Viejas Casino & Resort – Phase 3 Project Admin Draft TEIR

Appendix D

Supporting Water Supply Assessment

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SUPPORTING WATER SUPPLY EVALUATION: VIEJAS PHASE 3 HOTEL PROJECT TEIR

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1.0 INTRODUCTION

The purpose of this Supporting Water Supply Evaluation is to present an analysis of the potential off-Reservation impact of groundwater use associated with a new hotel structure to be connected to and located west of the Viejas Casino. It is referred to herein as the Phase 3 Hotel and is a component of the Viejas Casino & Resort – Phase 3 Project (Project). Similar water supply reports were produced in support of Tribal Environmental Impact Reports (TEIRs) for prior projects referred to as the North and South Towers (see BRG, 2012; and BRG, 2014). These hotel towers started operation in March 2013 and October 2015, respectively, and are located to the east of the Viejas Casino.

Water production, wastewater reclamation, potable water use, and reclaimed water irrigation data are collected by Viejas' Public Works Department. Relevant data from the past four years (2012 through 2015) are used to support this water supply evaluation.

Wastewater produced on the Viejas Reservation is collected by a Reservation-wide sewer system and treated to tertiary CA Title 22 standards[1] by a centrally-located wastewater treatment plant. Reclaimed water is used to the extent practicable for irrigation across the Reservation. The use of reclaimed water for the proposed Phase 3 Hotel Project is consistent with Viejas' 2005 Intergovernmental Agreement that states that the Tribe will make reasonable best efforts to continue to use tertiary treated (reclaimed) wastewater for landscape irrigation purposes. Excess reclaimed water is sent to an on-Reservation percolation basin where it recharges the groundwater system. Both uses of reclaimed water serve to reduce overall groundwater demand.

Water volumes in this report are expressed in gallons and in acre-feet (Acft). One Acft is the amount of water that will cover one acre (43,560 ft^2) to a depth of one foot, approximately 326,000 gallons.

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[1] Reclaimed (or recycled) water is wastewater that has been treated to meet the California Department of Health Services' (DHS) comprehensive recycled water regulations that define treatment processes, water quality criteria, and treatment reliability requirements for public use of recycled water. These regulations are contained in Title 22, Division 4, Chapter 3, of the California Code of Regulations, commonly referred to as Title 22.

The wastewater treatment plant treats wastewater to the disinfected tertiary level, the highest level of treatment categorized by Title 22. Approved uses of tertiary recycled water include: irrigation of food crops, parks and playgrounds, and residential landscaping. It can also be used for non-restricted recreational impoundments, toilet flushing, and fire suppression.

2.0 PROJECT DESCRIPTION

The Project includes a 170-room, multi-story hotel, located adjacent to the west of existing Viejas Casino (NOP, 2016). The Project will renovate and replace/remodel portions of the existing Casino. The western portion of the renovated Casino will be connected with the new Phase 3 Hotel tower. Specific to the water supply the following components are included in the Project:

- 170 room hotel
- 9,000 ft^2 spa
- 4,000 ft^2 swimming pool area
- 180,000 ft^2 of landscape with 20,000 ft^2 of associated hardscape

3.0 UPDATED WATER PRODUCTION AND WATER USE DATA

3.1 North Tower Hotel Water Use (2013 to 2015)

Water use measurements have been made on a monthly basis by Viejas for the North and South Tower hotels. Data through January 2016 were used to assess water demand for the existing hotels and to project water demand for the Phase 3 Hotel (Viejas DPW, 2016).

The North Tower hotel opened for business March 21, 2013 and includes 128 rooms. Water use data over a 31 month period support an average daily rate of 143 gallons per room for the North Tower (an annual average of 20.5 AcFt/yr). The South Tower hotel opened for business October 31, 2015 and includes 109 rooms that are very similar in design to those included in the North Tower. Three months of data obtained for the South Tower support a similar per room use rate (an annual average of 17.5 AcFt/yr for the smaller hotel). The hotel pool located between the North and the South Towers used an average of 2.4 AcFt/yr during 2014 and 2015.

The rooms in the Phase 3 hotel are larger in design and include spa-style bathtubs. An estimated water demand of 175 gallons per day per room is used in this analysis to allow for the potential increases in water use (an annual average of 33.3 AcFt/yr).

Effectively all of the hotel water demand is for interior use with minimal water loss. Consistent with prior reports a value of 95% is assumed for the return wastewater flow rate. Because of the high rate of water recovery the net use of all three hotels is projected to be 3.6 Acft/yr (5% of the total annual usage of 71.3 Acft/yr). The pool water use of 2.4 AcFt/yr is conservatively assumed to be fully consumptive; however, a portion of the water used for pool maintenance is sewered and reclaimed.

3.2 Viejas Reservation-wide Groundwater Production (2012 to 2015)

Viejas operates a series of production wells located across the Reservation to provide potable water for commercial, tribal, and residential use. Seven production wells are currently in use. The wells produce water at rates of approximately 40 to 300 gallons per minute (gpm), depending on the well capacity and pumps installed in the wells. The well locations are distributed across the Reservation- specific locations are not shown in this report due to security concerns.

All of the wells are operated at the same time and used to fill a series of storage tanks. Pumping ceases in all wells when the tanks are full. As a result the wells are cyclically operated, with an average operation time ranging from approximately 25 to 50% depending on seasonal demands.

Water and wastewater production and use data were compiled from Viejas' Department of Public Works reports and records. A summary is presented in **Table 1**. Review of the data shows that groundwater pumping rates have increased by approximately 3 to 9 percent from the base year of 2012 prior to hotel operation.

Table 1. VIEJAS WATER USE SUMMARY, 2012 through 2015

Units: Acft

	2012	2013	2014	2015	
Total Groundwater Pumping	300	312	309	327	AcFt
Treated Water Produced (Reclaimed)	144	158	154	175	AcFt
Reclaim Irrigation	91	86	85	65	AcFt
Percent of Reclaim Use	63%	54%	55%	37%	
Excess Discharged to Percolation Basin	53	72	69	110	AcFt
Annual Evaporation, Perc Basin	0.84	0.84	0.84	0.84	AcFt
Net Recharge	52	71	68	109	AcFt
Recharge as percent of water production	17%	23%	22%	33%	
Net Pumping	248	241	241	218	AcFt
Pumping Increase vs. 2012 (without recharge)		12	9	27	AcFt
Percent increase since 2012		4%	3%	9%	
Reclamation Production Increase vs. 2012		14	10	31	AcFt
Percent reclaimed (incremental vs 2012)		117%	111%	115%	see Note 6.

Notes:
1. Underline indicates Revised versus the 2014 TEIR.
(Pumping rates based on monthly totalizers, prior were timer-based estimates)
2. Evaporation Loss assumes 62.5 inches/yr (CIMIS Zone 16)
from a 7,000 ft^2 basin.
3. North Tower Hotel and Pool opened March 2013
4. South Tower Hotel opened October 31, 2015
5. Reclaim water use deceased in 2015 ~20 AcFt due to intentional reductions in irrigation.
6. Percentages greater than 100% indicate that incrementally more water was reclaimed than was pumped
as a result of improvements in the Reservation-wide water reclamation system.

Groundwater pumping rates have been revised since the 2014 TEIR and are judged to be more accurate. Prior estimates were calculated on a per well basis from pump run times and estimated flow rates. Totalizer data are now being collected for all wells and the monthly readings were used to determine the groundwater pumping rates for 2012 to 2015. Daily flow data from the wastewater treatment plant were used to calculate the rate of reclaimed water production and flow totalizers are being used to track reclaimed water use across the Viejas Reservation.

3.3 Reclaimed Water Production, Use, and Excess Recharge (2012 to 2015)

All of the commercial operations, all of the Tribal government buildings, and nearly all of the residences on the Reservation are supported by a wastewater treatment system operated by the Viejas Department of Public Works (DPW). The wastewater is treated in a closed membrane filtration treatment system that minimizes water loss. Following treatment the reclaimed water becomes available for non-potable, irrigation uses. Wastewater production and use rates for 2012 to 2015 are summarized in **Table 1**. Viejas' wastewater system output has increased from 144 to 175 AcFt/year since 2012, reflecting their successful wastewater reclamation program.

A large portion of the treated wastewater is discharged to a percolation basin where it us allowed to infiltrate. Evaporative losses are included in **Table 1**, conservatively assuming that the basin is full of water all year and that evaporation occurs across the entire percolation basin.

Discussions with Viejas DPW staff indicate that the use of reclaimed water for irrigation has been maximized and being used to the extent practicable to supply existing demands. Combined with some reductions in irrigation demand, the volume of water available to recharge groundwater has increased. Since no new uses for reclaimed water have been identified it is assumed that all of the reclaimed water produced by the Project that is not used for Project irrigation will be discharged to the percolation basin.

The first hotel was opened in March 2013. 2012 data are used as a baseline in **Table 1** to compare groundwater pumping increases to the corresponding change in reclamation water production rates for 2013 to 2015. The increased pumping is being captured by return flows to the wastewater treatment plant as shown by comparison of the changes in pumping versus the changes in reclaimed water production.

A 95% reclamation rate has been assumed for hotel water usage. The current percentage of reclaimed water being used is approximately 37%. The remainder of the reclaimed water that is not being used is recharged.

3.4 Projected Phase 3 Hotel Water Demand

The 170-room hotel is projected to have a potable water demand 175 gallons/day per room, with a 95% wastewater return flow. The new spa and pool area will also have potable water demands as summarized in **Table 2**.

The Project includes approximately 180,000 ft^2 of landscape area that can be irrigated by reclaimed water. Water demands are estimated based on 25% of the landscape area with a high demand (e.g. turf), and the remaining 75% being constructed with low water demand native xeriscape plantings.

Table 2: Project Water Demand							
Component	Demand			Source		Reclamation Rates	
	rate	units	gallons/yr	AcFt/yr, pumped GW	AcFt/yr, reclaimed WW	reclaim rate, %	reclaim, AcFt
170 room hotel	175	gpd/room	10,858,750	33.3		95%	31.7
Landscape Irrigation (180,000 ft2)							
high water demand, 25% area/ 80% ET	4.2	ET AcFt/Ac (80%)	1,400,256	2.1	2.1	0%	
(half is potable water used near pool and spa areas)							
low water demand, 75% area/ 25% ET	1.3	ET AcFt/Ac (25%)	1,312,740		4.0	0%	
Pool (4,000 ft^2, 0.092 Ac, 4 ft deep)	1.7	AcFt/yr: 2 refills + 2x ET	551,113	1.7		0%	0.0
Spa: 100 patrons	20	gpd/patron	730,000	2.2		95%	2.1
TOTALS				39.4	6.2		33.8
Net Use, AcFt/yr	11.8	= (pumping rate - excess reclaimed water that is recharged)					
	5%	Approximate change in net pumping from 2015 (was 218, projected is 230)					
Note: ET rate is 5.2 ft/yr; CIMIS zone 16							

3.5 Summary

Overall the projected net increase in groundwater pumping is calculated to be 12 AcFt/yr. This is based on inflows of 37.3 AcFt of potable water for the Phase 3 Hotel, return flows of 33.8 AcFt/yr to be treated and reclaimed, and 8.3 AcFt/yr being used for landscaping. Excess reclaimed water will be recharged. The potable water demand from the Phase 3 Hotel will largely be offset by groundwater recharge of reclaimed water.

Net groundwater pumping rates shown in **Table 1** have decreased from 248 AcFt/yr in 2012 to 218 AcFt/yr in 2015 due to large increases in reclaimed water production and associated recharge of reclaimed water. The Phase 3 Hotel will increase the net annual groundwater pumping demand from 218 to 230 AcFt/yr, an increase of approximately 5% from the 2015 baseline.

4.0 REVIEW OF GROUNDWATER RECHARGE, STORAGE, AND SUSTAINABLE YIELD ESTIMATES

4.1 Viejas Creek Watershed

The 1,600 acre Viejas Indian Reservation (Viejas) is centrally located within the 5,750 acre Viejas Creek Watershed as shown in **Figure 1**. Viejas is surrounded by publicly and privately-owned properties. Viejas Creek is centered in Viejas Valley, drains to the west, and exits the western side of the Reservation. A series of tributary drainages that flow into Viejas Valley provide seasonal flows that accumulate within central portion of the valley. The watershed is defined by the western boundary of the Reservation (**Figure 1**).

A larger 7,391 Viejas Creek Watershed is described in a hydrologic evaluation included in EIR analysis for the County of San Diego General Plan Update (County Appendix D, 2010). The area shown in **Figure 2** is larger in area than the watershed shown in **Figure 1** because it encompasses areas downstream and west of the Reservation.

Existing ground water conditions for the Viejas watershed were described in a July 2001 report by Brown & Caldwell Engineers entitled, "Viejas Indian Reservation Water and Wastewater Master Plan". Brown & Caldwell determined that the watershed basin encompassed approximately 5,750 acres, ranging from Viejas Mountain in the west, to Chiquito Peak on the east, from Poser Mountain in the north, to the hills south of I-8 in the south as shown in **Figure 1**.

The strongly-eroded Viejas stream channel was rehabilitated by Viejas in the 1980s and 1990s to facilitate groundwater management, restore riparian habitat, and accommodate commercial development. A series of check dams/retention basins were constructed to manage stormwater flows, to reduce erosion, support the riparian habitat restoration, and to enhance groundwater recharge. The rehabilitation was very successful and the lower (western-most) portion of the channel contains perennial water and is a thriving riparian habitat. **Figure 1** shows the check dam structures and associated retention basins.

The overall groundwater system is comprised of an unconfined aquifer system within alluvium and decomposed granite overlying granitic bedrock. The hillsides are comprised of granitic rock with a thin veneer of soils. The bedrock in the area is described as Mesozoic age granitic rock (between 65 to 248 million years old). The eastern portion of the watershed contains gabbroic rock (CA Division of Mines and Geology, 2000). Granite and gabbro are crystalline igneous rocks that have visible mineral grains in the rock.

The soils within the Viejas Valley reflect the infilling of the valley by soils and alluvium derived from the hillside drainages. A description of the soils various soils mapped in the valley has been obtained from the US Department of Agriculture (USDA, 2016). **Figure 3**, shows the various soils mapped in the valley.

Table 3 summarizes the various soils mapped within the Reservation.

Table 3. SOILS IDENTIFIED IN FIGURE 3		
	Map Unit Symbol	**Map Unit Name**
	AyE	Auld stony clay, 9 to 30 percent slopes
	CmE2	Cieneba rocky coarse sandy loam, 9 to 30 percent slopes , eroded
	CnE2	Cieneba-Fallbrook rocky sandy loams, 9 to 30 percent slopes, eroded
	CnG2	Cieneba-Fallbrook rocky sandy loams, 30 to 65 percent slopes, eroded
	FaD2	Fallbrook sandy loam, 9 to 15 percent slopes, eroded
	FeE	Fallbrook rocky sandy loam, 9 to 30 percent slopes
	LrE	Las Posas stony fine sandy loam, 9 to 30 percent slopes
	LrG	Las Posas stony fine sandy loam, 30 to 65 percent slopes
	PfC	Placentia sandy loam, thick surface, 2 to 9 percent slopes
	RaB	Ramona sandy loam, 2 to 5 percent slopes
	RaC	Ramona sandy loam, 5 to 9 percent slopes
	RcD	Ramona gravelly sandy loam, 9 to 15 percent slopes
	RcE	Ramona gravelly sandy loam, 15 to 30 percent slopes
	RkA	Reiff fine sandy loam, 0 to 2 percent slopes
	StG	Steep gullied land
	TuB	Tujunga sand, 0 to 5 percent slopes
	VaB	Visalia sandy loam, 2 to 5 percent slopes
	VaC	Visalia sandy loam, 5 to 9 percent slopes
	VaD	Visalia sandy loam, 9 to 15 percent slopes
	VvD	Vista rocky coarse sandy loam, 5 to 15 percent slopes
	WmB	Wyman loam, 2 to 5 percent slopes

Alluvium occurs within the central portion of the main channel of Viejas Creek and deepens to the west. The channel to the north of the commercial center was a deeply eroded channel prior to restoration. Following check dam construction the eroded channel naturally filled with water, soil, and alluvium. Groundwater levels within the western portion of Viejas Creek are maintained by the perennial stream and occur close to the ground surface as evidenced by the extent of vegetation that now occurs within the creek channel (**Figure 1**).

