

RECHARGE BASIN DESIGN, SOUTHERN SANJOAQUIN MUNICIPAL UTILITY DISTRICT

CONCEPTION DU BASSIN DE REALIMENTATION, DISTRICT MUNICIPAL DE SERVICES PUBLICS DE SAN JOAQUIN DU SUD

Sam Schaefer P.E.¹, Luis Flores², Fabian Acuna and Ethan Hunter³,
Grace Martin⁴, and Roland Gross⁵

ABSTRACT

The Southern San Joaquin Municipal Utility District (District) is adding recharge facilities to increase its capacity to deliver available surface water supplies to recharge groundwater. In the 1940s and 50s, the District recognized the need to bring in surface water to offset declining groundwater levels. The District supported the Bureau of Reclamation's development of the Central Valley Project (CVP) and constructed a water distribution system to help stabilize groundwater supplies using the delivery of Friant-Kern Canal (FKC) water for irrigation to agriculture. However, reductions in CVP water reliability and changes in timing of deliveries have occurred due to the San Joaquin River settlement and subsidence on the FKC that prevent full surface water deliveries when needed for crop irrigation.

Recently, the Sustainable Groundwater Management Act of 2014 (SGMA) has brought new concerns to the District regarding groundwater balance. To fully use the District's surface water supplies and balance groundwater pumping, recharge basins are needed to recharge groundwater with surface water delivered at times it cannot be used for irrigation. The District has identified a target need to develop roughly 607 hectares (1,500 acres) of recharge facilities over multiple years. In 2024 and 2026, the District purchased hundreds of acres of vineyard crop land, cleared the crop, and is now in the process of being converted into recharge basins. This presents the progress to date on the District's multi-year approach to planning, designing, funding, constructing, and operating as it converts the purchased land into recharge facilities with an emphasis on basin design factors.

Keywords: available surface water; groundwater levels; groundwater pumping; water deliveries; recharge basins.

RESUME

Le district municipal de services publics de San Joaquin du sud (District) met en place des installations de réalimentation afin d'augmenter sa capacité à fournir les réserves d'eau de surface disponibles pour réalimenter la nappe phréatique. Dans les années 1940 et 1950, le District a reconnu la nécessité d'apporter de l'eau de surface pour compenser la baisse des niveaux d'eau souterraine. Le district a soutenu le développement du projet de la vallée centrale (CVP) par le «Bureau of Reclamation» et a développé un système de distribution d'eau pour aider à stabiliser les approvisionnements en eaux souterraines en distribuant l'eau du canal Friant-Kern (FKC) pour l'irrigation de l'agriculture. Cependant, des réductions de la fiabilité de l'eau du projet de la vallée centrale (CVP) et des changements dans le calendrier de distributions se sont produits en raison du peuplement de la rivière San Joaquin et de

¹ GEI Consultants, Inc., Agriculture Services Practice Leader, Santa Barbara, CA sschaefer@geiconsultants.com; 805.729.4677

² Southern San Joaquin Municipal Utility District, 11281 Garzoli Ave., Delano, CA 93215, USA

³ GEI Consultants, Inc., Bakersfield, CA, USA

⁴ GEI Consultants, Inc., Bakersfield, CA, USA

⁵ Southern San Joaquin Municipal Utility District, 11281 Garzoli Ave., Delano, CA 93215

l'affaissement tout au long du canal Friant-Kern FKC qui empêchent les distributions de l'eau de surface complètes lorsque cela est nécessaire pour l'irrigation des cultures.

Récemment, la loi de 2014 sur la gestion durable des eaux souterraines (SGMA) a suscité de nouvelles préoccupations au sein du district concernant l'équilibre des eaux souterraines. Afin d'exploiter pleinement les ressources en eau de surface du district et d'équilibrer les prélèvements d'eau souterraine, il est nécessaire de créer des bassins de réalimentation permettant d'injecter dans les nappes phréatiques l'eau de surface disponible en dehors des périodes d'irrigation.

