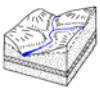


7 System Production

The previous Sections 4, 5, and 6 present estimates of the expected potential yield of SLVWD's individual sources of water. The actual potential supply provided by these sources relies on their conjunctive use within the constraints of the climatic cycle and existing and planned infrastructure. This section begins with a description of key aspects of the District's existing and planned water-distribution and storage infrastructure, and then assesses the role of conjunctive use in its historical and potential-future production record.

7.1 Existing and Planned System Infrastructure and Operation

A thorough analysis of SLVWD's water treatment and distribution system is beyond the scope of this water-supply plan. Aspects of the system having a significant water-supply influence are discussed below. As noted previously, this report pertains to SLVWD's water supply system prior to its recent annexation of the Felton system formerly operated by Cal-Am.

7.1.1 Storage

The SLVWD water distribution system consists of 22 individual pressure zones within the North System, 2 pressure zones in the South System, and the Mañana Woods system. Table 7-1 lists the tank and multi-tank storage facilities supplying these pressure zones.

The 23 storage facilities supplying the North System have a combined capacity of approximately 8 MG or 25 AF. Nearly 90 percent of this total is provided by the 8 largest facilities, those with capacities greater than 200,000 gallons each. The South System is served by three tanks with a combined capacity of 0.3 MG or 0.9 AF.

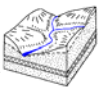
The District's constructed storage capacity is small relative to its rate of use. Storage equals about five times mean daily production in the North System and only one day's production in the South System. These low storage-to-use ratios illustrate the District's reliance on groundwater storage whenever direct stream diversions are insufficient. The storage capacity of the North System is of practical use to the District for helping to avoid diversions when stream turbidities are highest and seasonal demand is low.

7.1.2 Distribution

The scale and complexity of SLVWD's water distribution system reflect the San Lorenzo Valley's demanding geography with regard to topography, patterns of development, and distribution of raw water sources. The District's currently serviceable northern area extends along approximately 10 miles of the San Lorenzo River and an additional 10 miles of major tributaries (e.g., Bear, Boulder, and Zayante creeks); ranges 1,000 feet in elevation; and encompasses 22 square miles. In addition to gravity flow from the Lyon WTP and pumping wells, the District employs 24 booster-pump stations to distribute water among the 22 North-System pressure zones (Table 7-2). Water distribution among the southern system's two pressure zones requires a single booster station.

A key aspect of the North System is its capacity to reverse gradient as a function of seasonal changes in raw water supplies. During the wet season, the entire North System is supplied by stream diversions from the Lyon WTP. During dry conditions, a large portion of system demand is supplied by the Quail Hollow and Olympia wells near the southeastern, downgradient end of the system. The District's capacity to move water both up and down the valley is made possible by the following:

- A north-south 10- to 12-inch trunk line that extends south from Boulder Creek along Irwin Way, and continues along River and Riverside Roads, Sunnyside Avenue, and Glen Arbor Road through Brookdale and Ben Lomond.



- The two-way Irwin booster station.
- A north-south series of four major storage facilities: the Lyon, Big Steel, and Brookdale reservoirs, and the Quail tanks.

The District acknowledges and intends to address two major constraints that limit its ability to optimally convey treated water within the North System in response to seasonal water-supply availability and demand:

- The capacity of the 6-inch line from the Lyon WTP to Boulder Creek and areas south is too small, resulting in excessive friction losses, entrained sediment, and a limited potential to convey available stream diversions (e.g., to the South System via an intertie).
- The 6-inch line from the Olympia wells to the Quail tanks also is too small, resulting in excessive friction losses and a limited capacity to convey available Olympia groundwater when it is most needed during dry periods.

7.1.3 Operations

Typically, SLVWD operates the Olympia wells only when the combined production from stream diversions and the Quail Hollow wells is insufficient for maintaining adequate storage within the North System's storage facilities south of Boulder Creek.

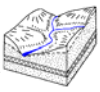
As described above, SLVWD draws on storage within its North System to help limit the diversion of turbid stormflows. Additionally, SLVWD draws down on its North-System storage during some dry-season periods of peak demand when available sources cannot maintain constant storage. Given the system's limited storage capacity, such conditions can only be successfully handled for up to several days at a time.

7.1.4 North-South System Intertie

The concept of an intertie between SLVWD's North and South Systems stems from recognition of the following water-supply conditions:

- As evaluated and discussed in Section 6.4.3, static groundwater levels in SLVWD's Pasatiempo wells have fallen 150 feet since 1985. The sustainability of the current rate of production is uncertain.
- As discussed in Section 4.3.4, potential stream diversions in excess of current North-System demand are estimated to average about 170 AF/yr (56 MG/yr) and range up to 200 AF/yr (65 MG/yr)–assuming repetition of the 1984-2006 climatic cycle with the existing diversion and WTP capacity.
- As discussed in Section 6.1, SLVWD has the right to purchase 313 AF/yr (102 MG/yr) of raw water from Loch Lomond reservoir.

An intertie between the North and South Systems would allow deliveries of excess available stream diversions and Loch Lomond water to the Southern Service Area to offset apparent over pumping in the groundwater subarea encompassing the District's Pasatiempo wells. Under current levels of seasonal demand, the Southern Service Area could utilize about 75 AF/yr (25 MG/yr) on average, ranging from 0 to 100 AF/yr (33 MG/yr). As discussed further in Section 7.3, maximum year conveyance to the South System via an intertie potentially could reach 250 AF/yr with access to excess available stream diversions and diversions from Loch Lomond under projected future demand. This would require maximum monthly conveyance of 35 AF, equivalent to average continuous rates of 260 gpm or 0.38 mgd. The feasibility and actual amount of needed instantaneous



conveyance capacity has not been estimated, and a formal conceptual design for a North-South Intertie has not been prepared.