Underlying the soil and alluvium within the Valley is weathered bedrock, referred to as decomposed granite or DG (County 2010). The amount of water contained in saturated DG is proportional to the degree of weathering and typically ranges from 2 to 8 percent by volume. Alluvium can store significantly more water, on the order of 10 to 20 percent by volume.

The extent of weathering decreases with depth and the granitic rock becomes harder, so the primary porosity of the rock occurs as a result of fracturing. A depth of 500 feet is typically assumed. Water production wells on the Viejas Reservation are completed within moderately fractured bedrock and produce water from depths of approximately 400 to 1,000 feet.

4.2 Groundwater Recharge Rate

Recharge is water that goes through the soil and replenishes the aquifer system. The recharge rate depends on the amount and rate of rainfall, the residence time of the water at the ground surface, evaporation and plant transpiration losses (evapotranspiration), and the ability of the soil to retain and transmit water to the aquifer.

Various methods can be used to estimate recharge. For example, the County of San Diego prepared generalized basin-by-basin calculations for ground water-dependent areas in the General Plan Update (County, 2010; Appendix D). The County recharge analysis uses a minimum 30-year monthly rainfall data series to examine changes in rainfall based on a soil moisture balance methodology. In essence recharge is evaluated based on whether enough rainfall occurs in a month period to sufficiently wet the soil, cause the soil to exceed its soil moisture capacity, and to allow water to flow through the soil column to the underlying aquifer system.

A large percentage of the rainfall is assumed to not be available for recharge because it is either lost as evapotranspiration or as run-off. The soil moisture balance approach does not consider surface water retention as a source of recharge. Viejas has constructed a series of check dams/retention basins along Viejas Creek to manage stormwater flows, to reduce erosion, enhance groundwater recharge, and support the riparian habitat restoration. A soil moisture balance recharge calculation methodology will underestimate recharge for the Viejas Reservation because it cannot account for reduced runoff, surface water storage, and associated enhanced recharge along Viejas Creek.

Brown & Caldwell (2001) estimated that ground water recharge of the basin would be 0.12 Acft/acre per year for the Viejas watershed. This recharge estimate is compared to the screening-level recharge calculations conducted by the County for the Viejas watershed and four adjacent watersheds that include Conejos Creek, Descanso, Japatul, and Loveland (**Figure 2)**. The intent of the comparison is to examine the 0.12 Acft/acre recharge rate relative to values determined for nearby watersheds in similar terrain and climatic conditions. **Table 4** shows that the average annual recharge rates for the four adjacent basins ranged from 0.14 to 0.33 acre-feet/acre- all greater than the 0.12 Acft/acre estimate used by Brown and Caldwell (2001).

Table 4. COMPARISON OF AVERAGE AQUIFER RECHARGE AND STORAGE

	Conejos Ck	Descanso	Japatul	Loveland	Viejas	Viejas		
GP EIR Table No.:	C-16	C-20	C-40	C-46	C-80	C-80mod	mods	B&C (2001)
Area, acres	33,581	13,413	1,486	22,717	5,791	7,391	1,600	5,750
Recharge, Acft/yr	7,183	4,441	206	4,044	816	1,173	357	690
acft/acre recharge	0.21	0.33	0.14	0.18	0.14	0.16		0.12
Storage, Acft	5807	4256	749	6287	2224	3319	1,095	not est
Acft/acre storage	0.17	0.32	0.50	0.28	0.38	0.45		

Notes:
(a) Recharge rate based on average annual rainfall
(b) Table C-80 modifications:
increase watershed by 1600 acres to include the Viejas Reservation
recharge in the reservation conservatively estimated using 700 acres @0.33 Acft/acre and 900 acres @0.14 Acft/acre
storage in the reservation estimated as 700 acres with 20 ft DG (5%) and 500 ft mod frx bedrock (0.1%),
and 900 acres w/ 500 ft slightly fractured rock (0.01%)

Since the Reservation is a sovereign entity, and not subject to County regulations, the County analysis “white-holed” the 1,600-acre Reservation and addressed only the watershed area of Viejas Creek basin area outside Viejas Reservation (i.e. the 5,791 acre area excludes the Reservation). The exclusion of the Viejas Reservation from the groundwater analysis leads to an underestimation of the amount of groundwater recharge shown in **Table 4**. Also shown in the Table is a revised estimate (C-80mod) that includes the 1,600 acre reservation. It assumes a high-range recharge rate of 0.33 acre-feet/acre for the 700 acre valley and a low-range recharge rate of 0.14 acre-feet/acre for the surrounding hillsides and upper stream valleys. This recalculation results in an average annual recharge rate of 0.16 acre-feet/acre (920 Acft/year versus 690 Acft/year). This value is conservative and less than observed in three of the four adjacent watersheds (**Table 4**). Also note that a significant portion of the Los Conejos watershed was also “white-holed”.

The soil moisture balance methods used in the County methodology do not explicitly evaluate surface water-groundwater interactions and will underestimate recharge related to surface water. While the soil moisture balance method provides for conservative recharge estimates when applied to the Viejas watershed, a different methodology is required to allow for the positive effect of the check dams and retention basins, especially when the basins are empty and ready to retain water.

The results of ongoing measurements by the Viejas Band supports that the check dams and riparian habitat management practices are highly effective, have raised groundwater levels, and provide drought-period benefits both on-Reservation and to adjacent off-Reservation properties.

4.3 Groundwater Storage Estimates

Groundwater is a renewable resource- rainfall recharges the aquifer system and replaces the water pumped out of the ground. During drought periods, the aquifer system provides for storage of groundwater in the absence of recharge. The amount of groundwater in subsurface storage depends on the ability of subsurface materials to hold water. Groundwater in subsurface storage is estimated based on a generally-accepted 10% storage coefficient for alluvium, 5% storage coefficient for DG (weathered bedrock), and a storage coefficient of 0.1% in moderately fractured bedrock.

Brown & Caldwell (2001) did not provide an estimate of groundwater storage. **Table 4** examines the storage calculations in a manner similar to the analysis done in the previous section for recharge. Calculated storage values range from 0.17 to 0.50 Acft/acre.

The exclusion of the Viejas Reservation from the County groundwater analysis leads to an underestimation of the amount of groundwater in storage because data obtained by the Viejas Band, consistent with data presented in Figure 3-7 of County (2010), demonstrate that the portion of the watershed along Viejas Creek within the Reservation contains saturated alluvium and deeply weathered granitic rock (decomposed granite, or DG). Because these materials contain more water per volume than the adjacent hillsides, the Viejas basin calculations were modified by conservatively assuming the approximately 700 acre valley contains 20 feet of saturated DG (at 5%) and 500 feet of moderately fractured rock (at 0.1%). The modification conservatively excludes the storage capacity of the alluvium known to occur within the Reservation. Surrounding hillsides were assumed to be composed of slightly fractured rock (500 feet at 0.01%). The result is an average of 0.45 Acft/acre storage over the watershed, or 3,319 acre-feet of storage in the 7,391 acre watershed.

4.4 Sustainable Yield/ Safe Yield

According to Brown & Caldwell (2001), “The unit recharge rate was developed from precipitation data collected over many years. Therefore, the 690 AFY [value] should be considered a long-term average recharge rate.” “[F]or planning purposes, the safe yield is nominally taken as being equal to the recharge rate for a particular year.” Therefore, based on the foregoing definition, the average safe yield for the Viejas basin would be approximately 690 Acft/yr. Brown & Caldwell provided a minimum basin safe yield of 450 Acft/yr for the entire 5,750 acre watershed. For comparison, this is equivalent to approximately half of the “C80-mod” annual average recharge value of 1173 Acft/yr (**Table 4**).

An alternative definition of safe yield generally used for water supply assessments by the County is based on the maximum sustainable pumping rate that will not cause the aquifer to have less than 50% of its total capacity at any time. The long-term available water supply is evaluated by using the historical rainfall record to calculate monthly groundwater recharge rates. The critical periods occur during prolonged drought periods and typically end with “El Nino”-type (above average) rainfall when the rainfall recharge replaces the groundwater that is used by pumping. In this case the methodology was used for the period of 1971 to 2015 to determine the maximum long-term pumping rate that can be sustained without causing the amount of water stored in the aquifer to drop to an amount equal to 50% of the total aquifer capacity.

A summary description of a water balance calculation using the County methodology based on rainfall data from 1971 to 2015 is included in **Appendix A** of this Report. The sustainable yield is estimated to be 504 AcFt/yr, a value that is similar to the estimate of 450 AcFt/yr provided by Brown & Coldwell and used in prior TEIRs (BRG, 2012 and BRG, 2014).

5.0 COMPARISON OF PROJECT GROUNDWATER DEMAND WITH COUNTY DPS CEQA SIGNIFICANCE CRITERIA

Exhibit B of the Amended and Restated Viejas-State Compact (2014) utilizes the following guidelines for determination of significance related to potential ground water use impacts.

- *Would the project substantially deplete off-reservation groundwater supplies or interfere substantially with groundwater recharge such that there should be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?*

The County of San Diego bases determinations of sustainable groundwater yield through usage of the County Groundwater Ordinance and the California Environmental Quality Act (CEQA). The County Guidelines for Determining Significance- Groundwater Resource (http://www.sdcounty.ca.gov/pds/docs/GRWTR-Guidelines.pdf) provide measurable standards for determining when an impact would be considered significant to groundwater resources pursuant to CEQA.

While acknowledging that County regulations do not apply on Tribal trust lands, the approach presented herein generally addresses the two criteria described by the County:

1. Evaluate water level decline resulting from groundwater pumping. “As an initial screening tool, off site well interference will be considered a significant impact if, after a five year projection of drawdown, the results indicate a decrease of 20 feet or more in the offsite wells. If site-specific data indicates water bearing fractures exist which substantiate an interval of more than 400 feet between the static water level in each offsite well and the deepest major water bearing fracture in the well(s), a decrease in saturated thickness of 5% or more in the offsite wells would be considered a significant impact. "

2. “Determine if extraction is in excess of sustained yield, which is defined in the County Guidelines as cumulative depletion of storage of greater than 50 percent capacity of the given basin.”

These are further described in the next two sections.

5.1 Water Level Decline Resulting from Groundwater Pumping

The change in water level (drawdown) that occurs within an aquifer associated with pumping at a given well decreases with distance away from the well. At the well, a small increase in the pumping rate will give rise to a proportional decrease in water level- here expected to be less than five percent. With distance the drawdown decreases rapidly (exponentially) and forms what is referred to as the cone of depression (Freeze and Cherry, 1979).

The water production wells are used to supply a single water supply system that serves private and commercial users on the Reservation. The proposed Project will be included in the Viejas water and wastewater system. Water from the all of the supply wells is combined, and the Project water demand will be spread across all of the wells.

A five percent (or more) long-term decrease in water levels and hence long-term pumping rates is judged to be significant. Data from 2013 to 2015 primarily obtained during the operation of the North tower hotel that opened March 2013 show that while potable water use has increased, net groundwater pumping rates did not increase due to increased recharge of reclaimed water. Net pumping has decreased since 2012 from 248 to 218 AcFt/yr (**Table 1**).

The projected annual net Project demand is estimated to be 12 Acft (see Table 2), with a wastewater reclamation rate of 95% for interior water uses. Water level changes associated with groundwater pumping will be proportional to pumping rates. Current County-accepted significance criteria allow for a maximum of a 5% water level decrease. Given the net increase in groundwater use associated with the hotel is no more than 5% over 2015 pumping rates, it is unlikely that water levels in off-Reservation wells will experience significant water level impacts due to the Project.

The presence of the perennial portion of Viejas Creek, sustained by the groundwater management and riparian habitat restoration work, provides hydraulic conditions that reduce the potential effect of off-Reservation water level changes. The location of these features are shown in **Figure 5**. In simple terms Viejas' production wells preferentially draw water from the on-Reservation portion of the aquifer being recharged by the creek. This effect, known as a hydrologic boundary condition, will significantly reduce the potential for off-Reservation wells to be impacted by on-Reservation pumping.

5.2 Aquifer Depletion Relative to Groundwater Extraction Rates

A cumulative depletion of water in subsurface storage of greater than 50% of the aquifer capacity is judged to be a significant impact per County Significance Guidelines. Here, 50% of storage is estimated to be 1,289 Acft based on a sustainable long-term pumping rate of 504 Acft/yr using a soil moisture balance methodology described in **Appendix A**.

A cumulative depletion calculation is done by examining the change in the amount of groundwater in the aquifer over time. Water is extracted from the aquifer at a hypothetical constant rate. Historical rainfall data from 1971 to 2015 are used to support calculations of the potential change in groundwater recharge that offset groundwater withdrawal.
The analysis was conducted using a monthly soil moisture water balance as follows:

- The 50% significance criterion occurs when only 1,289 Acft of water remains in the aquifer.

- The historical rainfall record was obtained from the nearby Alpine weather station (WRCC, 2016). The Alpine rainfall measurements are from a location that has lower rainfall than expected to occur in the Viejas Creek Watershed. The monthly data are shown in **Table 5**. Rainfall rates in the Viejas watershed are expected to be higher- the Alpine data are used as a proxy to approximate groundwater recharge rates.

  Review of the historical rainfall record shows that rainfall rates significantly vary over time. Rainfall variability occurs, in part, due to recognized climatic cycles such as the El Nino/ La Nina (http://www.elnino.noaa.gov/) and the Pacific Decadal Oscillation (PDO) (http://www.ncdc.noaa.gov/teleconnections/pdo.php). The data are shown in **Figure 4**. A July to June 'rain year' is used to present the data because area precipitation occurs primarily from November to April.

  The rainfall record for Alpine is incomplete as noted by the letter codes shown in **Table 5**, especially so for the period of 2005 to 2008. Review of nearby weather station data shows that rainfall rates at Lakeside 2E station (#044710) are comparable, and that the station has a more complete record for this period. The Lakeside data are substituted for this period to better approximate the historical rainfall record.

- Recharge is calculated on a monthly basis as a function of rainfall. In general if rainfall is less than the soil moisture capacity, no recharge is assumed to occur. Recharge is also limited by the aquifer capacity- once 'full' no additional water can be stored. The aquifer water balance calculation results show years where this condition occurs.

  These assumptions are based on review of other soil moisture balance recharge calculations, intended to be conservative, and to be used only for screening-level purposes. The calculations do not reflect the dry season effectiveness of the check dams along Viejas Creek to retain and recharge stormwater, and are not intended to simulate changes in water levels that may occur at any specific locations within the watershed.

- The calculations are summarized on an annual basis in **Appendix A** for a single aquifer system using the rainfall record from 1971 to present (45 years). Water is withdrawn (pumped out) at a constant annual rate of 504 Acft/yr. The pumping rate is the maximum rate that can be sustained without causing the amount of water in the aquifer to be less than 50% of the total aquifer volume in any year.

In summary, the calculations show that a sustainable yield estimate of 504 Acft/yr is reasonable because the aquifer does not drop below the 50% criterion in the cumulative demand calculations based on the foregoing calculations.

