitigation measure would not substantially decrease the area available for drilling new wells. Assuming the protected base flow reaches along Potrero Canyon, and San Clemente and San Jose Creeks (the base flow reach on Las Garzas Creek is outside Rancho San Carlos) are each approximately 2 miles long, the area of exclusion for new wells is only 1,455 ac, or 7% of the Rancho San Carlos area.

New wells may be installed less than 1,000 feet from a protected base flow reach. However, pumping at these wells during the dry season shall be limited to avoid adverse impacts on nearby riparian vegetation or flow in the protected base flow reach. Specifically, pumping shall be limited so that drawdown calculated using measured transmissivity at the well and the average pumping rate since April 1 does not exceed 2 feet in any nearby riparian vegetation area or 1 foot at any point along the protected base flow reach at any time.

Impact: Decreased Long-Term or Drought-Period Base Flow in Creeks

In addition to the localized effects of individual wells on streamflow, the overall effect of pumping at all wells could be a general lowering of groundwater levels that would tend to decrease the rate of groundwater seepage into creeks on a long-term basis. The Comprehensive Hydrological Study asserts that groundwater pumpage during the dry season will come principally from storage rather than from a depletion of streamflow, and that the storage deficits will be replenished during wet periods, when most recharge is occurring. In other words, the effects on streamflow of pumping would occur primarily during the winter streamflow season when water is abundant and biological effects would consequently be negligible. However, the mechanism by which pumping effects could be deferred from the dry season to the wet season is unclear.

For summer storage depletions to induce additional recharge in winter, winter water levels would have to be lowered near the base flow reaches where groundwater is hydraulically coupled to surface water. Groundwater pumping would not increase the amount of rainfall recharge or the amount of streamflow percolation upstream of the base flow reaches because there is no hydraulic coupling at those locations. The only ways to induce additional recharge from the creek during the winter streamflow season are to pump groundwater in winter or to begin the season with lower groundwater levels. The immediate effects of pumping in winter are considered less than significant because they would constitute a much smaller fraction of total flow and because they would probably not decrease streamflow to levels that would limit populations of natural organisms more than they are limited by low flows in summer.

Summer pumping would not increase the capacity for groundwater storage near the creek in winter. It would simply vacate some of the existing storage capacity. The creek fills groundwater storage to a point at which the percolation rate out of the creek is balanced by increased groundwater discharge into the creek along reaches farther downstream. In other words, additional recharge is rejected. This balance is determined by the percolation rate and aquifer characteristics, neither of which is affected by summer pumping. Thus, the only way for summer pumping to induce a greater volume of stream recharge in winter is to draw down water levels near the creek during the dry season. However, any such drawdowns would also deplete base flow during the dry season and could adversely affect aquatic biota.

The effects of pumping on streamflow are likely to be distributed fairly uniformly throughout the year, especially if pumpage is concentrated in areas away from the creeks (as the preceding mitigation measure recommends). Groundwater pumpage will be greater in summer than in winter because the irrigation component of water demand occurs only in summer. This seasonal fluctuation will not be extreme, however, because the indoor component of water use (about 45% of total water use after allowing for irrigation with reclaimed water) is essentially constant year round. The seasonal variations in drawdown near creeks will be more uniform than the variations in pumpage because the cones of depression created by individual wells will tend to overlap by the time they reach the creek and because the drawdown propagates slowly. Consequently, the effects of individual wells are attenuated and out of phase with one another when they reach the creek.

The average annual groundwater pumping rate for the GMPAP part of the project would be 219 gpm (354 af/yr). At buildout, average annual pumping would be 234 gpm (377 af/yr). Relatively small fractions of this total would be derived from decreases in subsurface outflow and phreatophyte transpiration (discussed below). Assuming no increase in groundwater recharge, the remainder would be derived from depletions in streamflow, approximately half of which would occur during the dry season. Even allowing for considerable uncertainty in the estimates of these flows, the long-term average amount of streamflow depletion in summer would probably be large relative to the total amount of streamflow (70-100 gpm in normal years and 40-60 gpm in dry years). These depletions would substantially decrease available aquatic habitat during the season when it is most limited. Consequently, the chronic effect of groundwater pumping on base flow in summer is considered a significant impact.