As discussed in Section 4.3, the North-South Intertie concept has the following caveats:

- Estimated amounts of stream diversion potentially available for conveyance to the Southern Service Area are relatively small compared to the total estimated volume of diversions. Thus, there is a proportionately higher degree of uncertainty associated with these relatively small amounts of potentially excess available diversions (i.e., they are roughly similar to the potential margin of error).
- On average, about 90 percent of the estimated available diversions occur from December through April. Actualizing these diversions requires the system to operate at near capacity during the wettest months, including storm periods.
- Excess diversions available to the Southern Service Area are highly variable, equaling 10 percent or less of annual demand during about 35 percent of all years, and up to 30 percent of annual demand during other years.

7.1.5 Loch Lomond Diversion

As presented in Section 6.1, SLVWD is entitled to 313 AF/yr (102 MG/yr) of Newell Creek streamflow stored in Loch Lomond, or an equivalent amount of treated water, purchased from the City of Santa Cruz. Delivery of treated water, however, would be interruptible during declared water-shortage emergencies. As projected in Section 7.3, SLVWD's maximum seasonal need from a supplemental source of water such as Loch Lomond could range up to 80 AF/month, equal to a continuous rate of nearly 600 gpm or 0.85 mgd. A conceptual design for the diversion, treatment, and conveyance of Loch Lomond water within the SLVWD system has not been prepared.

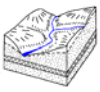
7.1.6 Expanded Groundwater Production Capacity and Treatment

As discussed in Section 5.8.1, SLVWD is considering construction of an additional production well in the Quail Hollow area so as to regain the capacity it had previously from multiple area wells. Furthermore, hydrogeologic conditions indicate that additional groundwater production capacity could be developed in the Olympia area (Section 5.8.2). Such new wells could improve pumping performance and enhance production capacity. However, whether or not such wells would provide a significant supply increase is unlikely in the case of Quail Hollow and uncertain in the case of Olympia. Increased groundwater production from the Olympia area probably would require increased treatment capacity for iron and manganese.

7.2 Past and Current Conjunctive Use

Conjunctive use refers to the optimized, sustainable use of multiple sources of water throughout annual and long-term climatic cycles. Access to both stream diversions and groundwater allows SLVWD to practice conjunctive use in its Northern Service Area. Factors controlling this practice include:

- The seasonal and year-to-year variability of streamflows available for diversion.
- Limited surface-water storage (equal to only a few days' average use).
- Rates of groundwater extraction that can be sustained by the volume of useable groundwater storage and average rate of recharge.
- The limited availability of supplemental water sources.



Past and current infrastructure does not allow for conjunctive use in the Southern Service Area or Mañana Woods, which instead rely solely on groundwater.

Table 7-3 and Figure 7-1 present SLVWD's 1984-2008 record of annual surface-water and groundwater use; Tables A-1 and A-2 and Figure 4-11 present the monthly record. The District's recent and historical use of surface-water and groundwater supplies may be summarized approximately as follows:[13]

	Annual Production (AF/yr)	
	2000-08	1984-2008
Northern Service Area	Average	Range
Stream Diversions	**935**	**500 - 1,200**
Foreman, Peavine, & Silver Cks	660	305 - 955
5-Mile Pipeline (Clear & Sweetwater Cks)	275	90 - 380
Groundwater	**760**	**330 - 1,000**
Quail Hollow Wells	315	125 - 515
Olympia Wells	450	170 - 555
North System Total	**1,700**	**1,330 - 1,800**
Southern Service Area		
Pasatiempo Wells	**410**	**205 - 445**
Mañana Woods	50	(data unavailable)
SLVWD Total	**2,120**	**1,595 - 2,210**

Since 2000, total stream diversions have averaged 935 AF/yr (305 MG/yr) and groundwater pumping from the North and South System wells has averaged 760 and 410 AF/yr (250 and 135 MG/yr), respectively. Since SLVWD annexed the Mañana Woods system in 2006, groundwater production has been about 50 AF/yr (17 MG/yr). Total SLVWD production has ranged from approximately 1,600 to 2,200 AF/yr (520 to 720 MG/yr) since 1984 and has averaged 2,120 AF/yr (690 MG/yr) since 2000.

The District's proportional use of these supplies since 1984 is shown graphically in Figure 7-2 and may be generalized as follows:

	Percent of Annual Production 1984-2008	
Northern Service Area	Average	Range
Stream Diversions	**55%**	**35% - 80%**
Foreman, Peavine, & Silver Cks	40%	20% - 65%
5-Mile Pipeline (Clear & Sweetwater Cks)	15%	5% - 25%
Groundwater Production	**45%**	**20% - 65%**
Quail Hollow Wells	20%	8% - 36%
Olympia Wells	25%	12% - 38%
Southern Service Area		
Pasatiempo Wells	100%	
Mañana Woods		
Mañana Woods Wells	100%	
Total SLVWD Production		
Stream Diversions	45%	30% - 65%
Groundwater	55%	35% - 70%
Used portion of Divertible Streamflows	**80%**	**70% - 95%**

[13] See Table 7-3 for values in MG/yr.