Table 5. Monthly Precipitation Data, Alpine, 1952 to 2016

YEAR	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		July to June Rain Year, RF (in.) Alpine	Lakeside
1952	0.00	z	0.00	z	0.00	z	0.00	z	0.00	z	0.00	z	0.00	z	0.00	z	0.00	z	0.00		0.00	z	3.02			
1953	1.13		1.50		1.98		1.25		0.91		0.00		0.04		0.00		0.00		0.00		0.96		0.24		9.79	no data
1954	5.40		1.95		7.66		0.18		0.19		0.09		0.30		0.00		0.00		0.00		0.46		0.94		16.71	15.27
1955	4.29	c	1.96		0.80		0.47		2.52		0.00		0.11		0.16		0.00		0.03		1.07	d	0.43	c	11.74	10.94
1956	3.19		1.19		0.00		2.88		0.12		0.00		0.06		0.00		0.00		0.39		0.00		0.44		9.18	8.24
1957	7.18		0.82		1.46		1.59		2.13		0.43		0.00		0.02		0.00		3.86		0.91		1.72		14.50	12.76
1958	1.33		3.89		7.23		4.27		0.36		0.00		0.00		0.15		0.33		0.05	a	0.50		0.07		23.59	22.54
1959	0.35		6.39		0.03		0.47		0.02		0.00		0.00		0.00		0.00		0.34		0.07		2.60		8.36	8.77
1960	3.58		4.14		0.66		2.01		0.89		0.00		0.06		0.00		0.02		0.20		2.22		0.00		14.29	10.27
1961	1.03		0.22		2.35		0.00		0.00		0.02		0.00		0.36		0.03		0.62		0.97		2.22		6.12	5.67
1962	3.45		5.33		1.93		0.00		1.39		0.15		0.00		0.00		0.08		0.05		0.00		0.60		16.45	17.22
1963	0.72		2.90		1.98		1.63		0.00		0.10		0.00		0.09		2.50		0.67		2.24		0.31		8.06	8.04
1964	2.34		1.05		3.69		1.28		1.02		0.03		0.00		0.00		0.02		0.35		2.50		2.34		15.22	13.03
1965	0.58		1.70		1.42		6.77		0.04		0.06		0.08		0.00		0.60		0.00		7.76		4.01		15.78	12.22
1966	1.63		2.08		1.31		0.02		0.15		0.00		0.00		0.00		0.19		0.84		1.93		8.64		17.64	17.22
1967	2.43		0.00		1.87		4.11		0.21		0.24		0.15		0.01		0.15		0.00		3.75		3.31		20.46	9.5
1968	0.74		0.50		1.32		0.93		0.61		0.04		0.09		0.00		0.00		0.10		0.65		1.19		11.51	10.00
1969	8.80		6.76		2.91		0.33		0.51		0.06		0.00	z	0.00		0.01		0.06		1.54		0.36		21.40	19.61
1970	0.89		1.25		4.08		0.70		0.08		0.09		0.01		0.19		0.00		0.32		1.46		2.94		9.06	8.44
1971	1.24		1.68		0.40		1.41		2.38		0.00		0.00		0.00	z	0.05		1.59		0.22		5.55		12.03	12.72
1972	0.03		0.30		0.00		0.32		0.46		2.20		0.00		0.02		0.57		1.73		0.00	z	2.87		10.72	9.23
1973	3.42		3.15		5.59		0.34		0.21		0.13		0.00	z	0.02		0.00		0.00		2.27		0.22		18.03	17.95
1974	7.07		0.12		1.73		0.77		0.00		0.00		0.32		0.00		0.22		3.94		0.23		1.48		12.20	10.25
1975	0.38		1.47		4.94		3.41		0.28		0.24		0.00		0.00		0.28		0.08		1.40		0.59		16.91	16.50
1976	0.00		6.06		2.84		2.58		0.07		0.00		0.62		0.00		4.36		2.05		1.17		1.94		13.90	12.66
1977	3.06		0.49		1.85		0.15		2.45		0.06		0.03		3.09		0.01		0.90		0.42		3.49		18.20	12.79
1978	7.37		7.31		9.68		1.92		0.38		0.00		0.00		0.00		0.36		0.02		4.13		3.56		34.60	30.61
1979	7.99		2.88		5.31		0.14		0.35		0.05		0.00		0.12		0.00		1.52		0.43		0.41		24.79	24.75
1980	8.99		9.71		4.39		2.24		0.62		0.00		0.00		0.00		0.00		0.83		0.00		0.00	a	28.43	26.30
1981	0.65	b	2.63		4.55		1.12		0.22		0.00		0.00		0.00		0.00		0.27		1.31		1.03		10.00	11.40
1982	5.01		0.00	z	7.02		1.14		0.40		0.36		0.00		0.13		0.87		0.18		5.91		2.66		16.54	17.00
1983	3.27		6.04		10.92		2.56		0.30		0.00		0.00		1.66		0.29		0.33		3.59		3.50		32.84	28.53
1984	0.45		0.05		0.00	z	0.43		0.00		0.16		1.86		0.86		0.11		0.49		2.08		5.42		10.46	7.62
1985	1.38		1.68		2.09		0.67		0.07		0.07		0.05		0.00		0.46		0.49		7.41		1.73		16.78	13.33
1986	0.28		4.59		5.37		0.58		0.00		0.00		0.08		0.00		1.14		1.66		0.82		1.78		20.96	19.42
1987	1.89		2.30		2.27		0.68		0.38		0.00		0.00		0.10		0.38		2.94		3.97		2.52	a	13.00	12.68
1988	3.00		0.99		1.04		3.60		0.22		0.00		0.00		0.00		0.10		0.00		1.42		2.66		18.76	17.28
1989	0.72		2.04		1.56		0.12		0.46		0.00		0.00		0.00		0.47		0.38		0.08		0.10		9.08	6.08
1990	3.87		1.68		1.56		1.02		0.48		0.84		0.62		0.15		0.00		0.00	z	1.05		1.71		10.48	8.99
1991	0.98		3.18		12.69		0.20		0.02		0.00		0.35		0.00		0.00	z	1.51		0.00		2.68		20.60	16.94
1992	2.61		3.97		0.00	z	0.35		0.14		0.00	z	0.13		1.23		0.00		1.30	a	0.00	z	4.69		11.61	18.06
1993	15.24		5.94	a	0.83	a	0.00		0.09		0.00	z	0.08		0.00		0.03		0.10		2.39		1.30		29.45	26.98
1994	1.47		4.54		4.04		2.27		0.58		0.00		0.25		0.00	z	0.00		0.00	z	1.53		1.26		16.80	15.20
1995	9.55		3.82		8.68		2.05		1.76		0.56		0.00		0.00		0.15		0.20	a	0.26		0.29		29.46	25.46
1996	1.87		3.28		2.78		0.77		0.03		0.00		0.36		0.00		0.11		0.00	z	2.12		2.37		9.63	11.17
1997	5.82		2.37		0.00	z	0.00	z	0.08	a	0.09		0.00		0.00		1.57		0.09		2.69		2.38		13.32	11.86
1998	0.00	z	12.96		5.08		0.00	z	0.00	z	0.59		0.00	z	0.00		0.00	z	0.00	z	0.00	z	0.00	z	25.36	18.68
1999	2.44		0.97		0.94		3.10		0.04		0.70		0.11		0.00		0.34		0.00		0.00	z	0.61		8.19	9.78
2000	0.68	a	5.08		1.49		1.01		0.24	a	0.01		0.00		0.53	a	0.24		1.17		1.07		0.00		9.57	8.40
2001	3.39	b	3.78		0.97		1.68		0.00		0.00		0.05		0.00		0.00		0.00		0.16		1.70	a	12.83	12.58
2002	0.50		0.16		1.59		0.61	b	0.00		0.00		0.11		0.00		0.45		0.01		3.22		1.27	b	4.77	4.53
2003	0.14		5.14		2.42		1.89		0.70		0.15	a	0.09		0.15		0.05		0.00		1.54	a	0.00	z	15.50	15.83
2004	0.21		4.44		0.04		1.46		0.00		0.00		0.00		0.00		0.00		4.96	e	0.65		2.95	b	7.98	9.75
2005	4.73	b	5.27	c	1.77	d	0.00	z	0.29	a	0.00		0.28	y	0.00		0.00		0.00	z	0.00	z	0.02		20.62	28.87
2006	0.30		0.00	z	0.00	z	0.00	z	0.42	a	0.00		0.27	d	0.00		0.00		0.75	c	0.10	j	0.00		1.02	7.00
2007	0.82	o	2.10	d	0.00		0.00		0.08		0.00	o	0.00		0.00		0.05	b	0.00		0.00		1.45	b	4.12	7.03
2008	4.44	d	2.13	u	0.18		0.00	v	0.57	c	0.00		0.00		0.17		0.00		0.00	z	1.20	g	4.94	c	8.82	15.08
2009	0.14		4.47		0.18		0.44		0.00		0.00		0.00		0.00		0.00		0.08		0.93		2.43		11.54	13.31
2010	3.74		4.38		0.96		2.61		0.05		0.00		0.08		0.00		0.58		2.80		1.88		7.74		15.18	18.95
2011	0.74		4.74		2.52		0.78		0.72		0.28		0.11		0.00		0.20		0.55		5.00		1.37		22.86	22.09
2012	0.81		1.97		3.51		2.77		0.00		0.00		0.00		0.18		0.18		0.32		0.48		2.73		16.29	12.53
2013	2.46		1.39		1.59		0.12		0.69		0		0.08		0		0		0.94		1.52		0.77		10.14	9.54
2014	0.42		1.16		2.18		1.04		0		0		0.06		0.12		0		0		0.56		3.15		8.11	6.13
2015	1.58		0.75		1.31		0.5		2.04		0.53		0.68		0.01		0.86		0.85		1.47		3.60		10.60	9.47
2016	4.49		0.18		1.53		1.07		0.70		-----	z	-----	z	-----	z	-----	z	-----	z	-----	z	-----	z	15.44	14.33
avg monthly	2.77		2.96		2.72		1.23		0.47		0.13		0.12		0.15		0.29		0.68		1.52		1.99			
% by month	18%		20%		18%		8%		3%		1%		1%		1%		2%		5%		10%		13%			

annual July-June avg

15.06 14.21

a = 1 day missing, b = 2 days missing, c = 3 days, ..etc..,

z = 26 or more days missing, A = Accumulations present

Incomplete rainfall record for Alpine, substituted by Lakeside data

Monthly Data from WRCC Stations 40136 (Alpine) and 044711 (Lakeside)

http://www.wrcc.dri.edu/index.html

5.3 Basin-wide Groundwater Demand

The 5,750 acre watershed includes both on- and off-Reservation properties with groundwater demands. The 2012 TEIR summarized the potential future off-Reservation groundwater demands to be 106 AcFt/yr. Refer to the prior TEIR for further details.

Current net on-Reservation groundwater demand is approximately 218 Acft/yr (**Table 1**). The Project is estimated to add 12 AcFt/yr to the net demand. Future off-Reservation demand is estimated to be 106 Acft/yr. These demands total to 336 AcFt/yr and are less that the long-term sustainable yield of 504 AcFt/yr presented in **Section 4** or the rate of 450 AcFt/yr presented in the 2014 TEIR.

5.4 Reclaimed Water Recharge

Viejas' water reclamation system allows for a substantial amount of groundwater to be treated to tertiary Title 22 standards and recharged. The proposed project will create more reclaimed water than needed for irrigation. The excess will be recharged. Currently reclaimed water is recharged in a percolation basin located to the east of the project area as shown in **Figure 5**. This recharged water supports flow within the Viejas Creek channel and supports a hydrologic boundary condition along the southern portion of the Reservation that mitigates the effect of on-Reservation pumping. A second hydrologic boundary condition has been established by the in-channel retention basins constructed along Viejas Creek.

A second recharge basin is proposed to be constructed in the eastern portion of the Reservation within the central valley. The purpose of this second recharge basin will be to increase groundwater levels within the eastern portion of Viejas Valley and thus expand the areal effect of recharge to be of benefit to areas north and east of the Reservation.

5.5 Summary

Neither of the County significance criteria is exceeded.

1. A decrease in saturated thickness of 5% or more in the offsite wells would be considered a significant impact. Pumping is distributed across the Reservation and changes in pumping rates and water level drawdown will be directly proportional to the net groundwater demand. The calculated net change in the groundwater pumping rate is 5%. Much of the potential impact from increased potable water demand is offset by wastewater reclamation, treatment, and recharge of tertiary-treated "Title 22 water".

2. Total on-Reservation and projected off-reservation groundwater extraction is not in excess of the calculated sustainable yield, as defined in the County Guidelines as cumulative depletion of storage of greater than 50 percent capacity of the given basin.

6.0 REFERENCES

BRG, 2012. Tribal Environmental Impact Report (TEIR) for the Viejas North Tower Hotel Project prepared for The Viejas Band of Kumeyaay Indians by BRG Consulting dated March 2012.

BRG, 2014. Tribal Environmental Impact Report (TEIR) for the Viejas South Tower Hotel Project prepared for The Viejas Band of Kumeyaay Indians by BRG Consulting dated April 2014.

Brown & Caldwell, 2001. Viejas Indian Reservation Water and Wastewater Master Plan. Brown & Caldwell Engineers, dated July 2001. A copy of the document was included in Appendix D of BRG, 2012 (cited above).

CA Division of Mines and Geology, 2000. State Geologic Map, DMG CD 2000-007, based on Jennings, 1977 Geologic Map of California

CIMIS, 2016. The California Irrigation Management Information System (CIMIS) is a program of the Office of Water Use Efficiency (OWUE), California Department of Water Resources (DWR) http://www.cimis.water.ca.gov

County of San Diego, 2010. County of San Diego Department of Planning and Land Use General Plan Update Groundwater Study. Prepared by the County of San Diego. Final dated April 2010. Included as Appendix D of the EIR for the County General Plan Update. The County of San Diego Board of Supervisors certified the Final Program Environmental Impact Report (EIR) for the General Plan Update and adopted the update to the General Plan on August 3, 2011.
(http://www.sdcounty.ca.gov/pds/gpupdate/environmental.html)

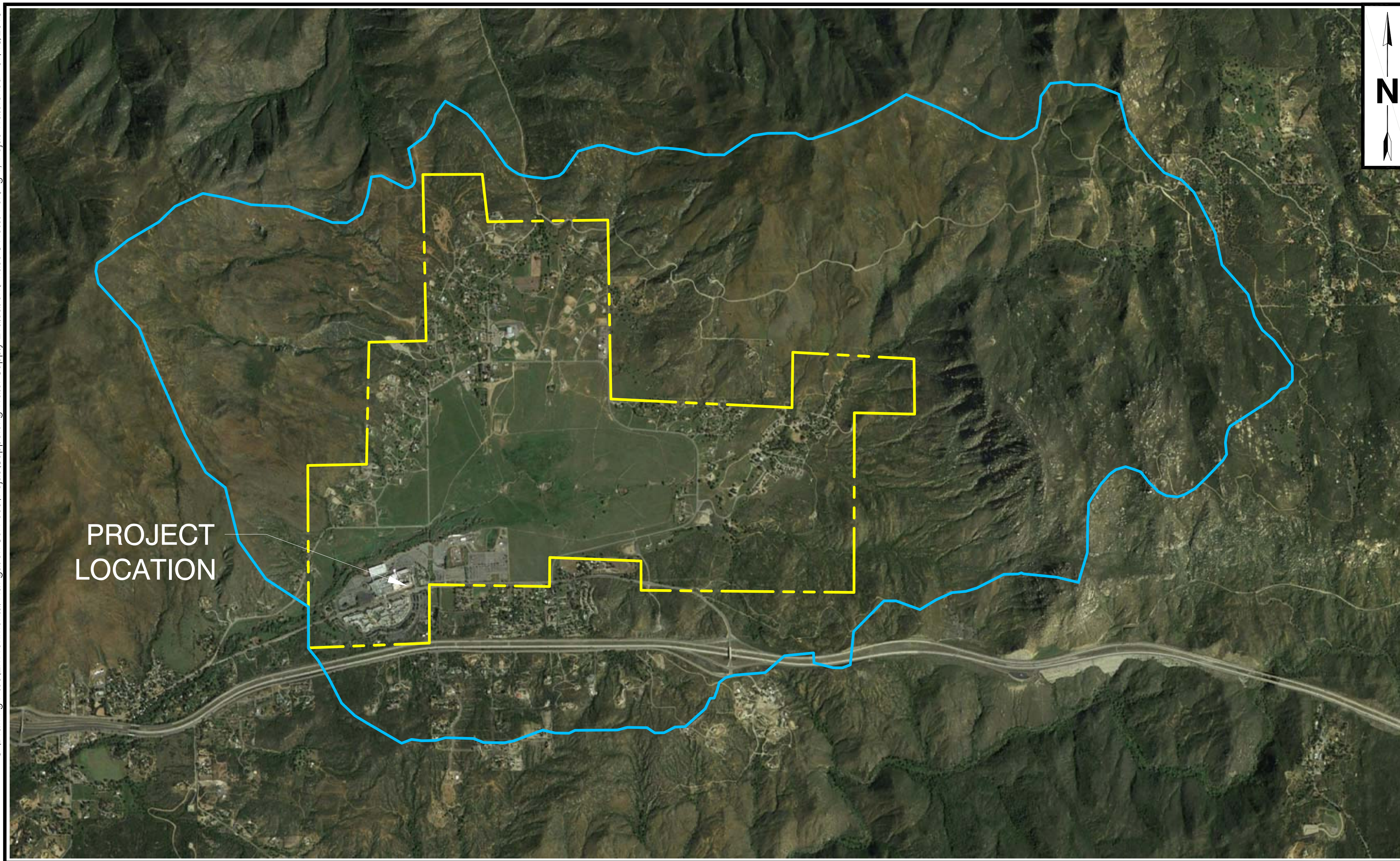
Freeze and Cherry, 1979. Textbook entitled *Groundwater*, by RA Freeze and JA Cherry, 1979, Prentice-Hall pub.