The Cattle Grazing Plan is expected to result in increased groundwater recharge and increased base flow that will fully mitigate most of the potential effects of groundwater pumping on aquatic habitat. Mitigation measures discussed in Chapter 9, "Runoff, Flooding, and Water Quality", relating to runoff and protection of water quality will minimize water quality degradation that could be especially harmful at low flows. However, given the uncertainty regarding the magnitude of the grazing effect and the high value of the biological resources at risk, monitoring and implementation of additional mitigation measures on a contingency basis to provide a safety net for the aquatic habitat is appropriate. This impact is considered significant. Implementation of the mitigation measure described below would reduce this impact to a less-than-significant level by providing a minimum level of protection for aquatic biological resources.

Additional Mitigation Measure *16*: Monitor Base Flow in Creeks and Provide Supplemental Water if Necessary. The project applicant shall measure and record daily flows in Potrero Canyon and Las Garzas and San Clemente Creeks at locations near the boundary of Rancho San Carlos. This essentially amounts to a continuation of the stream gaging program that has been in place on those creeks during the last several years. If MCWRA or MPWMD chooses to operate gages in similar locations on the creeks, records from those gages may be used instead of operating duplicate gages. San Jose Creek is not included in the gaging program because of the relatively large influence of land management activities in tributaries outside Rancho San Carlos; relatively large amounts of streambed sediment that make accurate measurement of low flows difficult; and the overriding effects on fisheries of natural barriers, landslides, and an unladdered dam downstream of Rancho San Carlos.

The project applicant shall conduct an annual survey of pools and base flow conditions in the gaged creeks and San Jose Creek for the same period of time as the stream gaging. The survey shall be conducted in September each year. The surveys should be similar to those done in 1990 and 1991. It is recommended that temperature and electrical conductivity also be measured at various locations *along the reach that has flow at the time of the survey.* ~~along each base flow reach.~~ The temperature and electrical conductivity should be measured at the same locations and approximately the same time of day each year. The surveyed reaches should include any reaches with pools or low flow down to the Rancho San Carlos property line on Potrero Canyon and San Clemente and San Jose Creeks and down to the end of pools or live flow in Las Garzas Creek (which point is usually on the Carmel Valley floor).

Periodically (at least every 5 years), the applicant shall prepare a report evaluating trends in base flow conditions and relationships between base flow in each creek and rainfall during the preceding winter, base flow in the other creeks, project pumpage, groundwater levels, and other project-related factors such as grazing that appear likely to affect base flow. Trends in base flow at MPWMD gage on lower Las Garzas Creek should also be similarly evaluated. It is also recommended that temperature and electrical conductivity data be evaluated for trends and for potential effects on resident fish species. The report shall be submitted to MCWRA, MPWMD, and DFG.

The analysis of the data shall be directed toward detecting and quantifying effects of the project on base flow in the creeks. Effects may be detected by changes in regression relationships among variables. For example, streamflow data for the Las Garzas Creek gage near the Carmel Valley during 1969-1978 could be used to characterize relationships between wet-season precipitation and total discharge during the following dry season. If the project substantially affects groundwater recharge or discharge processes, this relationship would probably be affected and could be detected by a statistical comparison of regression slopes. Another method for detecting the effects of the project would be to compare dry-season discharge in creeks on Rancho San Carlos with dry-season discharge in an undeveloped nearby watershed such as Pine Creek. Pine Creek is in the upper Carmel River watershed, and its drainage area is expected to remain undeveloped for the foreseeable future. MPWMD has operated a gaging station on Pine Creek since about 1992 (Oliver pers. comm.). Double-mass plots of dry-season discharge in Pine Creek versus dry-season discharge in each of the Rancho San Carlos creeks would reveal any significant changes in base flow conditions related to development on Rancho San Carlos. Both of these methods accommodate annual variations in base flow related to annual variations in precipitation. Obviously, natural factors such as fire and disease-related changes in vegetation type could also affect base flow conditions in any of the creeks. These factors would have to be evaluated on a case-by-case basis to distinguish effects caused by the project from effects caused by natural factors.

Using the documented base flow observations from 1990, 1991, and more recent surveys, the project applicant shall estimate the reach of each of the four creeks that contained pools or base flow in October 1990. For Potrero Canyon and San Clemente and San Jose Creeks, stream segments downstream of the Rancho San Carlos property line may be ignored and need not be included in the defined base flow reaches. For Las Garzas Creek, the base flow reach is the wetted reach documented in the report from the 1990 survey (Balance Hydrologics 1990). These reaches are referred to in this EIR as protected base flow reaches. *Approximate locations of the protected base flow reaches are shown in Figure 8-4a.*

Base flow conditions in October 1990 were selected to define the protected base flow reaches because they were at the end of the dry season after 4 years of drought and consequently represent the lowest flows that the aquatic habitat would probably have to endure in a 20- to 50-year period. These flows are used here to represent the minimum-flow management objective. That is, the objective of this mitigation measure is to prevent base flows from decreasing below the October 1990 level except possibly under more extreme and rare droughts than the 1987-1990 period.