Le district a identifié un besoin cible de développer une superficie d'environ 607 hectares de terre (1 500 acres) d'installations de réalimentation sur plusieurs années. En 2024 et 2026, le District a acheté des centaines d'hectares de terres viticoles, après avoir retiré les cultures, il procède actuellement à la transformation de ces terrains en bassins de réalimentation. Ce rapport présente les progrès réalisés à ce jour dans l'approche pluriannuelle du District en matière de planification, de conception, de financement, de construction et d'exploitation, car il transforme les terrains achetés en installations de réalimentation, en mettant l'accent sur les facteurs liés à la conception des bassins.

Mots clés : Eau de surface disponible; Niveaux des eaux souterraines; Pompage des eaux souterraines; Distribution de l'eau; Bassins de réalimentation.

INTRODUCTION

The Southern San Joaquin Municipal Utility District (District) located in southern Kern County, California, and serves a primarily agricultural area within the critically over drafted Kern County Subbasin (Figure 1). The District, under its present name, was organized in 1935 in accordance with the provisions of California laws pertaining to the formation and operation of municipal utility districts. The District was formed for the purpose of entering a contract for the purchase and distribution of water from the Central Valley Project (CVP). Prior to completion of the Southern Pacific Railroad through the vicinity in 1873, land in the area was used principally for livestock grazing.

With improved transportation facilities and the development of large capacity water wells, irrigated agriculture superseded livestock production in the area. In subsequent years, intensive pumping resulted in significantly lowering of the groundwater table underlying the District. This had necessitated drilling deeper wells, with large increases in costs for installation and operation. At present, the District's source of irrigation water is their surface supply from the Friant-Kern Canal (FKC) which is part of the CVP. The District has a surface water contract with the U.S. Bureau of Reclamation (Reclamation) identified as a perpetual 9(e) contract for Class 1 and Class 2 water from the CVP. This contract provides storable and non-storable water supplies from the CVP and conveyance capacity on the Friant-Kern Canal for delivery to the District.

However, over the past two decades, the reliability and timing of CVP water deliveries have become increasingly uncertain due to hydrologic variability, San Joaquin River (SJR) Settlement court actions resulting in the SJR Restoration Program, and land subsidence along the FKC reducing the canal's conveyance capacity. These constraints have prompted the District to re-evaluate its long-term water supply strategy.

In response, the District has identified groundwater recharge as a critical component of its sustainability efforts. To improve local groundwater conditions and comply with the Sustainable Groundwater Management Act (SGMA), the District has committed to developing approximately 607 hectares (1,500 acres) of existing and future recharge facilities. This case study presents the District's recent efforts to convert agricultural land into recharge basins, highlighting design considerations, construction practices, and early operational experience.

BACKGROUND

In 2014, California enacted the Sustainable Groundwater Management Act (SGMA), which mandates that the state's groundwater resources be managed to meet sustainability by 2040. SGMA requires Groundwater Sustainability Agencies (GSAs) to develop Groundwater Sustainability Plans (GSPs) that address six sustainability indicators: chronic groundwater-level decline, reduction in groundwater storage, seawater intrusion, water-quality degradation, land subsidence, and depletion of interconnected surface water. The act requires that groundwater basins identified as critically overdrafted prepare their GSPs for long-term sustainability by 2040. The Kern County Subbasin, in which the District is located, is a critically overdrafted groundwater basin.

To help meet subbasin sustainability targets, the District is implementing in-district groundwater recharge projects to increase beneficial use of available surface water and reduce long-term reliance on groundwater pumping.