NOP, 2016. Notice of Preparation of a Draft Tribal Environmental Impact Report. Prepared by Viejas Enterprises, dated May 2016.

Viejas DPW, 2016. Refers to confidential water supply and water treatment data provided to ENSI for this report by the Viejas Department of Public Works (DPW).

USDA, 2016. US Department of Agriculture Natural Resource Conservation Service “Websoil” on-line database (http://websoilsurvey.nrcs.usda.gov/app/).

WRCC, 2016. Monthly Precipitation obtained from the Western Regional Climate Center. Per their website "The Western Regional Climate Center, inaugurated in 1986, is one of six regional climate centers in the United States. The regional climate center program is administered by the National Oceanic and Atmospheric Administration. Specific oversight is provided by the National Climatic Data Center (NCDC) of the National Environmental Satellite, Data, and Information Service (NESDIS)". http://www.wrcc.dri.edu/ The Alpine and San Diego data were obtained at http://www.wrcc.dri.edu/summary/Climsmsca.html.



C:\Drawing Files\Environmental Navigation Services\Viejas\Supporting Water Supply Evaluation\Phase 3 Hotel Tier\Fig 1, Viejas Watershed - 07/13/2016

Environmental Navigation Services, Inc.

0 3,000 6,000 FEET

APPROXIMATE SCALE

EXPLANATION BLOCK

Viejas Reservation Boundary

Viejas Watershed Boundary

NOTE:

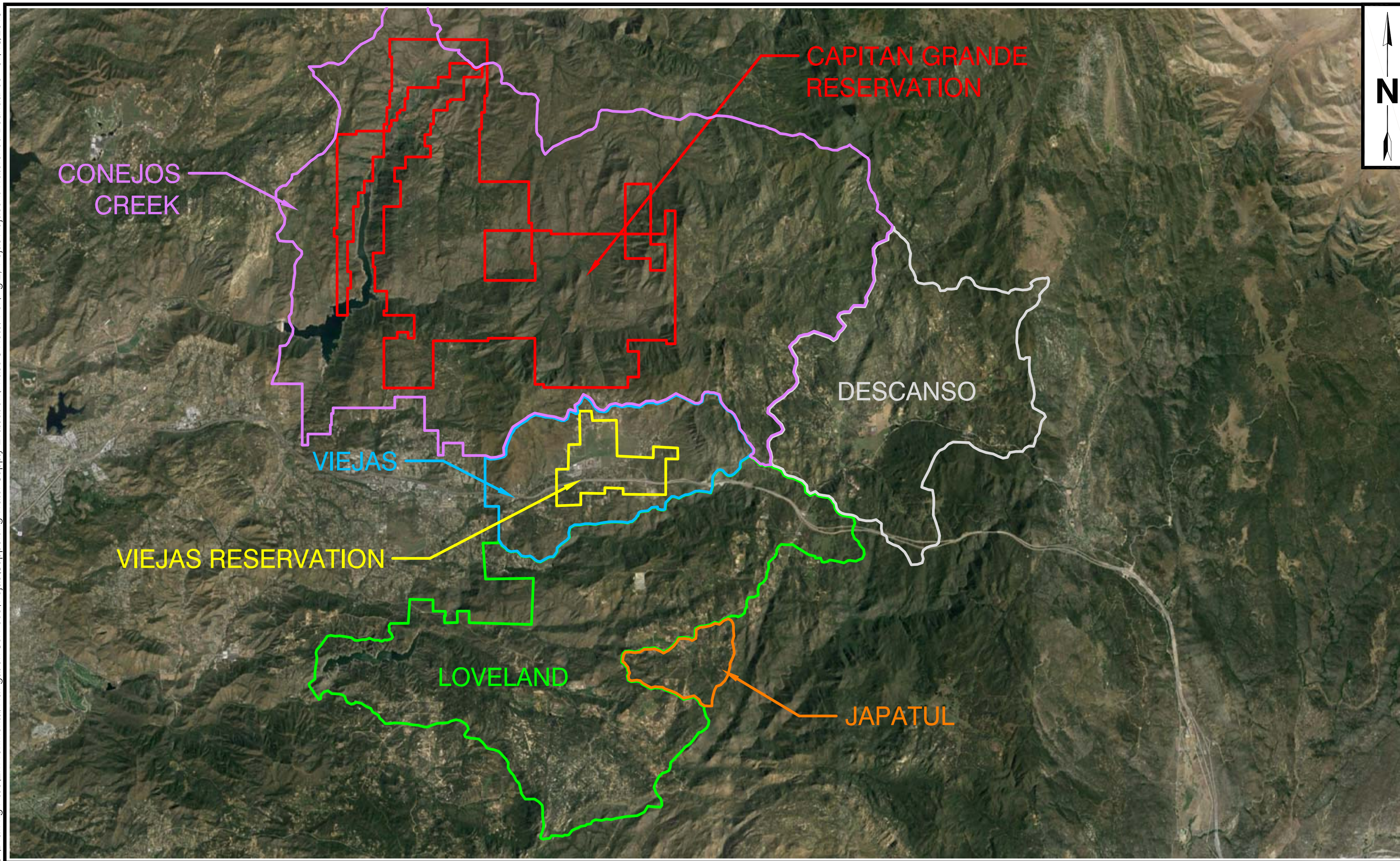
Base Map Sources:

Google Earth, Image Date 3/22/2016

VIEJAS WATERSHED

Supporting Water Supply Evaluation: Phase 3 Hotel Tier

PE/PG	Project Number		Figure
JWJ	VIEJAS		1
Project Manager	Drafter	Date	
JWJ	CM	7/13/2016	



C:\Drawing Files\Environmental Navigation Services\Viejas\Supporting Water Supply Evaluation\Phase 3 Hotel Tier\Fig 2, Viejas Adjacent Watershed Boundaries - 07/13/2016

Environmental Navigation Services, Inc.

0 15,000 30,000 FEET
APPROXIMATE SCALE

EXPLANATION BLOCK

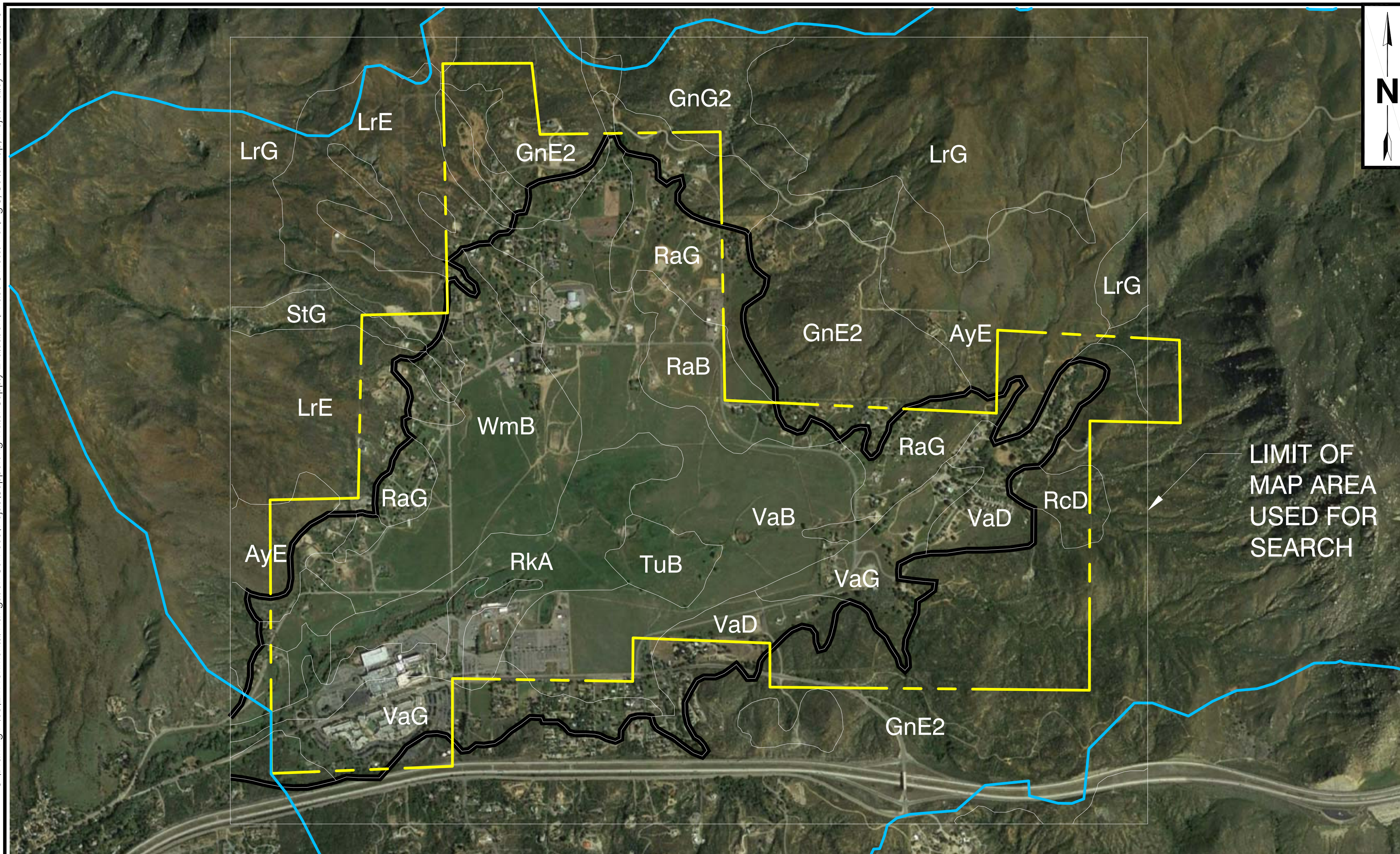
- Viejas Reservation Boundary
- Capitan Grande Reservation Boundary
- Descanso Watershed Boundary
- Japatul Watershed Boundary
- Loveland Watershed Boundary
- Conejos Creek Watershed Boundary
- Viejas Watershed Boundary

NOTE:
- Reference: County of San Diego DPS, General Plan Update Groundwater Study, Figure 3-8
- Base Map Source: Google Earth, Image Date 3/22/2016

VIEJAS ADJACENT WATERSHED BOUNDARIES

Supporting Water Supply Evaluation: Phase 3 Hotel Tier

PE/PG	Project Number		Figure
JWJ	VIEJAS		2
Project Manager	Drafter	Date	
JWJ	CM	7/13/2016	



C:\Drawing Files\Environmental Navigation Services\Viejas\Supporting Water Supply Evaluation\Phase 3 Hotel Tier\Fig 3, Soils Map, Viejas Valley - 07/13/2016

Environmental Navigation Services, Inc.

0 2,000 4,000 FEET
APPROXIMATE SCALE

EXPLANATION BLOCK

- Viejas Reservation Boundary
- Viejas Watershed Boundary

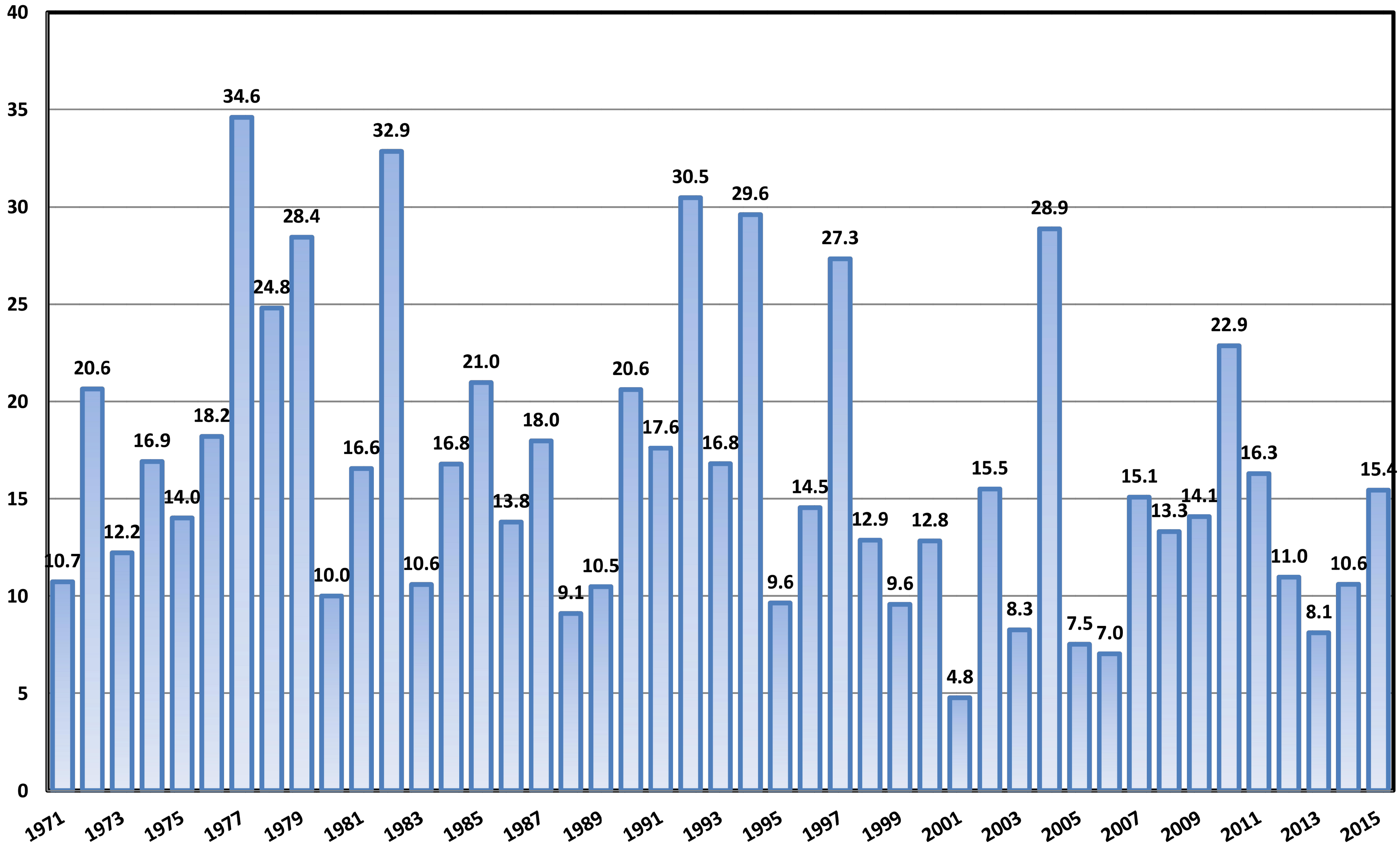
NOTE:
- Source: USDA Natural Resources Conservation Service (NRCS) Web Soil Soil Survey (WSS)
- Base Map Source: Google Earth, Image Date 3/22/2016

SOILS MAP FOR THE VIEJAS VALLEY

Supporting Water Supply Evaluation: Phase 3 Hotel Tier

PE/PG	Project Number		Figure
JWJ	VIEJAS		3
Project Manager	Drafter	Date	
JWJ	CM	7/13/2016	

C:\Drawing Files\Environmental Navigation Services\Viejas\Supporting Water Supply Evaluation\Phase 3 Hotel Tier\Fig 4, Annual Rainfall In Inches Per Year - 07/13/2016



Environmental Navigation Services, Inc.