During dry years when winter rainfall and spring and summer streamflow data indicate that base flow could decline below the October 1990 levels by the end of the dry season, the applicant shall monitor base flow conditions at least monthly beginning in July and continuing until surface runoff resumes the following winter.

If base flow in any of the four creeks drops below the October 1990 level as a result of the project, the applicant shall supplement flow by discharging water into the creek near the upstream end of the protected base flow reach. The rate of discharge should be great enough to sustain pools and base flow approximately equal to conditions in October 1990. The maximum required combined discharge for all four creeks is 30 gpm at the points where the discharged water reaches the protected base flow reaches. If this maximum amount is insufficient to maintain the objective of the creeks, it may be allocated among the creeks in whatever proportion maximizes the overall benefits for aquatic habitat.

The applicant shall use information from the base flow monitoring and analysis reports to determine whether the decline in base flow is from natural or project-related causes. If the project appears to have caused a substantial (20% or more) proportion of the decline, flow augmentation is required. For smaller proportions, augmentation is optional.

The maximum flow augmentation rate was chosen for two reasons. First, it approximately equals the sum of the summer base flows observed in the creeks in the late summer of 1990 and thus would be sufficient to substantially increase the flow under extreme low flow conditions. Second, it represents a reasonably small fraction (about 6%) of the total pumping capacity of the community water system and is therefore considered feasible for water supply and conveyance purposes.

If the total groundwater pumping rate is increased by 30 gpm to meet the streamflow augmentation requirement, groundwater levels would decline even farther and tend to further deplete flow in the base flow reaches. Because of the low aquifer permeability and fairly large distance of the wells from the creeks, the effect of increased seepage would be gradual and spread out over a long period (probably years). The direct discharge to the creeks would greatly exceed the increase in seepage loss for the duration of the dry season, and thus the net effect of pumping groundwater into the creeks would still be substantially beneficial.

The source of the supplemental water may be well water from the community supply system, releases from Moore's Lake or other impoundments, or reclaimed water treated through soil percolation or other means to a quality that would not adversely affect aquatic biota.

Hitchcock Canyon and Robinson Creek are not included in the monitoring and mitigation program because those watersheds appear to be too small and steep to generate prolonged base flow ~~capable of supporting a fishery~~. *Because* ~~because~~ of their locations, those watersheds would probably be less affected by the project than the four larger watersheds.

The stream gaging and flow augmentation program shall continue for a period of at least 20 years. Beyond that time, the applicant may submit a request to MCWRA that the program be discontinued if the following conditions are met:

- The project water demand has been fully developed and at a stable level for at least 5 years.
- Analysis of the streamflow data indicates that summer base flow has remained the same or has increased relative to existing conditions as a result of watershed management practices associated with the project, such as the Cattle Grazing Plan.

Otherwise, the stream gaging and flow augmentation program shall continue in perpetuity.

Impacts on Subsurface Outflow

Impact: Minor Reduction in Subsurface Outflow

In the Comprehensive Hydrological Study, the effect of the project on subsurface outflow was estimated by assuming the water level at the upgradient (rancho) end of the flow path would be lower by an average of 2 feet. This water-level decline was shown to be minuscule compared to the overall water-level drop along the flow path (1,500 feet upstream of the Narrows and 1,700 feet downstream of the Narrows). The calculated decrease in annual outflow was 5 af, or 0.2%.

The calculations were revised for this analysis to omit areas where groundwater probably discharges to local creeks rather than as subsurface outflow directly to the Carmel Valley. Revised areas of subsurface outflow were used, as described previously under "Water Balance" of the "Setting" section.