Since 1984, SLVWD's North System has obtained an average of 55 percent of its annual water supply from stream diversions and 45 percent from groundwater pumping. During any given year, stream diversions have supplied between 35 and 80 percent of North System demand, whereas groundwater has supplied between 20 and 65 percent annually. The complimentary use of these sources has resulted in a relatively smooth upward trend in total North System use since 1984 (Figure 7-1).

The effective yield of SLVWD's North System is largely controlled by its ability to divert available streamflows. The North System is estimated to use 80 percent of available diversions, on average, and never less than 70 percent. When streamflows are limited by season or drought, SLVWD meets its North System water demand by pumping more from groundwater storage. Under sustainable conditions, groundwater storage is allowed to recover at times when streamflow and recharge are plentiful and demand is lower. During all years, groundwater satisfies at least 20 percent of North System demand and is currently the only supply that ensures North System demand can be met under most expected conditions.

To date, SLVWD's groundwater extractions from its Quail Hollow and Olympia wells have not resulted in any substantial net decline in groundwater level (Figures 5-27 & 5-28). This suggests that the average yields of the Quail Hollow and Olympia wellfields are sustainable at somewhat more than 300 and 400 AF/yr (100 and 135 MG/yr), respectively, given the current configuration of wells.

SLVWD's stream and groundwater sources have been in balance with demand when averaged over the past 2½ decades. However, as droughts of historical or worse magnitude occur under current and increasing rates of demand, it appears that SLVWD's North System will require some type of supplemental supply combined with increased conservation.

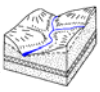
The groundwater levels of aquifers supplying the South System, Mañana Woods, and surrounding areas of Camp Evers and Scotts Valley have declined significantly since the mid-1980s (Figures 5-29 & -31). These aquifers comprise the sole potable water source for these communities. The ongoing sustainability of SLVWD's recent average rate of extraction from its Pasatiempo wells, slightly more than 400 AF/yr (135 MG/yr), is questionable.

Production from the Mañana Woods well, about 50 AF/yr (17 MG/yr), appears relatively sustainable given that other area wells pumping at substantially higher rates (e.g., SVWD wells 9 & 10) will experience declines in production first as a result of depressed groundwater levels. Santa Cruz County has obtained State funding to study potential conjunctive-use solutions to the Scotts Valley area's water supply deficit.

7.3 Potential Future Conjunctive Use

This section evaluates SLVWD's potential for future conjunctive use as a function of the following assumptions:

- Average demand projected for 2030, varied annually as a function of an assumed climatic cycle.
- Streamflows available for diversion, as estimated for the WY 1985-2008 climatic cycle.
- Sustainable rates of groundwater production from the current Quail Hollow and Olympia wellfields, as indicated by historical record.
- A goal of lowering production from the Pasatiempo wellfield as needed to stabilize and partially recover groundwater levels.
- The potential for an intertie between the North and South systems.



- The potential to obtain water from the City of Santa Cruz under SLVWD's right to up to 313 AF/yr of Newell Creek streamflow stored in Loch Lomond.

7.3.1 Assumptions

More detailed descriptions of the assumptions underlying the potential future conjunctive use analysis presented in Section 7.3.2 are provided below:

2030 Average Demand – As estimated in Section 2.3 and presented in Table 2-4, average 2030 production demand[14] is assumed to equal about 1,760 AF/yr (575 MG/yr) in the Northern Service Area, 440 AF/yr (145 MG/yr) in the Southern Service Area, and 60 AF/yr (20 MG/yr) in Mañana Woods, for a total average demand of 2,260 AF/yr (735 MG/yr). These estimates reflect significant expectations for improved water-use and conveyance efficiency, as demonstrated by reductions in system losses and per-connection usage.

Climatic Period – As presented in Section 3, the climatic cycle of the past several decades is well supported by the available data record and encompasses a wide range of drought and wet-period conditions. Although worse droughts have occurred (e.g., 1917-35), their rainfall and streamflow records are deficient. The future, local consequences of global climate change are poorly understood. For these reasons, the goal of this study has been to establish a firm estimate of SLVWD's future water supply as constrained by the climatic cycle of the past several decades. Because this has been a period of ongoing development and growth in water demand, it is important to evaluate the entire period against projected future demand. With this as a benchmark, subsequent analysis can evaluate the potential impacts of climate change to SLVWD's water supply as projections suitable for planning purposes become available.

Demand Variability – SLVWD's water-demand response to the climatic cycle since 1970 is evaluated in Section 2.2 and summarized in Figure 2-4. This complex response includes increased water use during single dry years, at the beginning of a drought, and one or two years following the end of a drought; and decreased water use during wet years and in response to requests for conservation during extended drought.

Table 7-4 and Figure 7-3 present a generalization of this analysis applied to 2030 demand. Water demand is assumed to change relative to the immediately preceding years as follows:

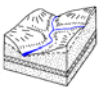
- Increase 2.5 to 5 percent, or sustain prior high levels, during single dry years and the initial years of a drought.
- Decline 2.5 to 5 percent per year following the first years of a drought as a result of requested and voluntary conservation.
- Increase 2.5 to 5 percent per year one to two years after the end of a drought.
- Decline 5 to 7.5 percent during exceptionally wet years.

As a result, annual water demand is assumed to fluctuate ±5 percent from projected 2030 demand in response to the climatic cycle. Under these assumptions, the cumulative response to a drought is a water-use reduction of up to 10 percent.

The analysis of potential future conjunctive use presented in Section 7.3.2 assumes demand is distributed monthly similar to corresponding past dry (1987-92, 1994), wet (1986,1995-2000,2005-06), and average years.