ANNUAL RAINFALL AT ALPINE
INCHES PER YEAR, JULY TO JUNE
(AVG=16.4)

Supporting Water Supply Evaluation:
Phase 3 Hotel Tier

PE/PG	Project Number		Figure
JWJ	VIEJAS		4
Project Manager	Drafter	Date	
JWJ	CM	7/13/2016	

C:\Drawing Files\Environmental Navigation Services\Viejas\Supporting Water Supply Evaluation\Phase 3 Hotel Tier\Fig 5, Recharge Basin Location & Viejas Creek Hydrologic Conditions - 07/13/2016

Environmental Navigation Services, Inc.

0 1,200 2,400 FEET
APPROXIMATE SCALE

EXPLANATION BLOCK

Viejas Reservation Boundary

Viejas Watershed Boundary

NOTE:
Base Map Sources:
Google Earth, Image Date 3/22/2016

RECHARGE BASIN LOCATION AND VIEJAS CREEK HYDROLOGIC CONDITIONS

Supporting Water Supply Evaluation: Phase 3 Hotel Tier

PE/PG	Project Number		Figure
JWJ	VIEJAS		5
Project Manager	Drafter	Date	
JWJ	CM	7/13/2016	

APPENDIX A:

SOIL MOISTURE-BASED AQUIFER WATER BALANCE

APPENDIX A: SOIL MOISTURE-BASED AQUIFER WATER BALANCE
Viejas Phase 3 Hotel TEIR Supporting Water Supply Analysis

July 13, 2016

SUMMARY

The water supply area for the Viejas Indian Reservation encompasses an approximately 5,750-acre watershed that includes the uppermost portion of the Viejas Creek Watershed (**Figures 1 and 2** of the Supporting Water Supply Evaluation). A series of production wells located within the watershed are operated by Viejas as a public water supply regulated by the US EPA.

Considered in this analysis is the availability of water from the upper portion of the aquifer system, composed of alluvium and decomposed granite (DG), and from the underlying granitic bedrock. The estimated long-term maximum groundwater withdrawal rates primarily depend upon the available groundwater in storage within the aquifer. The amount of water potentially available from the bedrock aquifer system is assumed to be roughly proportional to the watershed area, whereas the storage capacity of the alluvium and DG generally occurs within the central portion of the watershed within the Reservation coincident with Viejas Creek.

The long-term sustainable yield used in this analysis is consistent with that described in the County of San Diego Groundwater Ordinance wherein only 50% of the water in storage can actually be withdrawn by wells during any water year using historical rainfall to calculate groundwater recharge. This means that the maximum pumping rate is limited to the rate that can be produced during drought periods. Here local rainfall records from 1971 to 2016 are used to evaluate recharge and the overall aquifer water balance based on a July to June time period.

The soil moisture water balance methodology used here supports that the safe yield of the aquifer system within the watershed is 504 Acft/yr on a long-term basis, sufficient water to provide groundwater for the Project in the context of safe yield as currently defined by the County of San Diego standards and generally-accepted methodologies. The long-term average withdrawal from the aquifer system is much less than 50%, and in this instance the average annual storage volume under pumping conditions was 90% since 1971. Thus given the operation of the watershed under a condition of long-term safe yield, the long-term impacts of groundwater withdrawals from a volumetric perspective are not significant.

Wastewater is collected on-Reservation, processed by a wastewater treatment system, treated to tertiary CA Title 22 standards, and reclaimed.   A significance portion of the water used by the Project that is reclaimed will exceed tribal demand for irrigation water. Excess reclaimed water will be recharged on-Reservation.   Recharge of treated wastewater serves to offset groundwater extraction, mitigate potential off-reservation impacts related to groundwater extraction, and decrease the net Project demand.

Please note:
1) Water production is quantified in Acre-feet (AcFt). One AcFt is approximately 325,829 gallons and is the amount of water that will cover one acre of land to a depth of one foot.

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A.1 INTRODUCTION

The proposed Project is the Phase 3 expansion of Viejas' commercial area that currently includes a Casino, Outlet Center, and two hotel towers. Please refer to the TEIR for further details.

This Appendix provides an evaluation of the safe yield of the groundwater supply so that long-term groundwater depletion does not occur. Groundwater recharge must be sufficient to offset the withdrawal of water from the site to ensure that the available groundwater is not depleted during extended periods of low rainfall. Historical precipitation data (1971 to 2015) were used to determine the amount of water that will be available to recharge the aquifer on a continuing basis. While acknowledging that County regulations do not apply on Tribal trust lands, the approach presented herein follows the methodology generally accepted by the County of San Diego as described in the Groundwater Ordinance (No.s 7994 and 9644) and the County Standards for Site Specific Hydrogeologic Investigations that supplement the Groundwater Ordinance. (These can be referenced at http://www.co.san-diego.ca.us/dplu/Resource/docs/3~pdf/GROUNDWATER-ORD.pdf and http://www.co.san-diego.ca.us/dplu/Resource/docs/3~pdf/hydrogeostand.pdf).

Viejas' Tribal infrastructure includes a Reservation-wide wastewater collection and a centrally-located treatment system used to reclaim wastewater from residential, tribal, and commercial sources. The reclaimed water is redistributed across the 1600-acre Reservation and used for irrigation to the extent practicable to replace the direct use of groundwater.

Excess reclaimed water is sent to a percolation basin where it flows back into the ground to recharge the aquifer system. The return flow of treated wastewater serves to offset groundwater pumping and reduce the net groundwater pumping rate.

A.2 HYDROGEOLOGIC SETTING

This evaluation assesses the hydrologic water balance (supply versus demand) for the 5,750-acre upper Viejas Creek watershed located within and around the 1600-acre the Viejas Indian Reservation. Note that the aquifer boundaries are being approximated by the surface water watershed to facilitate the aquifer water balance calculations presented in this Report.

A.2.1 Viejas Creek Watershed and Aquifer System

The Reservation is located entirely within crystalline rock terrain. The upper Viejas Creek watershed includes an aquifer system that consists of sand and gravels along the creek channel derived from the adjacent granitic hills, an intermediate zone of decomposed granite (DG), and underlying unweathered, fractured crystalline rock. The central portion of the Viejas Creek watershed contains extensive deposits of alluvium and extensive decomposed granite.

Soils within the watershed formed in response to weathering of granitic rock. The soils mapped within the water shed include loamy coarse sands and sandy loams. Refer to the TEIR Water Supply Report for further discussion of the soils that occur in the area and specifically within the watershed.

Viejas has constructed a series of surface water retention structures along the alluvial stream channel within the central portion of the watershed. It is an area where groundwater replenishment is rapid and reliable and primarily controlled by infiltration of stormwater and seasonal streamflow.

A.2.2 Site-Specific Hydrogeologic Parameter Values

One of the most critical parameters to determine the long-term safe yield of a site is the storage capacity of the aquifer system. It is defined as the ratio of the volume of water released from the aquifer to the volume of aquifer containing the water when water is withdrawn from the aquifer under pumping conditions or as a result of a decrease in water levels. This essentially is the amount of water that can be obtained from and/or stored within the aquifer. Water is stored in the pore space of the rock- within unweathered crystalline rock the pore space consists of the volume created by rock fractures. Typically the storage capacity of unweathered crystalline rock is accepted to range between 0.1 and 0.01 percent of the rock volume (1×10^{-3} to 1×10^{-4}), depending on the overall state of fracturing and weathering within the rock mass.

The storage coefficient of an unconfined aquifer is termed the specific yield; for a confined aquifer the value is termed the specific storage. The fractured rock aquifer system may occur under a mix of confined and unconfined conditions, depending upon the style and extent of fracturing within the rock. Here the term storage coefficient is used to define the amount of extractable water available from the aquifer system.

The storage coefficient values will vary across the site as a function of the degree of fracturing and weathering within the rock mass. For this analysis, consistent with other projects reviewed and approved by the PDS, the following storage coefficients (S) will be assumed and used. Alluvial sands and gravels have a storage coefficient of 0.10 (10%); weathered granitic rock (decomposed granite, or DG) has a storage coefficient of 0.05 (5%); and the underlying bedrock has a storage coefficient of 0.0001 (0.01%).

The values used herein are conservative approximations that may be subject to revision following the future collection and review of site-specific data or analysis. A total aquifer storage of 2,579 AcFt is presented in this Appendix. A very similar value of 2,582 AcFt was used in a preceding Tribal EIR analysis in 2014.

A.3 WATER DEMAND AND USE

A.3.1 Known and Potential Water Use

On-reservation and Off-Reservation water use data and projections are included in Supporting Water Supply Evaluation. The data are summarized in **Tables 1 and 2** of the Supporting Water Supply Analysis.

The projected increase in total and net on-Reservation groundwater pumping is 37.3 and 12 AcFt/yr, respectively. The net pumping rate is due to the fact that a significant portion of the water from Viejas' wastewater reclamation program is recharged on-Reservation and offsets the total pumping. This is a net pumping increase of 5% compared to the net pumping rate observed in 2015.

Projected off-Reservation groundwater use is 106 AcFt/yr (from the 2014 TEIR).

A.4 PROJECT WELLS

Due to security concerns the well locations are not shown in this report. The cumulative observed long-term production capacity of the wells exceeds the projected water demand.

A.5 SAFE/SUSTAINABLE YIELD ESTIMATES

Safe yield is estimated herein based upon a long-term historical water balance for the 5,750 acre Viejas Creek watershed. The aquifer provides for seasonal storage where rainfall recharge is in a long-term balance with the groundwater withdrawal rate. In other words rainfall recharge replaces the groundwater that is used on a long-term basis. The historical rainfall record is used to account for historical drought periods. Groundwater storage is relied upon during drought cycles when rainfall recharge is low.

A soil moisture balance calculation is used to determine the rate of groundwater recharge. The overall water balance is determined on a monthly basis from the historical rainfall record. Each month that rainfall occurs, recharge will occur if the amount of rainfall exceeds the soil moisture capacity, water lost to surface water runoff, and the amount of water consumed by plants and lost to evaporation and plant transpiration (termed potential evapotranspiration, or pET). Note that the pET rate primarily accounts for evaporation from soil- native plants tend to have very low ET rates.

The soil moisture balance equation for recharge is given by:

$$Recharge_i = ppt_i - runoff_i - pET_i - (SM_i - SM_{i-1})$$

where:

ppt, is the rainfall in month i
pET, is the potential evapotranspiration rate in month i
SM, is the soil moisture in month i and previous month i-1
runoff, is the surface water runoff in month i as given by:

$$runoff_i = ppt_i * pct * (SM_{i-1}/SMcap)$$

where:

runoff, is the volume of runoff in month i
pct, is the assumed maximum percentage of rainfall runoff in month i
SM, is the soil moisture at the time of rainfall
(The antecedent moisture condition, previous month i-1)
SMcap, is the soil moisture capacity for the soil, a constant

All values herein are expressed in inches. Volumes are calculated based upon the area of consideration. An Excel spreadsheet developed for these calculations is attached to this report.

Recharge occurs when the precipitation exceeds runoff, evapotranspiration, and the soil moisture capacity. Water can be stored in the soil at an amount up to the soil moisture capacity. Each month the antecedent moisture condition is evaluated to determine if the soil moisture capacity has already been met. If the soil is at the soil moisture capacity, recharge will be immediate.

Runoff is calculated as a function of the soil moisture condition. It is assumed to be a maximum when the soil is saturated. Here a runoff value of 25 percent is assumed. Note that the runoff rate decreases (and the available groundwater increases) if the riparian habitat and valley slopes are naturally vegetated and support the retention of stormwater. This value is viewed to be conservative for the Viejas Reservation because it does not explicitly consider the beneficial impact of the in-channel retention basins.

A.5.1 Groundwater Storage Capacity and Aquifer Properties

Based upon the drilling and anticipated lateral extent of the aquifer system it is assumed herein that the aquifer properties are consistent with those observed in adjacent crystalline rock aquifer systems. Alluvium, DG, and bedrock all provide for groundwater storage.

The total storage is calculated to be a total of 2,579 AcFt as follows. Note that the water balance calculations assume that only 50% of the water is available for water production so the total effective storage capacity from the alluvium, DG, and bedrock used in the water supply calculations is 1289 AcFt.

266 AcFt in the alluvium section,
Based on an average thickness of 20 feet, an area of 133 acres, and a storage coefficient of 0.10. This estimate is limited to the alluvium known to occur within the lower portion of the Viejas Creek watershed.

2025 AcFt in the DG section,
Based on an average thickness of 30 feet, an area of 1350 acres, and a storage coefficient of 0.05. Review of available well logs for the water supply wells shows that the depth of DG in wells ranges from 30 to 80 feet below ground surface. These well logs are confidential and are not included in this publicly-available report. This estimate includes much of the valley floor within central Viejas Reservation. Tributary areas to the central portion of the drainage are not included in this estimate, but these are also likely to contain extensive DG.

288 AcFt in the bedrock
Based on an average thickness of 500 feet, an area of 5,750 acres, and a storage coefficient of 0.0001. This evaluation assumes that wells up to 500 feet below the water table (or below the DG/bedrock interface where DG occurs) can be installed to provide groundwater from the underlying bedrock aquifer system. This estimate is conservative as wells have been drilled that are on the order of 1000 feet in total depth. A higher bedrock storage coefficient was considered that would be used based on a midpoint between highly fractured bedrock (S= 0.001) and less fractured bedrock (S= 0.0001) since review of drilling logs indicate that extensive fracturing occurs with depth. This assumption is supported by the observation that Viejas' water supply wells are all completed in crystalline bedrock and produce water at rates of 40 to 300 gpm. However a lower value was conservatively used to assess the long-term water supply.

A.5.2 Recharge

Recharge occurs after the soil moisture capacity is exceeded according to the soil moisture balance equation. Sufficient precipitation must occur to wet the soil; however, evapotranspiration and runoff losses can offset rainfall recharge. The calculation of rainfall recharge is based upon climatological and soil properties and recharge occurs independent of the aquifer properties. Groundwater recharge occurs infrequently at the site and the bulk of the rainfall occurs during the winter rainy season. Rainfall events during the summer often occur when the soil is dry and evapotranspiration losses are high, thus limiting the potential recharge rate for low intensity rainfall events.

A series of retention basins have been constructed along Viejas Creek within the Reservation. These serve to slow the off-Reservation movement of stormwater and substantially enhance recharge rates.

A.5.3 Historical Precipitation

The historical rainfall record used for this analysis was obtained from the Alpine weather station. The period of record used in this analysis is between the years 1971 and 2015 (shown in **Figure 3** of the Supporting Water Supply Evaluation).

The County of San Diego DPLU (now Planning and Development Services [PDS]) developed a 30-year rainfall average rainfall for the period of 1971 to 2001. Their map provides contours depicting the average rainfall rates across the county and incorporates the effect of terrain and other factors to extrapolate the rainfall station data. The 30-year average shown for the Viejas Reservation includes two rainfall zones: 18 to 21 in/yr in the valley, and 21 to 24 in/yr in the adjacent hillsides. The primary reason for the difference is that the Alpine rainfall measurements were obtained from a location west of the Reservation whereas rainfall is observed to increase to the west with increasing elevation.

The Alpine rainfall data are used for the water balance based on a comparison of the Alpine rainfall with the PDS' 30-year average. Alpine rainfall averages 17.6 in/yr over the 30-year period whereas the DPLU map indicates a range of rainfall rates within the Viejas watershed with an average rainfall of approximately 21 inches per year. Thus the Alpine rainfall data have been adjusted (increased) by a factor of 1.19 for use in the water balance for the Viejas Reservation. Rainfall since 2001, on average, have been less than observed for the period of 1971 to 2001. When all of the data from 1971 to 2015 are considered, the average rainfall at Alpine was 16.4 in/yr and the average annual rainfall used for the Viejas Reservation is 19.6 in/yr (both less than the PDS 30-year averages used for the rainfall map).

The analysis includes rainfall data through May 2016 and incorporates the impact of the recent drought period.