The Santa Lucia Preserve project would decrease the average annual rate of subsurface outflow from Rancho San Carlos by generally decreasing water levels at the upgradient end of the flow paths. As discussed above in the section "Impacts on Groundwater Levels", the project could cause a general lowering of water levels of as much as 3 feet/yr, but the declines would not accumulate indefinitely. Water levels would equilibrate at a new average annual level at which decreases in head-dependent outflows (stream base flow, subsurface outflow, and phreatophyte transpiration) equal the increase in annual consumptive use of groundwater by the project. Water levels, of course, would continue to fluctuate about this level from year to year in response to annual variations in recharge and pumping. Although the equilibrium level is difficult to estimate with certainty, it can be shown that the change in subsurface outflow would be small in any case. For illustration purposes, a "worst case" set of assumptions might be that the long-term average water-level decline in the upland areas where most of the project wells are located is 20 feet relative to existing levels, that an additional decline of 12 feet accumulates during a 4-year drought, and that water levels in the Carmel Valley groundwater basin decline by only 10 feet during the drought. The overall effect of these declines at both ends of the flow paths would be a decrease in annual subsurface outflow of 17 af, or 1.3%. This is considered a worst-case estimate because the transient water-level declines at the upgradient end of the flow paths would be substantially attenuated by the time their effects reached the boundary of the Carmel Valley alluvium and because cumulative drawdown in the alluvium would probably exceed 10 feet during a 4-year drought.

The outflow calculations were tested for sensitivity to errors in the estimated hydraulic conductivity The calculated outflow is directly proportional to the hydraulic conductivity value. For example, the Comprehensive Hydrological Study reported that 85% of the measured hydraulic conductivity values for bedrock were between 0.02 and 2.0 gpd/ft^2. Inserting this range of values into the subsurface outflow equations yields a range of 100-10,000 af/yr. The actual average hydraulic conductivity is unlikely to be outside this range of values. The estimated change in outflow resulting from the project is also directly proportional to the estimated hydraulic conductivity because it is calculated as the difference of two outflow estimates. Thus, it is very unlikely that the actual change in outflow would be less than 1.3 af/yr or more than 130 af/yr.

The original outflow calculations used a flow equation appropriate for unconfined flow conditions. This assumption implied an effective flow depth of 1,800 feet at the upgradient ends of the prismatic flow tubes. Because permeability decreases with depth, it might be more realistic to conceptualize the subsurface outflow process as consisting of a sloping slab of porous medium of constant thickness. In this case, a linear flow equation can be used (such as the equation for flow in confined aquifers). The sensitivity of the original outflow calculations to the assumption of unconfined flow was tested by repeating the equations with an equation for confined aquifers and assuming a constant flow thickness of 800 feet. The resulting estimate of total subsurface outflow was within 1% of the original estimate. Thus, this assumption does not significantly affect the estimate in this case.

The project would result in a very minor reduction in subsurface outflow. This impact is considered less than significant because it would not substantially decrease the availability of groundwater to existing users.

Mitigation Measure: No mitigation measures are required.

Impacts on Riparian Vegetation and Wetlands

Riparian habitat is scarce in California and in many areas has diminished to only a small fraction of its extent under predevelopment conditions (prior to about 1850). Riparian vegetation occupies 8% of the total area of Rancho San Carlos and includes some of the southernmost stands of coast redwoods. Riparian vegetation is considered excellent wildlife habitat and often supports a relatively large diversity of wildlife. It also creates shade that maintains cool stream temperatures for aquatic organisms. Because of its relatively high habitat value and limited areal extent, a decrease of more than 5% in the total area of riparian vegetation on Rancho San Carlos is considered a significant impact. Further discussion of this significance threshold and the value of riparian habitat is presented in Chapter 11, "Biological Resources".

Riparian vegetation would be adversely affected by the same seasonal and long-term water-level declines that adversely affect base flow in streams, as described earlier. Water-level declines can decrease the total area of riparian vegetation by dewatering and killing mature plants or by decreasing the probability of reproductive success. These mechanisms are discussed as separate impacts below.

Impact: Direct Mortality of Established Riparian Vegetation Caused by Dewatering of Plant Roots

In general, established riparian vegetation would be less sensitive to gradual water-level declines than seedlings of the same species because the roots of mature plants are able to grow downward and remain in contact with the water table, as long as the rate of decline is gradual. Riparian vegetation would also be generally less vulnerable to water-level declines than aquatic organisms living in the base flow reaches, because the roots of phreatophytic plants extend below the level of the creekbed. That is, if the groundwater level along an existing base flow reach underwent a gradual decline to a new equilibrium level a few feet below the level of the creekbed, that reach of the creek would be dry much more frequently (with devastating consequences for aquatic organisms), but the roots of established phreatophytic plants would be capable of growing downward to the new water table level. For example, the roots of cottonwood seedlings grow at an average rate of 6 millimeters per day (mm/d) and have been observed to grow as much as 13 mm/d if the water table declines rapidly during the first summer of growth (Stromberg et al. 1991). In other areas where the water table has declined gradually with time, such as near a meandering or downcutting stream channel, adult cottonwoods and willows have roots as much as 8 meters (m) deep, which is much greater than the maximum depth for successful seedling establishment (Stromberg et al. 1991). Thus, gradual water-level declines of several feet over a few years would have a less-than-significant impact on established, mature riparian vegetation.