Stream Diversions – Section 4.3.3 estimates monthly streamflows available for diversion since 1984. A multiple regression of estimated annual streamflows available for diversion versus rainfall at Ben

[14] "Production demand" equals delivered water plus system losses and is equivalent to total raw water production.



Lomond during the corresponding year and two prior years has a relatively high correlation coefficient of about 0.8. This correlation, combined with assumed monthly distributions, could be used to synthesize a record of available flows for any period. Nevertheless, estimates of available monthly streamflow derived directly from the available diversion record were judged more representative and defensible for use in the analysis of future conjunctive use. Thus, the future-case analysis is conducted for a 24-year period of monthly streamflow availability equivalent to WYs 1985-2008. Rainfall at Ben Lomond was approximately 97 percent of average during these years (Table 7-4). Streamflows available for diversion during WY 1990 were adjusted to remove the influence of the Loma Prieta earthquake, resulting in a decrease from approximately 760 to 570 AF for this drought year.

Available streamflow diversions are assumed to satisfy monthly demand up to the estimated 155 AF/month (51 MG/month) capacity of the Lyon Water Treatment Plant, with the constraint that 10 AF/month (3 MG/month) of available diversions are lost during stormflow months due to a combination of factors including excessive turbidity and operation and maintenance of the diversion and treatment facilities.

Groundwater Production Capacity – In this assessment, the potential contribution of each SLVWD wellfield to future production demand is limited by maximum-monthly and sustainable-average pumping rates inferred from the historical record. As a base case, groundwater is assumed to contribute the following amounts once North System demand exceeds available stream diversions:

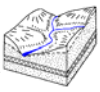
- Quail Hollow wellfield – maximum production of 35 AF/month (2.8 mgd or 260 gpm continuously) while maintaining average annual production of about 300 AF/yr (100 MG/yr).
- Olympia wellfield – maximum production of 75 AF/month (6 mgd or 560 gpm) once Quail Hollow wellfield reaches its maximum, while maintaining average annual production of about 400 AF/yr (135 MG/yr).

An alternate case allows higher pumping rates during dry periods offset by supplemental water use during wet periods.

Without any supplemental source, 2030 average demand in the Southern Service Area will require production of 440 AF/yr (145 MG/yr) from the Pasatiempo wells, a rate that currently does not appear sustainable. To the extent that one or more supplemental sources of water become available to the Southern Service Area, it is assumed that the Pasatiempo wellfield would benefit from a production rate roughly 100-AF/yr lower than projected for the purpose of sustainability.

North-South Intertie – As discussed in Section 7.1.4, an intertie between the North and South Systems would allow delivery of excess available stream diversions, and a portion of SLVWD's entitlement to Loch Lomond, to the Southern Service Area. This would help offset apparent groundwater overdraft in the subarea encompassing SLVWD's Pasatiempo wells. This analysis considered intertie conveyance rates up to approximately 40 AF/month (equivalent to continuous rates of 0.43 mgd and 300 gpm).

Loch Lomond Entitlement – As discussed previously in Sections 6.1 and 7.1.5, SLVWD is entitled to 313 AF/yr (102 MG/yr) of Newell Creek streamflow stored in Loch Lomond, or an equivalent amount of treated water (interruptible during declared water-shortage emergencies), purchased from the City of Santa Cruz. Use of this supply is considered with and without a North-South Intertie in the following analysis of potential future conjunctive use. Use rates up to a maximum of about 80 AF/month (0.85 mgd or 600 gpm continuous) are considered, although the feasibility of treating, conveying, and integrating this source into SLVWD's existing system has not been evaluated.



Additional Conservation – Historical levels of mainly voluntary conservation during drought are incorporated into the assumptions of demand variability described above. In the evaluated scenarios, higher levels of mandatory conservation are interchangeable with supplemental water use. In other words, the estimated need for supplemental water is equivalent to the amount of conservation needed if no supplemental source is developed. A more thorough analysis of conservation and demand management is beyond the scope of this report but needs to be addressed in subsequent work (e.g., as required for an Urban Water Management Plan).

7.3.2 Alternate 2030 Conjunctive-Use Scenarios

Two conjunctive use scenarios under 2030 demand conditions are evaluated, referred to as Scenarios A and B. Both consider a North-South Intertie and access to a "supplemental" source of water, i.e., Loch Lomond. Scenario A uses supplemental water only when needed by the North System, whereas Scenario B is a trial-and-error optimization of all sources for both systems. Each scenario represents multiple subscenarios given the exchangeability of additional conservation and/or increased groundwater production (including overdraft) for a North-South Intertie and supplemental source of water. The two scenarios are further defined as follows:

- **Scenario A** – SLVWD has the option to utilize a supplemental supply when its North System is otherwise unable to fulfill demand under the constraints defined in Section 7.3.1. The North-South Intertie is used to convey excess available stream diversions to the South System. In this base case, groundwater production by the District's three wellfields is as described above. Under worst-case drought conditions, purchases of supplemental water from the City of Santa Cruz could be interrupted at times when SLVWD needs it most.
- **Scenario B** – SLVWD routinely accesses a supplemental water supply for (a) "in-lieu" groundwater recharge[15] in both Service Areas and (b) when needed to meet North System demand. This has the advantage of exercising a portion of SLVWD's entitlement to Loch Lomond during periods when deliveries from the City of Santa Cruz are much less likely to be interrupted. In this case, the North-South Intertie delivers supplemental water as well as excess available stream diversions to the South System. In-lieu recharge allows higher monthly production rates from the wellfields during dry periods.
  - Supplemental water of up to 20 AF/month (0.21 mgd or 150 gpm continuously) for in-lieu recharge in each of the North and South Systems during non-stormflow months of years with above average rainfall. These conditions represent times when SLVWD demand is above seasonal lows, SLVWD stream diversions are below peak levels, and deliveries from Loch Lomond may be most feasible.
  - Quail Hollow wellfield – supply demand in excess of diversions up to a maximum of 47 AF/month (0.5 mgd or 350 gpm) during dry years; up to 20 AF/month (0.21 mgd or 150 gpm) during other years; average annual production maintained at about 300 AF/yr (100 MG/yr).
  - Olympia wellfield – supply demand in excess of diversions and Quail Hollow production up to a maximum of 80 AF/month (0.86 mgd or 600 gpm) during dry years; 60 AF/month (0.64 mgd or 445 gpm) otherwise; maintain average annual production at about 400 AF/yr (135 MG/yr).