A.5.4 Estimated Evapotranspiration Rates

The evapotranspiration (ET) rate is the rate that plants and soil lose water to the atmosphere due to rainfall by normal plant respiration and soil drying. Climatic parameters such as temperature, cloud cover, and wind strongly affect hydrologic conditions. The overall effect of these parameters can be seen in the rate of evaporation and plant transpiration (termed evapotranspiration, or ET). The ET rate used in this study is based on a state-wide monitoring system known as CIMIS (www.cimis.water.ca.gov). The California Irrigation Management Information System (CIMIS) is a program in the Office of Water Use Efficiency (OWUE), California Department of Water Resources (DWR) that manages a network of over 120 automated weather stations in the state of California. CIMIS was developed in 1982 by the California Department of Water Resource and the University of California at Davis to assist California's irrigators to manage their water resources efficiently.

The ET data published by CIMIS for zone 16 were used in this report. The Viejas watershed is located at the boundary of CIMIS zones 9 and 16; however, the ET values for zone 16 were used because they support a more conservative evaluation of rainfall recharge.

A.5.5 Recharge Area

Groundwater recharge may occur across the entire 5,750-acre basin. The recharge rate is based on spatially-averaged soil properties. Recharge is expected to be higher within alluvial channels and within the retention basins where stormwater will accumulate.

A.5.6 Soils and Recharge Rates

The soils within the watershed have been mapped and classified by the US Department of Agriculture (USDA) as shown in **Figure 3** of the Supporting Water Supply Evaluation**.** An average soil moisture capacity of 2.4 inches is used here for the moisture capacity of soils in the watershed.

A.5.7 Calculation of Recharge Using Soil Moisture Balance Methods

Estimates of the amount of groundwater recharge were conducted using an Excel spreadsheet that calculates the soil moisture balance (and recharge) on a monthly basis between 1971 and 2015. (The calculation methodology is consistent with that used by a FORTRAN program named Recharge2, written by Dr. David Huntley of San Diego State University and generally accepted for similar projects by the County PDS). <u>The spreadsheets are included at the end of this Appendix.</u>

The basis for the analysis includes the following:

1) Historical rainfall data from the Alpine, CA weather station and the DPLU rainfall map. Rainfall data from Lakeside have been used to supplement missing rainfall data.
2) Historical evaporation data obtained from CIMIS (climate zone 16).
3) Estimates of the storage coefficient of the alluvium, DG, and underlying crystalline rock.
4) Soils data obtained from the US Department of Agriculture (as described in **Section 5.2.4**). An area-weighted average value of 2.4 inches is used for the soil moisture capacity in the water balance calculations.
5) A general description and field review of the upper Viejas Creek watershed.

The following assumptions were made regarding the crystalline rock aquifer system:

1) Well production is limited to depths of approximately 500 feet below the water table. Per the County Groundwater Ordinance being used herein as a guide, only 50% of the storage is assumed to be available to the wells at the site. (Note that local wells often exceed this depth.)
2) The DG aquifer has an assumed storage coefficient of 0.05, and the underlying bedrock aquifer has an assumed storage coefficient of 0.0005. It is conservatively assumed that all storage occurs either in DG or within the underlying bedrock and that there is no storage in the alluvium.
3) All of the water is considered potable and useable.

Figure A.1 is based on a 5,750-acre aquifer with a total storage capacity of approximately 2413 AcFt, and an effective storage capacity of approximately 1206 AcFt per DPLU guidelines (50% of the total aquifer storage). It depicts the seasonal groundwater withdrawal and use on an annual basis. The maximum withdrawal rate basin-wide that can be sustained on a long-term basis is 490 AcFt per year. This reflects the driest historical period in the rainfall record; however, the aquifer remains at 90% of its capacity on an average annual basis.

A.5.8 Wastewater Return Flows

Groundwater recharge occurs via the return flow of excess recycled/ reclaimed water to an on-Reservation percolation basin. The water is being treated to tertiary CA Title 22 standards. The data are presented in the main report and are used to calculate the net on-Reservation groundwater demand.

A.6 Water Balance Summary

The overall water supply analysis is summarized in **Table 1**.

Table 1. Groundwater Supply Summary

Component	
Watershed Area, acres	5,750 acres
Groundwater Storage, AcFt	2,579 Ac-ft (total): 266 in alluvium 2025 in DG 288 from bedrock
Rainfall ft/year average	1971 to 2016 average annual rainfall is 19.6 inches/yr (9,379 Acft/yr)
Sustainable Extraction Rate (Maximum)	504 Acft/yr, 5.4% of average rainfall
Projected Viejas Net Demand	230 AcFt/yr
Future Off-Reservation Demand	106 AcFt/yr at buildout
TOTAL	336 AcFt/yr

A.7 LIMITATIONS

This Appendix provided estimates the potential safe groundwater yield for the upper portion of the Viejas Creek watershed using a methodology currently accepted by the County of San Diego PDS. These estimates of the aquifer properties and safe yield, similar to all geologic and hydrologic measurements, are subject to uncertainty. The results and findings of this report are limited to historical conditions and do not preclude the potential for drought conditions in excess of those observed between 1900 and 2015.

This report does not guarantee, either explicitly or implicitly, that an adequate long-term water supply exists on- or off-Reservation, or that existing or future water wells will provide a sufficient quantity and quality of potable water. For example, groundwaters naturally high in total dissolved solids, radionuclides, or minerals such as arsenic, iron, and sulfate occur in granitic terrain. However it is understood that the on-Reservation water supply is operated by Viejas as a public water supply and follows US EPA regulations and that they have a well-established a safe and reliable drinking water system. Off-reservation water supply wells are generally not subject to routine testing and monitoring.

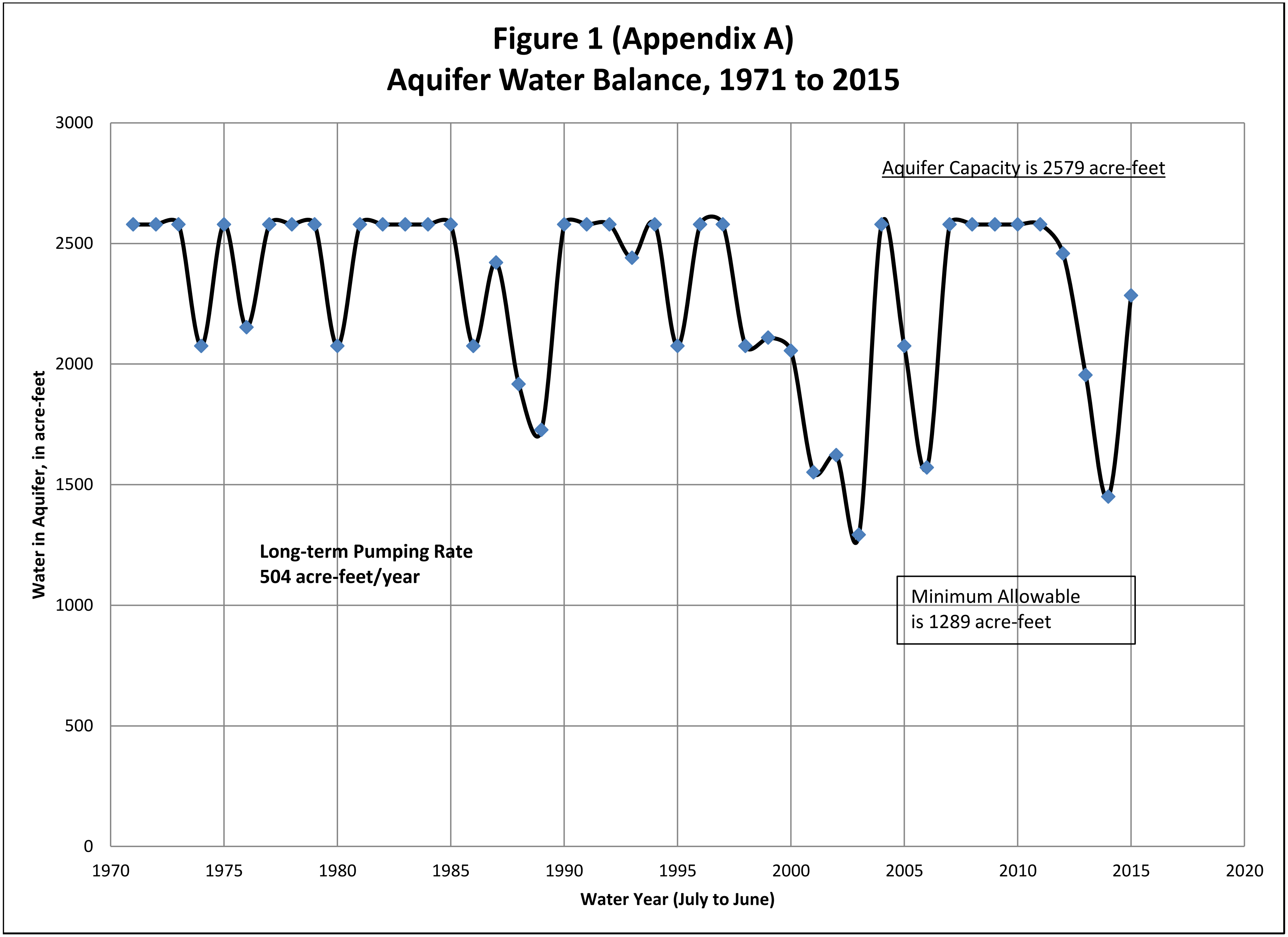
Figure 1 (Appendix A)
Aquifer Water Balance, 1971 to 2015
Aquifer Capacity is 2579 acre-feet
Long-term Pumping Rate
504 acre-feet/year
Minimum Allowable
is 1289 acre-feet
Water in Aquifer, in acre-feet
Water Year (July to June)
3000
2500
2000
1500
1000
500
0
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

RECHARGE CALCULATIONS: Soil Moisture Balance ver. 17June2016

Viejas Indian Reservation

Alpine Rainfall Statistics (inches/yr)			
maximum	**34.6**	**(1977 to 1978)**	
minimum	**4.8**	**(2001 to 2002)**	
average	**16.4**	**(1971 - 2016)**	
st dev	**7.4**		
30 year avg (Alpine: 1971 to 2001)			**17.6**
DPLU Map Rainfall for Site (30 yr)			**21.0**
Difference (increase vs DPLU map)			**1.19**
Adjustment Factor			**1.19 (rf)**

Soil Parameters	
2.40	Soil Moisture Capacity, smcap
0.25	Runoff Coefficient, roff

Indicates Input Variables

19.6 Avg Annual Viejas RF (adjusted, 1971 - 2016)

EvapoTranspiration

ET coeff		**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**total**
1	**ET rate**	9.30	8.37	6.30	4.34	2.40	1.55	1.55	2.52	4.03	5.70	7.75	8.70	**62.51**
	CIMIS 16	9.30	8.37	6.30	4.34	2.40	1.55	1.55	2.52	4.03	5.70	7.75	8.70	

Monthly Rainfall Data: July 1971- February 2016

YEAR		**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**Annual RF Total**	**Annual Roff, Rch**	**by pct.**	
1971		0.01	0.00	0.05	1.59	0.22	5.55	0.03	0.30	0.00	0.32	0.46	2.20	**10.73**		**12.77**	adj RF
Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.00	0.00	0.00	0.00		**0.04**	0%	runoff
SM param		-9.29	-8.37	-6.24	-2.45	-2.14	5.05	0.89	-1.28	-4.03	-5.32	-7.20	-6.08				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	2.40	0.89	0.00	0.00	0.00	0.00	0.00			79%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	2.65	0.00	0.00	0.00	0.00	0.00	0.00		**2.65**	21%	recharge
1972		0.00	0.02	0.57	1.73	2.61	2.87	3.42	3.15	5.59	0.34	0.21	0.13	**20.64**		**24.56**	adj RF
Runoff		0.00	0.00	0.00	0.00	0.00	0.25	1.02	0.94	1.66	0.10	0.00	0.00		**3.97**	16%	runoff
SM param		-9.30	-8.35	-5.62	-2.28	0.71	2.57	4.92	3.63	5.02	-2.90	-7.50	-8.55				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.71	2.40	2.40	2.40	2.40	0.00	0.00	0.00			73%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.29	0.96	0.00	0.00	0.00		**2.75**	11%	recharge
1973		0.00	0.02	0.00	0.01	2.27	0.22	7.07	0.12	1.73	0.77	0.01	0.00	**12.22**		**14.54**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.04	0.00	0.00	0.00	0.00		**0.05**	0%	runoff
SM param		-9.30	-8.35	-6.30	-4.33	0.30	-0.99	6.86	0.02	-1.95	-4.78	-7.74	-8.70				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.30	0.00	2.40	0.02	0.00	0.00	0.00	0.00			69%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	4.46	0.00	0.00	0.00	0.00	0.00		**4.46**	31%	recharge
1974		0.32	0.00	0.22	3.94	0.23	1.48	0.38	1.47	4.94	3.41	0.28	0.24	**16.91**		**20.12**	
Runoff		0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.78	0.01	0.00		**0.81**	4%	runoff
SM param		-8.92	-8.37	-6.04	0.35	-1.78	0.21	-0.89	-0.77	1.85	0.21	-7.21	-8.41				
Soil Mo.	0.00	0.00	0.00	0.00	0.35	0.00	0.21	0.00	0.00	1.85	0.21	0.00	0.00			96%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		**0.00**	0%	recharge
1975		0.01	0.00	0.38	0.08	1.40	0.59	0.00	6.06	2.84	2.58	0.07	0.00	**14.01**		**16.67**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.56	0.00	0.00		**1.40**	8%	runoff
SM param		-9.29	-8.37	-5.85	-4.24	-0.73	-0.85	-1.55	4.69	1.75	-0.88	-7.67	-8.70				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.40	1.75	0.00	0.00	0.00			78%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.29	0.00	0.00	0.00	0.00		**2.29**	14%	recharge
1976		0.62	0.00	4.36	2.05	1.17	1.94	3.06	0.49	1.85	0.15	2.45	0.06	**18.20**		**21.66**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.15	0.11	0.00	0.00	0.00		**0.54**	2%	runoff
SM param		-8.56	-8.37	-1.11	-1.90	-1.01	0.76	2.85	0.46	-1.37	-5.52	-4.83	-8.63				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	0.76	2.40	0.46	0.00	0.00	0.00	0.00			97%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00		**0.16**	1%	recharge
1977		0.03	3.09	0.01	0.90	0.42	3.49	7.37	7.31	9.68	1.92	0.38	0.00	**34.60**		**41.17**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.00	2.19	2.17	2.88	0.57	0.00	0.00		**7.82**	19%	runoff
SM param		-9.26	-4.69	-6.29	-3.27	-1.90	2.60	9.62	8.58	9.89	-1.02	-7.30	-8.70				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	2.40	2.40	2.40	2.40	0.00	0.00	0.00			47%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.20	5.03	4.00	4.61	0.00	0.00	0.00		**13.84**	34%	recharge
1978		0.00	0.01	0.36	0.02	4.13	3.56	7.99	2.88	5.31	0.14	0.35	0.05	**24.80**		**29.51**	
Runoff		0.00	0.00	0.00	0.00	0.00	1.06	2.38	0.86	1.58	0.04	0.00	0.00		**5.91**	20%	runoff
SM param		-9.30	-8.36	-5.87	-4.32	2.51	5.09	10.36	3.31	4.69	-3.13	-7.33	-8.64				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	2.40	2.40	2.40	2.40	2.40	0.00	0.00	0.00			53%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.11	1.63	5.58	0.05	0.71	0.00	0.00	0.00		**8.08**	27%	recharge
1979		0.01	0.12	0.00	1.52	0.43	0.41	8.99	9.71	4.39	2.24	0.62	0.00	**28.44**		**33.84**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.89	1.31	0.67	0.00	0.00		**4.86**	14%	runoff
SM param		-9.29	-8.23	-6.30	-2.53	-1.89	-1.06	9.15	11.43	3.59	-0.63	-7.01	-8.70				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.40	2.40	2.40	0.00	0.00	0.00			48%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	6.75	6.15	0.00	0.00	0.00	0.00		**12.89**	38%	recharge
1980		0.00	0.00	0.00	0.83	0.00	0.00	0.65	2.63	4.55	1.12	0.22	0.00	**10.00**		**11.90**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.28	0.00	0.00		**0.62**	5%	runoff
SM param		-9.30	-8.37	-6.30	-3.35	-2.40	-1.55	-0.78	0.61	1.99	-2.37	-7.49	-8.70				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	1.99	0.00	0.00	0.00			95%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		**0.00**	0%	recharge
1981		0.01	0.00	0.00	0.27	1.31	1.03	5.01	0.00	7.02	1.14	0.40	0.36	**16.55**		**19.69**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.00		**0.34**	2%	runoff
SM param		-9.29	-8.37	-6.30	-4.02	-0.84	-0.32	4.41	-0.12	4.32	-1.94	-7.27	-8.27				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.40	0.00	2.40	0.00	0.00	0.00			78%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	2.01	0.00	1.92	0.00	0.00	0.00		**3.94**	20%	recharge
1982		0.01	0.13	0.87	0.18	5.91	2.66	3.27	6.04	10.92	2.56	0.30	0.00	**32.85**		**39.09**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.79	0.97	1.80	3.25	0.76	0.00	0.00		**7.57**	19%	runoff
SM param		-9.29	-8.22	-5.26	-4.13	4.63	4.02	4.74	7.07	11.36	-0.25	-7.39	-8.70				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	2.40	2.40	2.40	2.40	2.40	0.00	0.00	0.00			47%	ET bal
Recharge		0.00	0.00	0.00	0.00	2.23	0.82	1.37	2.87	5.72	0.00	0.00	0.00		**13.01**	33%	recharge
1983		0.00	1.66	0.29	0.33	3.59	3.50	0.45	0.05	0.12	0.43	0.01	0.16	**10.59**		**12.60**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.81	0.13	0.01	0.00	0.00	0.00	0.00		**0.95**	8%	runoff
SM param		-9.30	-6.39	-5.95	-3.95	1.87	4.49	1.39	-1.08	-3.89	-5.19	-7.74	-8.51				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	1.87	2.40	1.39	0.00	0.00	0.00	0.00	0.00			82%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	1.27	0.00	0.00	0.00	0.00	0.00	0.00		**1.27**	10%	recharge
1984		1.86	0.86	0.11	0.49	2.08	5.42	1.38	1.68	2.09	0.67	0.07	0.07	**16.78**		**19.97**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.05	0.41	0.50	0.49	0.03	0.00	0.00		**1.48**	7%	runoff
SM param		-7.09	-7.35	-6.17	-3.76	0.08	4.98	2.49	1.88	0.34	-4.57	-7.67	-8.62				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.08	2.40	2.40	1.88	0.34	0.00	0.00	0.00			80%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	2.52	0.00	0.00	0.00	0.00	0.00	0.00		**2.52**	13%	recharge

