Playas, which are shallow, centrally located basins in which water gathers after a rain and quickly evaporates are not present in the Palo Verde Mesa and Palo Verde Valley as the surface topography generally slopes eastward towards the Colorado River along the east side of the Palo Verde Valley. The closest playa to the BSPP site is Ford Dry Lake, which is about 8 to 9 miles west of the site in Chuckwalla Valley. Ford Dry Lake is not located Palo Verde Mesa Groundwater Basin and is hydraulically up-gradient from Palo Verde Valley. Moreover, the McCoy Mountains separate Ford Dry Lake from the BSPP site. As a result, Ford Dry Lake will not be affected by groundwater extraction from the BSPP site.

References

Division of Mines and Geology (DMG), 1967. Geologic Map of California, Salton Sea Sheet, Scale 1:250,000,

Department of Water Resources (DWR), 1978. Bulletin 91-23. Water Wells and Springs in Palo Verde Valley, Riverside and Imperial Counties, California, Sacramento, California.

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Information Required:

Please conduct a more thorough analysis of the groundwater recharge/discharge that is likely occurring in the Palo Verde Mesa Groundwater basin. Please provide a table with estimates either by reference or by actual calculations of the estimated amount of recharge/discharge that is occurring. Anticipated recharge can be calculated using a procedure described in Hely & Peck (1964). The analysis should use isohyetal maps of average annual precipitation overlaid on the basin boundaries. Several factors (2, 5, & 10%) should be applied to the calculated volume to give a range of anticipated recharge.

Response:

Recharge from Runoff

Methods to estimate runoff proposed by Hely and Peck (Hely and Peck, 1964) were used to estimate mean annual runoff in the Palo Verde Mesa Groundwater Basin. Hely and Peck (1964) found that "a large part of the runoff generated by precipitation within the area is absorbed in the alluvium of the valleys and plains" and proposed to estimate runoff based on precipitation data, rainfall-runoff relations and observed characteristics of the terrain. Project hydrogeologists reviewed topographic and geological data to generate Figure DR-S&W-179-1 that divided the Palo Verde Mesa Groundwater Basin into localities that approximated the localities as described by Hely and Peck (i.e. mountains, hills, alluvium-steep slope or alluvium-shallow slope – see their Figure 10). The hydrogeologists then calculated the area for each locality. Figure 10 in Hely and Peck (1964) was used to select an average runoff curve number for each locality assuming an average of all soil types which roughly corresponded to a median of the soil type "B" as defined by the US Bureau of Reclamation. For example, an average runoff number of 74 was selected for alluvium-steep slope. Hely and Peck (1964) developed a relationship between the runoff curve number and the runoff as a percentage of the precipitation (see Hely and Peck, 1964 Figure 9). Using this relationship, the annual volume of runoff from each locality was calculated by multiplying the area of each locality times the mean annual precipitation times the percentage of runoff estimated for the runoff curve number. The mean annual precipitation was approximated for each locality by overlaying the mean annual runoff from small tracts information (Plate 3, Hely & Peck, 1964) with Figure DR-S&W-179-1 of localities for the Chuckwalla/Palo Verde basins.

From the estimated total runoff for the Chuckwalla/Palo Verde basin, simple percentages of 3 percent 5 percent and 10 percent were applied to the estimated total runoff to generate a total annual infiltration volume (acre-feet) for the basin. Table DR-S&W-179-1 presents the estimate of total annual infiltration for the Palo Verde Mesa Groundwater Basin.

Metzger et al. (1973) and Owens-Joyce et al. (1987) followed the approach outlined by Hely and Peck (1964) reporting that recharge from runoff through the McCoy Wash was about 800 acre-ft/year and runoff from the Palo Verde Mountains was 1,200 acre-feet/year. The value assuming 10% of runoff infiltrates and recharges the groundwater best matches the value reported by Metzger et al. (1973) for the McCoy Wash, but in general the values estimated as noted above are lower than reported by previous investigations.

Recharge from underflow from the Colorado River

As provided in the August 2009 BSPP AFC, geochemical and water level data indicate that groundwater from outside the basin is flowing into the area as flux from the Colorado River. The USBR in their analysis of the accounting surface has concluded that groundwater below the Project site is in communication with the Colorado River. Geochemical data show that there is a gradual mixing of water from the river to the west and into the Project site as TDS concentrations progressively increase away from the River. An estimate of groundwater flux from the River into the Palo Verde Mesa Groundwater Basin was made using a simple underflow calculation and Darcian flow across a cross sectional area at the upper portion of the basin (see AFC Figure 5.17-7). The aquifer was assumed to extend a distance of 19,000 feet perpendicular to flow and at a depth of 600 feet below the water table at this location. Using the average transmissivity of 26,000 ft^2/day from Leake et al. (2008) and a groundwater gradient of 0.0003 ft/ft from measurements taken in 2000 (AFC Figure 5.17-7), the groundwater flux across this area is approximated at 1,241 acre-feet per year.