These scenarios are evaluated on a monthly basis, as presented in Figures 7-4 and 7-5. This monthly time-step analysis is essential to an accurate assessment of conjunctive-use feasibility. The results are summarized on an annual basis in Tables 7-5 and 7-6 and Figure 7-6.

[15] In-lieu recharge refers to the direct use of an alternative water supply in lieu of pumping groundwater.

7.3.2.1 Scenario A: North-South Intertie and Supplemental Source for North System

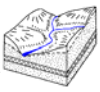
Figure 7-4 provides a set of five plots, labeled (a) through (f), illustrating SLVWD's estimated monthly water supply assuming 2030 demand, a repeat of the WY 1985-2008 climatic cycle, and conjunctive use Scenario A. These show: the compliment of sources supplying (a) the North and (b) the South Systems; (c) the need for supplemental water and/or additional conservation; (d) use of the North-South Intertie; (e) groundwater production; and, (f) used and unused available stream diversions.

Under this scenario:

- The North System requires a supplemental source and/or additional conservation[16] when assumed maximum rates of wellfield production do not satisfy demand during the dry-season months of greater than half of all years (Figures 7-4a & -4c). This has the disadvantage of relying on Loch Lomond as a supplemental source of last resort during drought when competition for stored water is greatest and deliveries from the City may be interrupted.
- During wet-periods, excess available streamflow diversions are conveyed to the South System via the North-South Intertie, allowing the complete resting of the Pasatiempo wellfield during some wet-season months of more than half of all years (Figures 7-4b, -4d, & -4f). Without the Intertie, the sustainability of groundwater supplies in the vicinity of the Pasatiempo wellfield would be further threatened by increased South System demand and production in 2030.
- Maximum monthly conveyance of excess available stream diversions via the North-South Intertie is 32 AF/month, equivalent to 0.34 mgd or 240 gpm. Instantaneous rates would be significantly larger but have not been estimated or evaluated for conveyance feasibility.
- The maximum monthly use of supplemental water is 65 AF/month, equivalent to 0.70 mgd or 485 gpm. Again, the instantaneous rates would be larger but have not been estimated or evaluated for conveyance feasibility.

On an annual basis (Table 7-5, Figure 7-6), the average and range of water-supply contributions from each source under Scenario A are as follows:

[16] Additional in the sence that up to 10 percent conservation is already factored into the assumed variation in demand as a function of the climatic cycle.

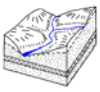


	2030 Demand Scenario A, WYs 1985-2008 AF/yr	
Northern Service Area	Average	Range
Production Demand	**1,760**	**1,660 - 1,835**
Stream Diversions	960	535 - 1,385
Groundwater	710	340 - 1,010
Quail Hollow Wells	310	235 - 405
Olympia Wells	400	100 - 640
Add'l Conservation / Supplemental Source	**90**	**0 - 265**
Southern Service Area		
Production Demand	**440**	**415 - 460**
Pasatiempo Wells	440	415 - 460
Pasatiempo Wells If Intertie	365	285 - 460
Stream Diversions Via Intertie	**75**	**0 - 140**
Mañana Woods Well	60	55 - 65
Total Production Demand	**2,260**	**2,132 - 2,355**
Total Stream Diversions	1,035	535 - 1,505
Total Groundwater	1,135	685 - 1,515
Total Add'l Conservation/Supplemental Source	90	0 - 265
Unused Divertible Streamflows	65	0 - 125
Unused Loch Lomond Entitlement	**225**	**50 - 315**

In the Northern Service Area, production from the Quail Hollow and Olympia wellfields is maintained at historically sustainable averages. Use of a supplemental source (and/or additional conservation) averages 90 AF/yr (30 MG/yr) and ranges up to 265 AF/yr (86 MG/yr), within SLVWD's Loch Lomond entitlement of 313 AF/yr. Stream diversions delivered to the South System via a North-South Intertie average 75 AF/yr (24 MG/yr) and range from 0 to 140 AF/yr (0 to 46 MG/yr). As a result, average production from the Pasatiempo wellfield is reduced by an equivalent amount to about 365 AF/yr. Total SLVWD production ranges between 2,130 to 2,360 AF/yr (695 to 765 MG/yr) and averages 2,260 AF/yr (735 MG/yr).

The results of Scenario A are summarized on an annual-percentage basis in the table below and discussed as follows:

- Use of a supplemental source and/or additional conservation provides 5 percent of North System demand on average, ranging from zero to 14 percent. As a result, production from the Quail Hollow and Olympia wellfields provides 5 percent less of the North System supply, on average, compared to the historical averages presented in Section 7.2.
- If the entire need for supplemental water were offset by additional conservation, this would represent average and maximum conservation increases of approximately 5 and 15 percent of the water supply, over and above as much as 10 percent of drought conservation already factored into the 2030 demand projections.
- Excess available streamflow diversions delivered via a North-South Intertie provide 16 percent of South System demand on average, ranging from zero to 33 percent, with a corresponding decline in Pasatiempo wellfield production.
- On average, the North and South Systems under Scenario A use 95 percent of available stream diversions, whereas historically the North System has utilized only 80 percent. One quarter of this increase is due to greater North System demand in 2030, with the remainder a result of the Intertie.