1985		0.05	0.00	0.46	0.49	7.41	1.73	0.28	4.59	5.37	0.58	0.01	0.00	**20.97**		**24.95**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.51	0.08	0.67	1.60	0.17	0.00	0.00		**3.04**	12%	runoff
SM param		-9.24	-8.37	-5.75	-3.76	6.42	2.91	1.18	4.13	4.76	-2.61	-7.74	-8.70				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	2.40	2.40	1.18	2.40	2.40	0.00	0.00	0.00			64%	ET bal
Recharge		0.00	0.00	0.00	0.00	4.02	0.00	0.00	1.05	0.76	0.00	0.00	0.00		**5.83**	23%	recharge
1986		0.08	0.00	1.14	1.66	0.82	1.78	1.89	2.30	3.07	0.68	0.38	0.00	**13.80**		**16.42**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.36	0.56	0.09	0.00	0.00		**1.15**	7%	runoff
SM param		-9.20	-8.37	-4.94	-2.36	-1.42	0.57	1.27	1.48	1.11	-3.78	-7.30	-8.70				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	0.57	1.27	1.48	1.11	0.00	0.00	0.00			93%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		**0.00**	0%	recharge
1987		0.01	0.10	0.38	2.94	3.97	2.52	3.00	0.99	0.24	3.60	0.22	0.00	**17.97**		**21.38**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.73	0.89	0.29	0.03	0.00	0.00	0.00		**1.94**	9%	runoff
SM param		-9.29	-8.25	-5.85	-0.84	2.32	3.77	4.42	1.06	-2.69	-1.42	-7.49	-8.70				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	2.32	2.32	2.40	2.40	1.06	0.00	0.00	0.00			83%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.65	1.13	0.00	0.00	0.00	0.00	0.00		**1.77**	8%	recharge
1988		0.00	0.01	0.10	0.01	1.42	2.66	0.72	2.04	1.56	0.12	0.46	0.00	**9.10**		**10.83**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.23	0.16	0.00	0.00		**0.54**	5%	runoff
SM param		-9.30	-8.36	-6.18	-4.33	-0.71	1.62	0.92	0.83	-1.34	-5.56	-7.20	-8.70				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	1.62	0.92	0.83	0.00	0.00	0.00	0.00			95%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		**0.00**	0%	recharge
1989		0.00	0.00	0.47	0.38	0.08	0.10	3.87	1.68	1.56	1.02	0.48	0.84	**10.48**		**12.47**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.36	0.00	0.00	0.00		**0.86**	7%	runoff
SM param		-9.30	-8.37	-5.74	-3.89	-2.30	-1.43	3.06	1.88	-0.29	-4.49	-7.18	-7.70				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.40	1.88	0.00	0.00	0.00	0.00			88%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.00		**0.66**	5%	recharge
1990		0.62	0.15	0.00	0.00	1.05	1.71	0.98	3.18	12.69	0.20	0.02	0.01	**20.61**		**24.53**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.04	2.15	0.06	0.00	0.00		**2.31**	9%	runoff
SM param		-8.56	-8.19	-6.30	-4.34	-1.15	0.48	0.10	1.37	12.44	-3.06	-7.73	-8.69				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.10	1.37	2.40	0.00	0.00	0.00			58%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.89	0.00	0.00	0.00		**7.89**	32%	recharge
1991		0.35	0.01	0.00	1.51	0.00	2.68	2.61	3.97	5.98	0.35	0.14	0.00	**17.60**		**20.94**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.53	1.18	1.78	0.10	0.00	0.00		**3.59**	17%	runoff
SM param		-8.88	-8.36	-6.30	-2.54	-2.40	1.64	3.20	4.60	5.49	-2.88	-7.58	-8.70				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	1.64	2.40	2.40	2.40	0.00	0.00	0.00			70%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.26	1.02	1.31	0.00	0.00	0.00		**2.60**	12%	recharge
1992		0.13	1.23	0.00	1.30	0.11	4.69	15.24	5.94	0.83	0.01	0.09	0.90	**30.47**		**36.26**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.00	4.53	1.77	0.25	0.00	0.00	0.00		**6.55**	18%	runoff
SM param		-9.15	-6.91	-6.30	-2.79	-2.27	4.03	18.99	6.95	-0.64	-5.69	-7.64	-7.63				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	2.40	2.40	2.40	0.00	0.00	0.00	0.00			37%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	1.63	12.05	2.78	0.00	0.00	0.00	0.00		**16.46**	45%	recharge
1993		0.08	0.00	0.03	0.10	2.39	1.30	1.47	4.54	4.04	2.27	0.58	0.00	**16.80**		**19.99**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.07	0.08	0.36	1.20	0.68	0.00	0.00		**2.39**	12%	runoff
SM param		-9.20	-8.37	-6.26	-4.22	0.44	0.44	0.64	3.52	3.18	-0.60	-7.06	-8.70				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.44	0.44	0.64	2.40	2.40	0.00	0.00	0.00			84%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.00	0.00	0.00		**0.76**	4%	recharge
1994		0.25	0.00	0.01	0.13	1.53	1.26	9.55	3.82	8.68	2.05	1.76	0.56	**29.60**		**35.22**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.14	2.58	0.61	0.00	0.00		**4.33**	12%	runoff
SM param		-9.00	-8.37	-6.29	-4.19	-0.58	-0.05	9.81	4.43	8.70	-0.86	-5.66	-8.03				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.40	2.40	2.40	0.00	0.00	0.00			54%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	7.41	0.89	3.72	0.00	0.00	0.00		**12.02**	34%	recharge
1995		0.01	0.00	0.15	0.20	0.26	0.29	1.87	3.28	2.78	0.77	0.03	0.00	**9.64**		**11.47**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.71	0.13	0.00	0.00		**1.11**	10%	runoff
SM param		-9.29	-8.37	-6.12	-4.10	-2.09	-1.20	0.68	2.06	1.34	-3.45	-7.71	-8.70				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	2.06	1.34	0.00	0.00	0.00			90%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		**0.00**	0%	recharge
1996		0.36	0.00	0.11	0.97	2.12	2.37	5.82	2.37	0.07	0.18	0.08	0.09	**14.54**		**17.30**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.04	1.01	0.71	0.02	0.00	0.00	0.00		**1.77**	10%	runoff
SM param		-8.87	-8.37	-6.17	-3.19	0.12	1.39	6.77	2.70	-1.55	-5.49	-7.65	-8.59				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.12	1.39	2.40	2.40	0.00	0.00	0.00	0.00			70%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	3.36	0.00	0.00	0.00	0.00	0.00		**3.36**	19%	recharge
1997		0.00	0.00	1.57	0.09	2.69	2.38	0.62	12.96	5.08	0.94	0.41	0.59	**27.33**		**32.52**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.24	0.16	2.04	1.51	0.28	0.00	0.00		**4.23**	13%	runoff
SM param		-9.30	-8.37	-4.43	-4.23	0.80	2.08	1.27	14.17	4.42	-2.18	-7.26	-8.00				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.80	2.08	1.27	2.40	2.40	0.00	0.00	0.00			56%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.73	0.50	0.00	0.00	0.00		**10.24**	31%	recharge
1998		0.00	0.01	0.13	0.14	2.49	1.91	2.44	0.97	0.94	3.10	0.04	0.70	**12.87**		**15.32**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.13	0.39	0.29	0.12	0.00	0.00	0.00		**0.93**	6%	runoff
SM param		-9.30	-8.36	-6.15	-4.17	0.56	1.29	2.64	1.03	-1.88	-2.01	-7.70	-7.87				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.56	1.29	2.40	1.03	0.00	0.00	0.00	0.00			94%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		**0.00**	0%	recharge
1999		0.11	0.00	0.34	0.00	0.00	0.61	0.68	5.08	1.49	1.01	0.24	0.01	**9.57**		**11.39**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.02	0.00	0.00		**0.46**	4%	runoff
SM param		-9.17	-8.37	-5.90	-4.34	-2.40	-0.82	-0.74	3.53	0.14	-4.36	-7.46	-8.69				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.40	0.14	0.00	0.00	0.00			86%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.13	0.00	0.00	0.00	0.00		**1.13**	10%	recharge
2000		0.00	0.53	0.24	1.17	1.07	0.00	3.39	3.78	0.97	1.68	0.00	0.00	**12.83**		**15.27**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12	0.29	0.00	0.00	0.00		**1.41**	9%	runoff
SM param		-9.30	-7.74	-6.01	-2.95	-1.13	-1.55	2.48	4.38	-0.48	-3.70	-7.75	-8.70				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.40	2.40	0.00	0.00	0.00	0.00			85%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.85	0.00	0.00	0.00	0.00		**0.94**	6%	recharge
2001		0.05	0.00	0.00	0.00	0.16	1.70	0.50	0.16	1.59	0.61	0.00	0.00	**4.77**		**5.68**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00		**0.03**	1%	runoff
SM param		-9.24	-8.37	-6.30	-4.34	-2.21	0.47	-0.48	-2.33	-2.14	-4.97	-7.75	-8.70				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.00			99%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		**0.00**	0%	recharge
2002		0.11	0	0.45	0.01	3.22	1.27	0.14	5.14	2.42	1.89	0.7	0.15	**15.50**		**18.45**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.23	0.02	0.01	0.72	0.29	0.00	0.00		**1.27**	7%	runoff
SM param		-9.17	-8.37	-5.76	-4.33	1.43	1.39	0.01	3.61	1.25	-2.20	-6.92	-8.52				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	1.43	1.39	0.01	2.40	1.25	0.00	0.00	0.00			87%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00	0.00		**1.20**	7%	recharge
2003		0.09	0.15	0.05	0	1.54	0.28	0.21	4.44	0.04	1.46	0	0	**8.26**		**9.83**	
Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00		**0.01**	0%	runoff
SM param		-9.19	-8.19	-6.24	-4.34	-0.57	-1.22	-1.30	2.76	-1.58	-3.96	-7.75	-8.70				
Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.40	0.00	0.00	0.00	0.00			96%	ET bal
Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.00		**0.36**	4%	recharge

2004			0	0	0	7.55	0.74	3.17	5.26	6.29	2.12	3.22	0.5	0.02	**28.87**		**34.36**	
	Runoff		0.00	0.00	0.00	0.00	0.22	0.35	1.56	1.87	0.63	0.36	0.00	0.00		**4.99**	15%	runoff
	SM param		-9.30	-8.37	-6.30	4.64	0.88	3.10	7.11	7.37	0.89	-0.98	-7.16	-8.68				
	Soil Mo.	0.00	0.00	0.00	0.00	2.40	0.88	2.40	2.40	2.40	0.89	0.00	0.00	0.00			60%	ET bal
	Recharge		0.00	0.00	0.00	2.24	0.00	0.36	3.14	3.09	0.00	0.00	0.00	0.00		**8.84**	26%	recharge
2005			0.4	0	0	0.92	0.02	0.03	1.01	1.71	0.52	2.37	0.54	0	**7.52**		**8.95**	
	Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		**0.00**	0%	runoff
	SM param		-8.82	-8.37	-6.30	-3.25	-2.38	-1.51	-0.35	-0.49	-3.41	-2.88	-7.11	-8.70				
	Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			100%	ET bal
	Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		**0.00**	0%	recharge
2006			0.11	0.05	0	0.16	0.45	0.96	0.86	3.28	0.27	0.88	0.01	0	**7.03**		**8.37**	
	Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00		**0.05**	1%	runoff
	SM param		-9.17	-8.31	-6.30	-4.15	-1.86	-0.41	-0.53	1.38	-2.33	-4.65	-7.74	-8.70				
	Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.38	0.00	0.00	0.00	0.00			99%	ET bal
	Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		**0.00**	0%	recharge
2007			0	0.07	0.55	0.17	1.89	3.18	5.46	3.14	0.09	0.01	0.52	0	**15.08**		**17.95**	
	Runoff		0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.93	0.03	0.00	0.00	0.00		**2.47**	14%	runoff
	SM param		-9.30	-8.29	-5.65	-4.14	-0.15	2.23	7.18	3.62	-1.52	-5.69	-7.13	-8.70				
	Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	2.23	2.40	2.40	0.00	0.00	0.00	0.00			66%	ET bal
	Recharge		0.00	0.00	0.00	0.00	0.00	0.00	3.27	0.28	0.00	0.00	0.00	0.00		**3.55**	20%	recharge
2008			0	0	0	0.03	3.24	4.66	0.13	4.71	0.1	0.37	0.07	0	**13.31**		**15.84**	
	Runoff		0.00	0.00	0.00	0.00	0.00	0.84	0.04	0.59	0.03	0.00	0.00	0.00		**1.50**	9%	runoff
	SM param		-9.30	-8.37	-6.30	-4.30	1.46	5.45	1.00	4.09	-1.51	-5.26	-7.67	-8.70				
	Soil Mo.	0.00	0.00	0.00	0.00	0.00	1.46	2.40	1.00	2.40	0.00	0.00	0.00	0.00			70%	ET bal
	Recharge		0.00	0.00	0.00	0.00	0.00	2.21	0.00	1.10	0.00	0.00	0.00	0.00		**3.31**	21%	recharge
2009			0	0	0	0.08	0.93	2.43	2.64	4.38	0.96	2.61	0.05	0	**14.08**		**16.76**	
	Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.44	1.30	0.29	0.00	0.00	0.00		**2.03**	12%	runoff
	SM param		-9.30	-8.37	-6.30	-4.24	-1.29	1.34	2.93	5.09	-0.49	-2.59	-7.69	-8.70				
	Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	1.34	2.40	2.40	0.00	0.00	0.00	0.00			79%	ET bal
	Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.09	1.39	0.00	0.00	0.00	0.00		**1.48**	9%	recharge
2010			0.08	0	0.58	2.8	1.88	7.74	0.74	4.74	2.52	0.78	0.72	0.28	**22.86**		**27.20**	
	Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.22	1.02	0.75	0.13	0.00	0.00		**2.12**	8%	runoff
	SM param		-9.20	-8.37	-5.61	-1.01	-0.16	7.66	1.73	4.85	1.37	-3.40	-6.89	-8.37				
	Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	2.40	1.73	2.40	1.37	0.00	0.00	0.00			68%	ET bal
	Recharge		0.00	0.00	0.00	0.00	0.00	5.26	0.00	1.43	0.00	0.00	0.00	0.00		**6.69**	25%	recharge
2011			0.11	0	0.2	0.55	5	1.37	0.81	1.97	3.51	2.77	0	0	**16.29**		**19.39**	
	Runoff		0.00	0.00	0.00	0.00	0.00	0.41	0.24	0.44	0.71	0.61	0.00	0.00		**2.42**	12%	runoff
	SM param		-9.17	-8.37	-6.06	-3.69	3.55	2.48	1.81	1.64	1.79	-0.62	-7.75	-8.70				
	Soil Mo.	0.00	0.00	0.00	0.00	0.00	2.40	2.40	1.81	1.64	1.79	0.00	0.00	0.00			82%	ET bal
	Recharge		0.00	0.00	0.00	0.00	1.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00		**1.15**	6%	recharge
2012			0	0.18	0.18	0.32	0.59	3.45	2.46	1.39	1.59	0.12	0.69	0	**10.97**		**13.05**	
	Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.73	0.41	0.30	0.00	0.00	0.00		**1.45**	11%	runoff
	SM param		-9.30	-8.16	-6.09	-3.96	-1.70	2.56	3.78	1.53	-0.60	-5.56	-6.93	-8.70				
	Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	2.40	2.40	1.53	0.00	0.00	0.00	0.00			83%	ET bal
	Recharge		0.00	0.00	0.00	0.00	0.00	0.16	0.65	0.00	0.00	0.00	0.00	0.00		**0.80**	6%	recharge
2013			0.08	0	0	0.94	1.52	0.77	0.42	1.16	2.18	1.04	0	0	**8.11**		**9.65**	
	Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		**0.00**	0%	runoff
	SM param		-9.20	-8.37	-6.30	-3.22	-0.59	-0.63	-1.05	-1.14	-1.44	-4.46	-7.75	-8.70				
	Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			100%	ET bal
	Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		**0.00**	0%	recharge
2014			0.06	0.12	0	0	0.56	3.15	1.58	0.75	1.31	0.5	2.04	0.53	**10.60**		**12.61**	
	Runoff		0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.22	0.13	0.00	0.00	0.00		**0.78**	6%	runoff
	SM param		-9.23	-8.23	-6.30	-4.34	-1.73	2.20	2.53	0.77	-1.70	-5.11	-5.32	-8.07				
	Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	2.20	2.40	0.77	0.00	0.00	0.00	0.00			94%	ET bal
	Recharge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		**0.00**	0%	recharge
2015			0.68	0.01	0.86	0.85	1.47	3.60	4.49	0.18	1.53	1.07	0.70	0	**15.44**		**18.37**	
	Runoff		0.00	0.00	0.00	0.00	0.00	0.00	1.34	0.05	0.02	0.00	0.00	0.00		**1.41**	8%	runoff
	SM param		-8.49	-8.36	-5.28	-3.33	-0.65	2.73	6.19	0.09	-2.12	-4.43	-6.92	-8.70				
	Soil Mo.	0.00	0.00	0.00	0.00	0.00	0.00	2.40	2.40	0.09	0.00	0.00	0.00	0.00			77%	ET bal
	Recharge		0.00	0.00	0.00	0.00	0.00	0.33	2.46	0.00	0.00	0.00	0.00	0.00		**2.79**	15%	recharge