In contrast, the localized but large and rapid water-level drawdown near individual pumping wells could cause localized vegetation mortality. A well-known example of this impact occurred in the Carmel River valley during the 1976-1977 drought, when pumping and lack of recharge from the river caused water levels in the reach below the Narrows to decline as much as 40 feet below normal dry-season water levels. This resulted in widespread mortality of riparian vegetation (Kondolf and Curry 1984). Localized dry-season drawdowns around wells near creeks in Rancho San Carlos would typically be on the order of tens of feet. Although root depth, soil moisture characteristics, and groundwater flow patterns are probably different in the fractured bedrock terrain on Rancho San Carlos than in the Carmel Valley alluvium, seasonal drawdowns near project supply wells could be large enough to dewater the roots of any nearby riparian vegetation and cause drought stress or mortality. Also, the declines near water supply wells will be much larger than declines that would occur from natural causes to which vegetation might be adapted. This impact is considered significant. To reduce this impact to a less-than-significant level, the following mitigation measures should be implemented.

Applicant's Proposed/Additional Mitigation Measure *14*: Delay Pumping at Wells near Base Flow Reaches. This mitigation measure is described above under "Impact: Induced Seepage Losses from Creeks and Substantial Depletion of Dry-Season Base Flow".

Applicant's Proposed/Additional Mitigation Measure *15*: Drill New Wells Away from Base Flow Reaches. This mitigation measure is described above under "Impact: Induced Seepage Losses from Creeks and Substantial Depletion of Dry-Season Base Flow".

Impact: Long-Term Decrease in the Total Area of Riparian Vegetation Caused by Decreased Reproductive Success

Groundwater pumping at the water supply wells could result in groundwater levels that are frequently lower by an average of several feet over a large part of the Rancho San Carlos area. These declines would appear gradually as water demand increases during the 20-year period of project construction. Water-level declines in riparian areas would probably be less than the average regional water-level decline because water levels in riparian areas are generally fairly stable. Seepage to the creek prevents water levels from rising above the level of the creek, and convergent groundwater flow from surrounding upgradient areas tends to prevent large water-level declines.

On Rancho San Carlos, moderate gradual declines in water levels could potentially impair the long-term reproductive success of phreatophytes near the upstream ends and outer (upslope) fringes of riparian areas, because the depth to water would be too great for seedling establishment. Seedlings depend on soil moisture derived from rainfall until their roots reach the water table. If the water table declines, successful establishment could become altogether impossible or possible only in very wet years or sequences of years.

The effect of water-level declines on seeding establishment would be most noticeable near the upstream ends of existing base flow reaches and along the outer, upslope fringes of the riparian corridors. Base flow would tend to retreat downstream to shorter reaches as a result of lowered groundwater levels. Phreatophytic vegetation upstream of the base flow reaches would experience lower water levels and less frequent and prolonged base flow. Even mature individuals of obligate phreatophytes commonly found along stream channels (such as willows) could suffer mortality. *Similarly, hillside springs supplied by the regional groundwater system could also experience decreases in flow that could adversely affect downslope vegetation.*

Although available information regarding aquifer characteristics, pumping rates and locations, water table slopes, and base flow reaches may not be accurate or detailed enough to quantitatively estimate the long-term decrease in total riparian area, it is reasonably likely that the decrease would be more than 5%.

This impact might be entirely mitigated by the Cattle Grazing Plan, which is expected to increase groundwater recharge, base flow, and groundwater levels in riparian areas. *The Cattle Grazing Plan will also benefit riparian vegetation by greatly decreasing livestock access to riparian areas. This will decrease browsing and trampling of vegetation and will improve infiltration of rainfall, which will promote successful seedling establishment.* However, the magnitude of the beneficial effect of the Cattle Grazing Plan is difficult to estimate with certainty. The mitigation measure that would provide supplemental water for protected base flow reaches during dry years would also help to sustain riparian vegetation along those reaches. Riparian vegetation upstream of those reaches could still suffer long-term declines, however. The amounts of riparian vegetation and base flow may be interdependent because ample groundwater and base flow are needed to support riparian vegetation, yet transpiration by riparian phreatophytes consumes groundwater.