- The use of a supplemental water source averages 28 percent of SLVWD's entitlement to Loch Lomond, ranging up to 84 percent of the entitlement in some years. As mentioned above, the potential disadvantage of this scenario is that it relies on Loch Lomond as a supplemental source of last resort during drought when competition for stored water may be greatest and deliveries from the City could be interrupted.
- Groundwater pumping for Mañana Woods represents 3 percent of total system production.

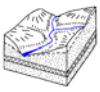
	2030 Demand Scenario A, WYs 1985-2008 AF/yr	
Northern Service Area	Average	Range
Stream Diversions	**55%**	**30% - 80%**
Groundwater	**40%**	**20% - 61%**
Quail Hollow Wells	18%	13% - 24%
Olympia Wells	23%	6% - 40%
Add'l Conserv./ Supplemental Source	**5%**	**0% - 14%**
Southern Service Area		
Pasatiempo Wells If Intertie	84%	67% - 100%
Stream Diversions Via Intertie	**16%**	**0% - 33%**
Total Production Demand		
Total Stream Diversions	46%	25% - 70%
Total Groundwater	50%	30% - 70%
Total Add'l Conserv./ Supplemental Source	4%	0% - 11%
Mañana Woods portion of SLVWD Total	3%	3% - 3%
Used portion of Divertible Streamflows	95%	90% - 100%
Used portion of Loch Lomond Entitlement	**28%**	**0% - 84%**

7.3.2.2 Scenario B: North-South Intertie and Supplemental Source for North and South Systems

Figure 7-5 provides a set of plots illustrating SLVWD's estimated monthly water supply assuming 2030 demand, a repeat of the WY 1985-2008 climatic cycle, and conjunctive use Scenario B.

Under this scenario:

- The North System receives a supplemental source as both (1) in-lieu recharge during non-drought years and (2) a source of last resort during drought. As a result, the Quail Hollow and Olympia wellfields are able to produce at higher peak-month rates. This has the advantage of using some of SLVWD's Loch Lomond entitlement when both supply and demand are adequate, and reducing usage during drought when competition for stored water is greatest and deliveries from the City of Santa Cruz may be interrupted.
- Via the North-South Intertie, the South System receives (1) excess available streamflow diversions and (2) supplemental water (i.e., from Loch Lomond), both of which constitute in-lieu recharge by allowing the Pasatiempo wellfield to recover. Whereas the conveyed stream diversions offset some wet-season pumping, the delivered supplemental water offsets dry-season pumping during years of above average rainfall.
- Maximum monthly conveyance via the North-South Intertie increases to 35 AF/month. Equivalent continuous rates are 0.38 mgd or 260 gpm; however, actual instantaneous rates would be greater and have not been estimated.
- The maximum monthly use of supplemental water is 80 AF/month, equivalent to 0.84 mgd or 585 gpm.



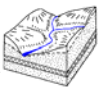
On an annual basis (Table 7-5, Figure 7-6), the average and range of water-supply contributions from each source under Scenario B are as follows:

	2030 Demand Scenario B, WYs 1985-2008 AF/yr	
Northern Service Area	Average	Range
Production Demand	**1,760**	**1,660 - 1,835**
Stream Diversions	960	535 - 1,385
Groundwater	660	225 - 1,105
Quail Hollow Wells	300	145 - 515
Olympia Wells	365	80 - 605
Supplemental Source	**130**	**17 - 305**
In-Lieu Recharge	50	0 - 160
Add'l Conserv. / Deficit Makeup	80	0 - 205
Southern Service Area		
Production Demand	**440**	**415 - 460**
Pasatiempo Wells	440	415 - 460
Pasatiempo Wells If Intertie	335	170 - 460
Stream Diversions Via Intertie	75	0 - 140
Add'l Conserv./Supplemental Source	35	0 - 125
Total Intertie	**105**	**0 - 255**
Mañana Woods Well	60	55 - 65
Total Production Demand	**2,260**	**2,130 - 2,355**
Total Stream Diversions	1,035	535 - 1,505
Total Groundwater	1,060	455 - 1,615
Total Add'l Conserv./Supplemental Source	160	17 - 310
Unused Divertible Streamflows	65	0 - 125
Unused Loch Lomond Entitlement	**150**	**2 - 295**

Compared to Scenario A, average annual production from the Olympia wellfield is reduced 10 percent; Quail Hollow wellfield peak production increases; supplemental water use during drought is reduced; production from the Pasatiempo wellfield is reduced an additional 30 AF/yr, on average, achieving a 100 AF/yr reduction compared to 2030 demand; such that is maintained at historically sustainable averages. Use of a supplemental source (and/or additional conservation) averages 90 AF/yr (30 MG/yr) and ranges up to 265 AF/yr (86 MG/yr), within SLVWD's Loch Lomond entitlement of 313 AF/yr. Stream diversions delivered to the South System average 75 AF/yr (24 MG/yr) and range from 0 to 140 AF/yr (0 to 46 MG/yr). As a result, average production from the Pasatiempo wellfield is reduced by an equivalent amount to about 365 AF/yr. Total SLVWD production is the same as in Scenario A, ranging between 2,130 to 2,360 AF/yr (695 to 765 MG/yr) and averaging 2,260 AF/yr (735 MG/yr).