RECHARGE CALCULATIONS: Recharge and Storage

SM capacity	**2.40**	inches		
runoff coeff.	**25%**			
storage Alluv.	**0.10**		**10.00**	percent effective porosity
Alluvium Area	**133.00**	acres		
Sat'd Alluvium	**20.00**	feet		
storage DG	**0.05**		**5.00**	percent effective porosity
DG aq area	**1350**	acres		
DG sat_depth	**30.00**	feet		
storage frx	**0.0001**		**0.01**	percent eff porosity (500 ft deep)
WS aq area	**5750**	acres		
Eff. capacity	**1289**	Available Ac-ft (50% allowed)		
Discharge rate	**504**	Ac-ft/yr	**312.44**	in gpm (24 hr/day)
			449,912	gallons per day
min active aquifer vol	**3.0**	**50%**	Ac-ft (% of total)	
avg active aquifer vol	**1024.0**	**90%**	Ac-ft (% of total)	

Effective Recharge Rates, AcFt/yr (limited by aquifer storage)

7889	maximum
0.0	minimum
1722	average

19.6	Average Annual Rainfall, inches
9,379	Acft/yr in Watershed
5.4%	GW Use as pct of rainfall

Alluv. Storage	**266**	total, Acft		
DG storage	**2025**	total, Acft		
Rock storage	**288**	total, Acft	"allowed"	
GW Storage	**2579**	**total**	**1289**	**total**
Initial Volume	at beginning of calc. period		**644.63**	3/4 full

Indicates Input Variables

YEAR	Annual RF Total		
1971	10.73	12.77	adj RF
	0.04	0.00	runoff
		0.00	calc. parameter
		0.79	ET bal
	2.65	0.21	recharge
1972	20.64	24.56	
	3.97	0.16	
		0.00	
		0.73	
	2.75	0.11	
1973	12.22	14.54	
	0.05	0.00	
		0.00	
		0.69	
	4.46	0.31	
1974	16.91	20.12	
	0.81	0.04	
		0.00	
		0.96	
	0.00	0.00	
1975	14.01	16.67	
	1.40	0.08	
		0.00	
		0.78	
	2.29	0.14	
1976	18.20	21.66	
	0.54	0.02	
		0.00	
		0.97	
	0.16	0.01	
1977	34.60	41.17	
	7.82	0.19	
		0.00	
		0.47	
	13.84	0.34	
1978	24.80	29.51	
	5.91	0.20	
		0.00	
		0.53	
	8.08	0.27	
1979	28.44	33.84	
	4.86	0.14	
		0.00	
		0.48	
	12.89	0.38	
1980	10.00	11.90	
	0.62	0.05	
		0.00	
		0.95	
	0.00	0.00	
1981	16.55	19.69	
	0.34	0.02	
		0.00	
		0.78	
	3.94	0.20	
1982	32.85	39.09	
	7.57	0.19	
		0.00	
		0.47	
	13.01	0.33	
1983	10.59	12.60	
	0.95	0.08	
		0.00	
		0.82	
	1.27	0.10	
1984	16.78	19.97	
	1.48	0.07	
		0.00	
		0.80	
	2.52	0.13	
1985	20.97	24.95	
	3.04	0.12	
		0.00	
		0.64	
	5.83	0.23	
1986	13.80	16.42	
	1.15	0.07	
		0.00	
		0.93	
	0.00	0.00	
1987	17.97	21.38	
	1.94	0.09	
		0.00	
		0.83	
	1.77	0.08	
1988	9.10	10.83	
	0.54	0.05	
		0.00	
		0.95	
	0.00	0.00	
1989	10.48	12.47	
	0.86	0.07	
		0.00	
		0.88	
	0.66	0.05	
1990	20.61	24.53	
	2.31	0.09	
		0.00	
		0.58	
	7.89	0.32	

Year	ET	Runoff	recharge (inches) Recharge	adj. RF	recharge Ac-ft.	net pot'l inflow (Rechge - pumping)	start aquifer volume	end aquifer volume	recharge accepted (w/pumping)	pct accepted	recharge rejected Ac-ft/yr	inches/yr	Total Runoff inches/yr
1971	10.07	0.04	2.65	12.77	1271.95	767.95	644.63	1289.25	1148.63	90%	0.00	0.00	0.04
1972	17.84	3.97	2.75	24.56	1319.05	815.05	1289.25	1289.25	504.00	38%	311.05	0.65	4.62
1973	10.03	0.05	4.46	14.54	2138.66	1634.66	1289.25	1289.25	504.00	24%	1130.66	2.36	2.41
1974	19.31	0.81	0.00	20.12	0.00	-504.00	1289.25	785.25	0.00	0%	0.00	0.00	0.81
1975	12.98	1.40	2.29	16.67	1097.96	593.96	785.25	1289.25	1008.00	92%	0.00	0.00	1.40
1976	20.96	0.54	0.16	21.66	77.75	-426.25	1289.25	863.00	77.75	100%	0.00	0.00	0.54
1977	19.51	7.82	13.84	41.17	6633.78	6129.78	863.00	1289.25	930.25	14%	5199.52	10.85	18.67
1978	15.52	5.91	8.08	29.51	3872.94	3368.94	1289.25	1289.25	504.00	13%	2864.94	5.98	11.89
1979	16.09	4.86	12.89	33.84	6178.51	5674.51	1289.25	1289.25	504.00	8%	5170.51	10.79	15.65
1980	11.28	0.62	0.00	11.90	0.00	-504.00	1289.25	785.25	0.00	0%	0.00	0.00	0.62
1981	15.42	0.34	3.94	19.69	1885.86	1381.86	785.25	1289.25	1008.00	53%	373.86	0.78	1.12
1982	18.51	7.57	13.01	39.09	6235.02	5731.02	1289.25	1289.25	504.00	8%	5227.02	10.91	18.48
1983	10.37	0.95	1.27	12.60	610.88	106.88	1289.25	1289.25	504.00	83%	0.00	0.00	0.95
1984	15.97	1.48	2.52	19.97	1209.65	705.65	1289.25	1289.25	504.00	42%	201.65	0.42	1.90
1985	16.08	3.04	5.83	24.95	2794.85	2290.85	1289.25	1289.25	504.00	18%	1786.85	3.73	6.77
1986	15.27	1.15	0.00	16.42	0.00	-504.00	1289.25	785.25	0.00	0%	0.00	0.00	1.15
1987	17.67	1.94	1.77	21.38	850.30	346.30	785.25	1131.55	850.30	100%	0.00	0.00	1.94
1988	10.29	0.54	0.00	10.83	0.00	-504.00	1131.55	627.55	0.00	0%	0.00	0.00	0.54
1989	10.95	0.86	0.66	12.47	314.00	-190.00	627.55	437.55	314.00	100%	0.00	0.00	0.86
1990	14.33	2.31	7.89	24.53	3780.02	3276.02	437.55	1289.25	1355.70	36%	1920.32	4.01	6.31

1991	17.60	20.94
	3.59	0.17
		0.00
		0.70
	2.60	0.12
1992	30.47	36.26
	6.55	0.18
		0.00
		0.37
	16.46	0.45
1993	16.80	19.99
	2.39	0.12
		0.00
		0.84
	0.76	0.04
1994	29.60	35.22
	4.33	0.12
		0.00
		0.54
	12.02	0.34
1995	9.64	11.47
	1.11	0.10
		0.00
		0.90
	0.00	0.00
1996	14.54	17.30
	1.77	0.10
		0.00
		0.70
	3.36	0.19
1997	27.33	32.52
	4.23	0.13
		0.00
		0.56
	10.24	0.31
1998	12.87	15.32
	0.93	0.06
		0.00
		0.94
	0.00	0.00
1999	9.57	11.39
	0.46	0.04
		0.00
		0.86
	1.13	0.10
2000	12.83	15.27
	1.41	0.09
		0.00
		0.85
	0.94	0.06
2001	4.77	5.68
	0.03	0.01
		0.00
		0.99
	0.00	0.00
2002	15.50	18.45
	1.27	0.07
		0.00
		0.87
	1.20	0.07
2003	8.26	9.83
	0.01	0.00
		0.00
		0.96
	0.36	0.04
2004	28.87	34.36
	4.99	0.15
		0.00
		0.60
	8.84	0.26
2005	7.52	8.95
	0.00	0.00
		0.00
		1.00
	0.00	0.00
2006	7.03	8.37
	0.05	0.01
		0.00
		0.99
	0.00	0.00

1991	14.75	3.59	2.60	20.94	1243.51	739.51	1289.25	1289.25	504.00	41%	235.51	0.49	4.09
1992	13.25	6.55	16.46	36.26	7889.12	7385.12	1289.25	1289.25	504.00	6%	6881.12	14.36	20.91
1993	16.84	2.39	0.76	19.99	365.41	-138.59	1289.25	1150.66	365.41	100%	0.00	0.00	2.39
1994	18.87	4.33	12.02	35.22	5759.94	5255.94	1150.66	1289.25	642.59	11%	4613.36	9.63	13.96
1995	10.36	1.11	0.00	11.47	0.00	-504.00	1289.25	785.25	0.00	0%	0.00	0.00	1.11
1996	12.17	1.77	3.36	17.30	1611.85	1107.85	785.25	1289.25	1008.00	63%	99.85	0.21	1.98
1997	18.06	4.23	10.24	32.52	4904.45	4400.45	1289.25	1289.25	504.00	10%	3896.45	8.13	12.36
1998	14.38	0.93	0.00	15.32	0.00	-504.00	1289.25	785.25	0.00	0%	0.00	0.00	0.93
1999	9.80	0.46	1.13	11.39	539.16	35.16	785.25	820.41	539.16	100%	0.00	0.00	0.46
2000	12.92	1.41	0.94	15.27	449.34	-54.66	820.41	765.75	449.34	100%	0.00	0.00	1.41
2001	5.65	0.03	0.00	5.68	0.00	-504.00	765.75	261.75	0.00	0%	0.00	0.00	0.03
2002	15.98	1.27	1.20	18.45	575.06	71.06	261.75	332.80	575.06	100%	0.00	0.00	1.27
2003	9.45	0.01	0.36	9.83	174.23	-329.78	332.80	3.03	174.23	100%	0.00	0.00	0.01
2004	20.53	4.99	8.84	34.36	4235.71	3731.71	3.03	1289.25	1790.22	42%	1941.49	4.05	9.04
2005	8.95	0.00	0.00	8.95	0.00	-504.00	1289.25	785.25	0.00	0%	0.00	0.00	0.00
2006	8.32	0.05	0.00	8.37	0.00	-504.00	785.25	281.25	0.00	0%	0.00	0.00	0.05

2007	15.08	17.95
	2.47	0.14
		0.00
		0.66
	3.55	0.20
2008	13.31	15.84
	1.50	0.09
		0.00
		0.70
	3.31	0.21
2009	14.08	16.76
	2.03	0.12
		0.00
		0.79
	1.48	0.09
2010	22.86	27.20
	2.12	0.08
		0.00
		0.68
	6.69	0.25
2011	16.29	19.39
	2.42	0.12
		0.00
		0.82
	1.15	0.06
2012	10.97	13.05
	1.45	0.11
		0.00
		0.83
	0.80	0.06
2013	8.11	9.65
	0.00	0.00
		0.00
		1.00
	0.00	0.00
2014	10.60	12.61
	0.78	0.06
		0.00
		0.94
	0.00	0.00
2015	15.44	18.37
	1.41	0.08
		0.00
		0.77
	2.79	0.15

2007	11.92	2.47	3.55	17.95	1701.96	1197.96	281.25	1289.25	1512.00	89%	0.00	0.00	2.47
2008	11.03	1.50	3.31	15.84	1587.57	1083.57	1289.25	1289.25	504.00	32%	579.57	1.21	2.71
2009	13.24	2.03	1.48	16.76	710.79	206.79	1289.25	1289.25	504.00	71%	0.00	0.00	2.03
2010	18.39	2.12	6.69	27.20	3208.00	2704.00	1289.25	1289.25	504.00	16%	2200.00	4.59	6.71
2011	15.82	2.42	1.15	19.39	551.04	47.04	1289.25	1289.25	504.00	91%	0.00	0.00	2.42
2012	10.81	1.45	0.80	13.05	383.84	-120.16	1289.25	1169.09	383.84	100%	0.00	0.00	1.45
2013	9.65	0.00	0.00	9.65	0.00	-504.00	1169.09	665.09	0.00	0%	0.00	0.00	0.00
2014	11.83	0.78	0.00	12.61	0.00	-504.00	665.09	161.09	0.00	0%	0.00	0.00	0.78
2015	14.18	1.41	2.79	18.37	1337.51	833.51	161.09	994.60	1337.51	100%	0.00	0.00	1.41