Given the uncertainty regarding the effects of the Cattle Grazing Plan and the limited extent of the protected base flow reaches, a reasonable possibility exists that the area of riparian vegetation would decline by more than 5% in the long term. This impact is considered significant. To reduce this impact to a less-than-significant level, the following mitigation measure should be implemented.

Additional Mitigation Measure *17*: Monitor Riparian Vegetation and Maintain Total Area of Riparian Vegetation. Because of the long life span (decades to centuries) of many riparian plant species, the effects of a slight decrease in reproductive success caused by water-level declines could be difficult to detect. Long-term vegetation monitoring is needed to distinguish this trend from short-term fluctuations in vegetation area and vigor caused by drought, fire, disease, or insect infestations.

The project applicant shall monitor riparian vegetation along selected transects *on average* ~~at least once~~ every 3 years *with no periods of more than 4 years between surveys. This allows a typical year with extreme conditions (wet, dry, or affected by fire, pests, or diseases) to be skipped.* Line-intercept or belt transects shall be established along the outer perimeter of the riparian corridor just upstream of the upper end of the protected base flow reaches of Potrero Canyon and Las Garzas, San Clemente, and San Jose Creeks. *A similar transect shall be established through the area of vegetation dependent on flow from one or more springs on Long Ridge on the north side of the San Clemente Creek valley.* Percent cover of riparian versus nonriparian species shall be measured along each transect. Canopy cover shall be measured separately from understory cover. Other variables that shall be recorded are species, stand age structure, evidence of recruitment, *vigor, habitat value,* and evidence of stress or disease. The vegetation types included within the definition of "riparian" shall be the same ones used in the biological resources report (BioSystems Analysis 1994b).

The exact locations, lengths, and widths of the transects shall be specified in a detailed monitoring plan to be developed by the project applicant and submitted to MCWRA and DFG for consultation and review. The detailed monitoring plan and initial vegetation survey along the transects shall be completed within 1 year after final project approval.

The project applicant (or its successor in natural resources management at the site, the Santa Lucia Preserve) shall plant and actively restore riparian vegetation if all of the following conditions occur:

- the percent cover of riparian species in either the canopy or understory is less than three-fourths of the percentage measured in the initial vegetation survey for two successive triennial surveys or less than one-half the initial percentage in any one survey,
- analysis of base flow monitoring data required by the mitigation measure "Monitor Base Flow in Creeks and Provide Supplemental Water if Necessary" indicates that base flows are declining as a result of the project, and

- the cause of the decrease in riparian vegetative cover is not clearly attributable to a factor unrelated to water-level declines, such as fire, flooding, drought, disease, insect infestation, or competition from invasive exotic species.

The allowable decrease in percent riparian cover along the transects (25% decrease) is larger than the significance threshold for decrease in total riparian area because the transects are located in the areas most likely to be adversely affected. It is assumed that the transects represent the 20% of overall riparian area that is most vulnerable to impact and that the remaining 80% would not be affected. A 25% decrease in 20% of the overall area equals a 5% decrease in the overall area.

The vegetation restoration shall restore the total area of riparian vegetation on Rancho San Carlos to at least 95% of the total area (1,600 acres) measured in the 1994 survey by BioSystems Analysis (1994). The mix of species planted shall be similar to the mix of species documented in the 1994 survey. The number of plantings to be installed will depend on the area of riparian habitat affected. Woody species should be spaced irregularly throughout the area typically to be restored on 9-foot centers. Planted vegetation shall be actively irrigated and maintained until it becomes self-sustaining.

Vegetation restoration includes actively monitoring plantings for 5 years after the plants are installed. The plantings should be monitored for survival, vigor, and height. Success will be achieved if there is a minimum of 40% survival during the first year, no more than 5% mortality during the second and third years, and stable viable populations for the remainder of the monitoring period. Annual monitoring reports should be submitted to the Monterey County Planning and Building Inspection Department *and the California Department of Fish and Game*. If survival is determined to fall short of the target at any annual monitoring visit, the project applicant should replant and implement any remedial measures. The monitoring period should begin again if significant remedial action is required at any time.