On an annual-percentage basis, the results of Scenario B are summarized in the table below and differ from Scenario A as follows:

- Average annual use of supplemental water increases 2 percent to a total of 7 percent of North System demand, ranging up to 17 percent. Supplemental water use is roughly split between in-lieu recharge and drought supply when the wellfields are producing at their planned maximum capacity. The combined production of the North System wellfields decreases by a corresponding few percent, but increases in variability, providing from 13 to 65 percent of North System annual usage. Peak-year production from the Quail Hollow wellfield is able to increase under these conditions, while peak-year production from the Olympia wellfield is allowed to decrease.



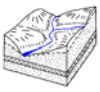
	2030 Demand Scenario B, WYs 1985-2008 AF/yr	
Northern Service Area	Average	Range
Stream Diversions	**55%**	**30% - 80%**
Groundwater	**38%**	**13% - 65%**
Quail Hollow Wells	17%	8% - 30%
Olympia Wells	21%	5% - 35%
Supplemental Source	**7%**	**1% - 17%**
In-Lieu Recharge	3%	0% - 10%
Additional Conservation/ Deficit Makeup	4%	0% - 12%
Southern Service Area		
Pasatiempo Wells If Intertie	76%	40% - 100%
Stream Diversions Via Intertie	16%	0% - 33%
Additional Conserv./ Supplemental Source	8%	0% - 28%
Total Intertie	**24%**	**0% - 60%**
Total Production Demand		
Total Stream Diversions	46%	25% - 70%
Total Groundwater	47%	21% - 73%
Total Add'l Conserv./ Supplemental Source	7%	1% - 14%
Mañana Woods portion of total	3%	3% - 3%
Used portion of Divertible Streamflows	95%	90% - 100%
Used portion of Loch Lomond Entitlement	**52%**	**5% - 99%**

- Delivery of supplemental water via the North-South Intertie reduces the Pasatiempo wellfield's contribution to demand in the Southern Service Area by another 8 percent, over-and-above the 16 percent reduction provided by conveyance of excess available streamflow diversions via the Intertie. The Intertie supplies up to 60 percent of South System annual demand during some years.
- Average annual supplemental water use increases to more than 50 percent of SLVWD's entitlement to Loch Lomond, ranging up to nearly 100 percent during some years. On average, about half this amount is used during non-drought conditions when competition for stored water is low and the City is least likely to interrupt the transfer of water under SLVWD's entitlement to a portion of the yield of Loch Lomond.

7.3.3 Conclusions

Factors currently controlling the production potential of SLVWD's water supply system include:

- Seasonal and year-to-year variability of streamflows available for diversion (as evaluated in this report for 1984-2008).
- Seasonal and year-to-year variability of water demand, fluctuating ±5 percent as a function of the climatic cycle (i.e., up to 10 percent reduction in response to drought).
- Limited surface-water storage (equal to only five times mean daily use of the North System).
- Large volumes of groundwater storage (roughly 50 times greater than total average annual wellfield production).
- Sustainable groundwater production as a function of useable groundwater storage and average recharge (Quail Hollow and Olympia wellfields)



- Potentially unsustainable groundwater production from the Pasatiempo wellfield, with no current means to convey excess available streamflow diversions from the Northern to the Southern Service Areas.
- No means to exercise SLVWD's entitlement to Newell Creek streamflow stored in Loch Lomond.

The annual yield of SLVWD's existing water system is summarized as follows:

	Annual Production (AF/yr)	
	Recent Average	Range Period of Record
Stream Diversions	935	500 - 1,200
Quail Hollow & Olympia Wellfields	760	330 - 1,000
North System Total	1,700	1,330 - 1,800
South System – Pasatiempo Wellfield	410	205 - 445
Mañana Woods	50	(data unavailable)
SLVWD Total	**2,150**	**1,600 - 2,210**

On average throughout a representative hydrologic cycle, the system utilizes about 80 percent of the streamflows available for diversion, and never less than 70 percent. As noted previously, these estimates do not reflect potential environmental constraints, uncertain projections of climate change, or SLVWD's recently annexed Felton system.

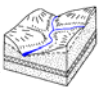
Groundwater storage is currently SLVWD's only reliable source for satisfying water demand during periods of low streamflow. Because groundwater storage is many times greater than annual use, several years of above average groundwater production can be sustained with relatively limited consequences. However, if not balanced by long-term average recharge, a significant potential for groundwater overdraft exists (e.g., as has occurred in the Camp Evers and Scotts Valley areas). The potential for overdaft is exacerbated by the difficulty of accurately measuring and/or estimating groundwater storage and recharge.

Groundwater level records indicate that production from the Quail Hollow and Olympia wellfields has been effectively balanced by recharge during the last 24 years, largely because of conjunctive use practices. Depressed groundwater levels in the vicinity of the Pasatiempo wellfield indicate that its recent rates of production may not be sustainable. As SLVWD integrates its water supply systems to address this and other aspects of the system, it is critical that it evaluate the viability of its conjunctive use through a representative climatic cycle and reflecting realistic demand projections.

Conjunctive use has provided the North System with an apparently balanced supply over the past 24 years, as indicated by the little or no cumulative decline in Quail Hollow and Olympia groundwater levels. However, current demand is 16 percent greater than average demand for the 1984-2008 period of record. Under repetition of 1976-77 and 1987-94 droughts, SLVWD's water system could not supply demand as it did previously, relying instead on potentially unsustainable groundwater production and/or unprecedented rates of demand management.