Recharge from Return from Irrigation

Recharge from applied irrigation water diverted from the Colorado River through the Palo Verde Irrigation District is unknown, although it could be significant given that 375,000 acre-feet were provided in 2007. Under an assumption that 10 percent of the applied water infiltrates and recharges the groundwater basin, an estimated 37,500 acre-feet per year recharges the Palo Verde Valley, which includes a portion of the Palo Verde Mesa Groundwater Basin. Adjusting for the areal distribution of the basin relative to the extent of agricultural land within the valley yields a recharge of about 15,750 acre-feet/year.

Discharge

An estimate of discharge from the Palo Verde Mesa could not be completed. Information on groundwater supply well pumping and history could not be established although inquiries were made for these data of the Palo Verde Irrigation District. The USGS NWIS database, while having well information to a certain extent, does not have the pumping history for most of the wells in the database.

As noted in the AFC, while the discharge from the Palo Verde Mesa Groundwater Basin is not known, it is reasonable to assume that the discharge for agriculture use has in the past exceeded the recharge from sources other than the Colorado River. The absence of significant changes in water level data in the Palo Verde Mesa Groundwater Basin over time suggest a buffering affect from another source of recharge, which is presumed to be the Colorado River.

Water Balance

Without a certain understanding of discharge from the Palo Verde Mesa Groundwater Basin, it is not possible to construct a reasonable water balance. Table DR-S&W-179-2 summarizes the information above including a variation of recharge to the basin from assumptions of differential infiltration. As noted, in the AFC and in this DR response, the significant recharge from the Colorado River underflow is the primary mechanism for recharge to the basin along with inflow and agricultural return. Recent historic water level data indicate relative stability within the basin, and published reports suggest that the shallow aquifer discharges to surface water returning water to the River. Given the proposed amount of water usage, and the buffering effect of the River, the proposed Project water use is not significant and would not significantly impact storage within the Palo Verde Mesa Groundwater Basin.

References

A.G. Hely and E.L. Peck, Precipitation, Runoff and Water Loss in the Lower Colorado River-Salton Sea Area, Geological Survey Professional Paper 486-B, 1964 (Hely & Peck, 1964).

Leake, S. A., Greer, W., Watt, D., and Weghorst, P., 2008. Use of Superposition Models to Simulate Possible Depletion of Colorado River Water by Ground-Water Withdrawal - Scientific Investigations Report 2008-5189 (Prepared in Cooperation with the Bureau of Reclamation): U.S Geological survey, Reston, Virginia, 25p.

Metzger, D.G., Loeltz, O.J., and Burdge Irelna, 1973. Geohydrology of the Parker-Blythe-Cibola Area, Arizona and California, U.S. Geological Survey Professional Paper 486-G.

Owen-Joyce, Sandra J., and Kimsey, Steven L., 1987. Estimates of Consumptive Use and Ground-Water Return Flow Using Water Budgets in Palo Verde Valley, California, U.S. Geological Survey Water-Resources Investigations Report 87 – 4070, December.

Table DR-S&W-179-1 Estimates Of Runoff And Infiltration Palo Verde Mesa Groundwater Basin

Layer See Figure DR-S&W-179-1	Area (acres)	Mean Annual Precipitation (inches)	Total Volume of Rainwater from Mean Annual Precip (AcFt)	Runoff Curve Classification	Runoff Curve Number	Runoff (% of precip)	Total Annual Volume of Runoff (AcFt)	Total Annual Volume of Infiltration (AcFt) Based on 3%	Total Annual Volume of Infiltration (AcFt) Based on 5%	Total Annual Volume of Infiltration (AcFt) Based on 10%
unit1-pvm	23,695	4	7,898	Alluvium, Steep Slope	74	3.5%	276	8	14	28
bedrock-pvm	5,624	4	1,875	Mountains	93	29.1%	546	16	27	55
bedrock-pvm	16,819	6	8,409	Mountains	93	29.1%	2,447	73	122	245
bedrock-pvm	13,571	4	4,524	Mountains	93	29.1%	1,316	39	66	132
bedrock-pvm	18,298	4	6,099	Hills	83	10%	610	18	30	61
unit1-pvm	79,574	5	33,156	Alluvium, Steep Slope	74	3.5%	1,160	35	58	116
unit2-pvm	382	4	127	Hills	83	10%	13	0	1	1
unit2-pvm	122,370	4	40,790	Alluvium, Flat Slope	69	2%	816	24	41	82
Totals	**280,332**		**102,878**				**7,184**	**216**	**359**	**718**