It is recognized that specific mitigation measures are based on the current state of knowledge of riparian restoration, and upon experience elsewhere in the state, and in other hydrological systems and can be modified when needed to provide an approximate equivalent level of protection.

If base flow and riparian habitat conditions have clearly remained stable or improved following construction of the project, the project applicant or the Santa Lucia Preserve may submit a request to MCWRA and DFG to discontinue the monitoring program. The request should provide documentation of trends in base flow and riparian vegetation conditions and may not be submitted until all of the presently planned development has been completed or 24 years following project approval, whichever is later.

Impact: Degradation of Wetlands Caused by Groundwater Pumping

Wetlands occupy only about 1% of the total area of Rancho San Carlos. Most of these are wet meadow wetlands, including small areas around seeps and springs. Others are emergent marsh wetlands around permanent water bodies, principally Moore's Lake. Shallow piezometers were installed in several wet meadow areas by the project applicant's hydrologic consultants to measure near-surface groundwater levels and water quality (Hecht pers. comm.). Water levels were consistently at or slightly below the land surface, whereas water levels in nearby wells were 10-15 feet below the land surface. Similarly, the electrical conductivity of the shallow water was very low, indicating that it was derived from rainfall rather than rising groundwater. These results indicate that the wet meadow wetlands are formed by rainfall ponding on clay soils rather than by groundwater rising to the land surface. These wetlands would not be affected by groundwater pumping and associated declines in the level of the underlying water table. Wetlands associated with springs and seeps on hillsides *probably* would not be affected by groundwater pumping because *most of* these springs and seeps are perched above the main groundwater system tapped by wells. *Wetland-type vegetation sustained by springs that might receive regional groundwater discharge would be monitored and protected by the additional mitigation measure, "Monitor Riparian Vegetation and Maintain Total Area of Vegetation".* Wetlands associated with permanent water bodies, such as lakes and base flow reaches in creeks, are considered part of the riparian environment for this discussion of groundwater impacts and would be protected by the mitigation measures recommended to protect riparian vegetation. Impacts of groundwater pumping on wetlands are considered less than significant.

Mitigation Measure: No mitigation measures are required.

Impacts on Offsite Water Users

Impact: Decrease in Water Supply in Offsite Areas Resulting from Decreased Subsurface and Surface Outflow

Subsurface and surface outflow from Rancho San Carlos contribute to groundwater recharge in offsite areas. The effect of the project on water users in these areas is the combined effect of the change in subsurface outflow and the change in surface outflow that would have infiltrated from the creeks and become recharge. All of the creeks on the rancho except San Jose Creek are tributary to the Carmel River. Groundwater in the Carmel Valley is for practical purposes fully developed for water supply. Groundwater withdrawals by community water purveyors are closely regulated under MPWMD's Water Allocation Plan, and MPWMD even irrigates riparian vegetation along the Carmel River to avoid impacts on vegetation during periods of substantial groundwater pumping.

The impact of the project on the water supply for existing users in the Carmel Valley can be evaluated by first estimating the long-term average effects of the project on flows entering the valley and then considering how these effects would change during droughts. The safe or firm yield of the water supply in the valley is the amount of groundwater that can be pumped reliably every year during a critical drought period. For the existing level of water demand and development in the Carmel

Valley groundwater basin, the critical drought period is 1987-1991, although the 1976-1977 drought also imposed operational constraints (Oliver pers. comm.).

On a long-term average annual basis, any increase in consumptive use of groundwater on the ranch is most likely to be compensated for by a decrease in surface outflow in the creeks. This can be deduced from information presented in the preceding sections dealing with effects on each of the outflows. Subsurface outflow was estimated to decrease by no more than 17 af/yr. Phreatophyte transpiration would probably not decrease substantially because one of the objectives of the additional mitigation measure ("Monitor Riparian Vegetation and Maintain Total Area of Riparian Vegetation") is to maintain the total area of riparian vegetation at the existing level. Thus, decreases in these outflows probably account for only 6% of the 295 af/yr of net groundwater use for the project. The remainder (278 af/yr) must be derived from increased stream recharge during the wet season and intercepted base flow during the dry season. Based on the estimated distribution of groundwater yield among the watersheds on the ranch, approximately 24% of the total streamflow depletion would occur in the San Jose Creek watershed, which is not tributary to the Carmel River. This leaves approximately 211 af/yr of depletion to be obtained from the tributary creeks.