The monthly analysis presented above for SLVWD's projected 2030 demand indicates that successful future conjunctive use will require supplemental water and expanded conveyance. As demonstrated, this can be accomplished by exercising SLVWD's entitlement to Loch Lomond and providing supplemental water to the Southern Service Area via a North-South Intertie.

The results of estimating SLVWD conjunctive use under projected 2030 demand and a repeat of the 1984-2008 climatic cycle is as follows, assuming (1) excess available stream diversions are conveyed



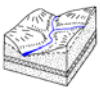
to the south system to supplement the Pasatiempo wellfield and (2) diversions from Loch Lomond (and/or additional conservation) are used to supplement the North System at times when sustainable groundwater withdrawals are insufficient to meet demand:

	2030 Demand Scenario A, WYs 1985-2008 AF/yr	
	Average	Range
Stream Diversions	960	535 - 1,385
Quail Hollow & Olympia Wellfields	710	340 - 1,010
Add'l Conservation / Supplemental Source	90	0 - 265
North System Total	1,760	1,660 - 1,835
Pasatiempo Wells If Intertie	365	285 - 460
Stream Diversions Via Intertie	75	0 - 140
South System Total	440	415 - 460
Mañana Woods Well	60	55 - 65
Total Production Demand	**2,260**	**2,132 - 2,355**

In this future-case scenario, stream diversions provide 17 percent of demand in the Southern Service Area via a North-South Intertie, on average, allowing a 50 AF/yr reduction in average Pasatiempo wellfield production compared to recent years. As a result, about 95 percent of streamflows available for diversion are used on average, compared to about 80 percent currently. In the Northern Service Area, diversions from Loch Lomond (or an equivalent amount of treated water from the City of Santa Cruz, and/or additional conservation) provide up to 265 AF/yr during drought conditions, allowing production from the Quail Hollow and Olympia wellfields to decrease slightly (7 percent) compared to recent years and remain sustainable over the long term. However, the City is more likely to interrupt water transfers to SLVWD under worst-case drought conditions.

Offsetting supply deficits entirely through conservation would require average and maximum conservation increases equal to 5 and 15 percent of the water supply, respectively, over and above up to 10 percent drought conservation already factored into the 2030 demand projections.

In the alternate scenario summarized below, supplemental water from Loch Lomond (or an equivalent amount of treated City water) is used more routinely, and in both service areas, in order to maintain groundwater storage and allow more intensive groundwater production during drought.



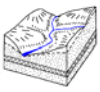
	2030 Demand Scenario B, WYs 1985-2008 AF/yr	
	Average	Range
Stream Diversions	960	535 - 1,385
Quail Hollow & Olympia Wellfields	660	225 - 1,105
In-Lieu Recharge	50	0 - 160
Add'l Conserv./ Deficit Makeup	80	0 - 205
Total Supplemental Use	**130**	**17 - 305**
North System Total	**1,760**	**1,660 - 1,835**
Pasatiempo Wells If Intertie	335	170 - 460
Stream Diversions Via Intertie	75	0 - 140
Add'l Conserv./Supplemental Source	35	0 - 125
Total Intertie	**105**	**0 - 255**
South System Total	**440**	**415 - 460**
Mañana Woods Well	60	55 - 65
Total Supplemental Source	160	17 - 310
Total Production Demand	**2,260**	**2,130 - 2,355**

In this case:

- Supplemental water provides 24 percent of the South System supply, on average, allowing a 105 AF/yr reduction in average Pasatiempo wellfield production compared to recent years.
- Use of up to 300 AF/yr of supplemental water by the North System allows lowering average Quail Hollow and Olympia wellfield production by about 13 percent compared to recent years and increasing their production capacity during drought.
- Use of supplemental water increases to more than 50 percent of SLVWD's entitlement to Loch Lomond, on average, ranging up to nearly 100 percent of its entitlement during some years.
- About half of the supplemental water is used during non-drought conditions when competition for stored water is low and diversions from Loch Lomond, or an equivalent supply of City treated water, are least likely to be interrupted.
- Maximum monthly conveyance via the North-South Intertie is 35 AF/month, equivalent to continuous rates of 0.38 mgd or 260 gpm.
- The maximum monthly use of supplemental water by both service areas is 80 AF/month, equivalent to 0.84 mgd or 585 gpm.

These future cases assume:

- Feasible conveyance and treatment of the instantaneous flows implicit to the projected use of a North-South Intertie and supplemental water.
- SLVWD will address critical conveyance limitations within the existing system (e.g., the sections of 6-inch pipeline described in Section 7.1.2).
- SLVWD will achieve the significant reductions in system losses and per-connection usage that underlie its projected demand for 2030.
- Potential water supply limitations imposed by environmental constraints will be addressed by studies subsequent to this report.



Additionally, this report does not attempt to estimate future water supplies as a function of currently uncertain projections of climate change. However, this report's approach and results do address this issue as follows:

- Provides a well-documented and thoroughly analyzed benchmark of the existing water supply as a function of climatic variability during the past quarter of a century.
- Formalizes recognition of SLVWD's conjunctive-use system and reliance on groundwater storage during drought. The flexibility and optimization of this system will be critical to responding successfully to the potential effects climate change.
- Supports major improvements to SLVWD's existing water supply system, i.e., a North-South Intertie and exercising SLVWD's entitlement to Loch Lomond, that will greatly enhance its capacity for managing the potential effects of climate change.
- Provides a procedure for updating these estimates once projections of climate change suitable for planning purposes become available.