During periods when the Carmel River flows to the ocean, depletions in surface outflow from the ranch would not decrease recharge and water availability for users in the Carmel Valley because additional recharge is rejected during those periods. During critical drought periods, however, the river does not flow all the way to the ocean, and all surface and subsurface inflow to the Carmel Valley becomes groundwater recharge. Some of the project pumping during droughts will be derived from temporary decreases in groundwater storage depletions that will be refilled during subsequent wet periods when the water supply situation in the Carmel River valley is not as critical. Even during droughts, however, annual discharge in the creeks tributary to the Carmel River exceeds project water demand. Estimated historical streamflow data for the creeks on Rancho San Carlos were presented in the Comprehensive Hydrological Study and indicated that the smallest combined annual discharge during 1958-1991 was 263 af in 1977, and the average combined annual discharge during 1987-1991 was 1,910 af. Surface outflow would not decrease below 48 af/yr, however, which is the amount of groundwater that would be pumped into protected base flow reaches upstream of the Carmel Valley to maintain in-stream habitat (30 gpm continuously).

In summary, a high estimate of the decrease in surface and subsurface outflow to the Carmel Valley during a critical drought period is approximately 180 af/yr. This equals the worst-case estimate of decrease in subsurface outflow plus the fraction of annual project consumptive use expected to be derived from decreases in surface flow in creeks tributary to the valley, minus supplemental base flow provided under the mitigation measure, "Monitor Base Flow in Creeks and Provide Supplemental Water if Necessary". This estimate is certainly high because it assumes no groundwater storage depletions during the drought. However, even this high estimate is a little more than 1% of the annual amount of groundwater pumped from the Carmel Valley (approximately *12,500* ~~21,000~~ af/yr).

This small decrease in inflow to the Carmel Valley during critical drought periods might not decrease the water yield available to users in the Carmel Valley. This was found to be the case in simulations of the New Los Padres Reservoir project using the CVSIM model. The simulations were completed as part of the environmental impact analysis for the project EIR/EIS (EIP Associates 1994). When all tributary inflows (including the flows from all creeks on Rancho San Carlos that are tributary to the Carmel River) were decreased by 15%, there was no decrease in simulated project yield and the number of months of water rationing that would be required during a critical drought period increased by only 1%. These results refer to the yield of the reservoir project or the reservoir project plus the existing water supply system, which might be different from the yield of the existing system alone. Nevertheless, the results indicate that water supply in the Carmel Valley during critical drought periods is not extremely sensitive to decreases in tributary inflow.

The impact of the Santa Lucia Preserve project on the Carmel Valley water supply is considered less than significant for the following reasons, which together present a picture of reasonable use and minimal impact:

- The decrease in annual surface and subsurface inflow to the Carmel Valley during critical droughts would be *a little more* ~~less~~ than 1% of annual groundwater use in the Carmel Valley.
- Modeling studies of the New Los Padres Reservoir project indicate that the yield of water supplies in the Carmel Valley during critical droughts is not appreciably affected by fairly large (15%) decreases in tributary inflows.
- The Cattle Grazing Plan is expected to largely or entirely offset the increased consumptive use of groundwater by the project.
- The project will incorporate water-conserving design features consistent with Monterey County Ordinance No. 3539 regarding water conservation standards.
- The project is outside the boundaries of MPWMD and not subject to MPWMD's Water Allocation Plan.
- The use of groundwater on overlying lands is consistent with water rights law.
- The intensity of water use is extremely low compared to the intensity of use by other overlying landowners. The net consumptive use of 330 af/yr on an area of 19,900 acres is equivalent to a rate of 0.017 foot per year (ft/yr). Consumptive use of groundwater on agricultural fields (e.g., irrigated pasture) in the Carmel Valley is approximately 2.1 ft/yr (California Department of Water Resources 1975).
- *Irrigation of the golf trail would be reduced during critically dry periods. A water management and conservation plan that includes public education, alternating landscape irrigation schedules, and other techniques will be developed for use during critically dry periods.*

- The annual consumptive use of groundwater by the project can be sustained by the groundwater system without resulting in overdraft.
- Because the water use by the project is less intense than water use by others in the region and the water use is within the local safe yield, it constitutes a reasonable correlative share of groundwater resources.
- The project sets aside 18,000 acres of land in a natural preserve and thereby avoids potential future development that would further deplete inflow to the Carmel Valley.

Mitigation Measure: No mitigation measures are required.