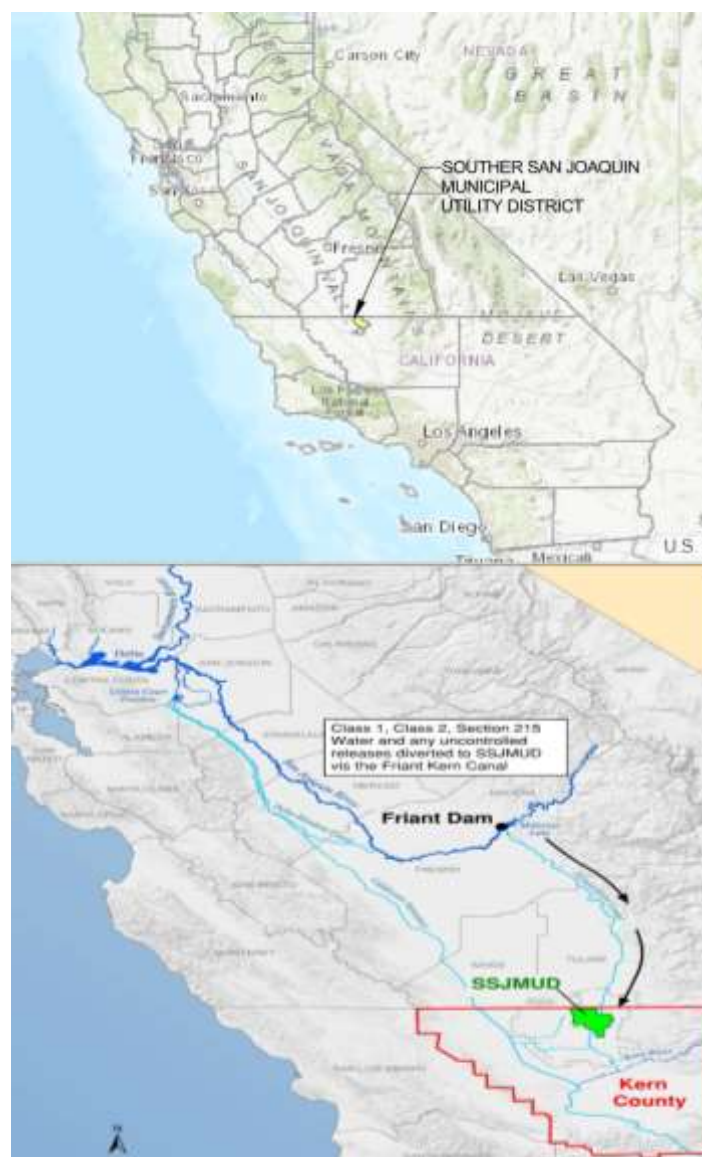


Figure 1. District location and regional conveyance infrastructure in Northern Kern County, CA.

PRIOR RECHARGE SITING AND SIZING EVALUATION

A recharge siting and sizing evaluation was conducted to describe the basic need for in-district recharge, identify suitable locations within the District, and estimate the acreage needed to recharge available wet-year supplies as a CVP federal water contractor. The evaluation considered factors such as soil infiltration capacity, topography, proximity to existing conveyance infrastructure, and historical land use. The evaluation provided priority areas within the District as guidance for obtaining land for recharge sites.

Once the sites were identified, a sizing analysis was performed to match the target area needed to recharge available surface water at estimated percolation rates. This assessment helped determine the size and scale of recharge facilities development and prioritize parcels for acquisition and conversion. Following site selection, preliminary basin layout and grading concepts were developed for two purposes; to evaluate conveyance requirements and earthwork needs and to align recharge sites with grant funding opportunities. The site evaluation included identifying feasible conveyance delivery routes from the FKC and estimating the volume of cut and fill required to reshape former agricultural land into functioning recharge basins. The preliminary designs were tailored to balance recharge performance, operational flexibility, and construction efficiency.

The results of the siting and sizing evaluation provided the basis for deciding on a large amount of land that suddenly became available for purchase in 2024. A rare rain event in August 2023 caused a failure in Table Grapes harvest and led to a family trust's decision to sell approximately 1,620 Hectares (4,000 acres) within the District. The District's evaluation effort leading up to 2024 allowed them to select and purchase 275 hectares (680 acres) that became available and were identified within the preferred area for recharge sites. The preliminary design and completion of existing sites also help understand the benefits of locating the future recharge sites near the District's conveyance facilities and guided the detailed design to be used with future sites. With suitable locations and recharge targets identified, the District proceeded to refine site-specific design parameters to guide basin layout, grading, and conveyance infrastructure. Figure 2 illustrates the general location of the District's existing and future recharge basin sites identified.

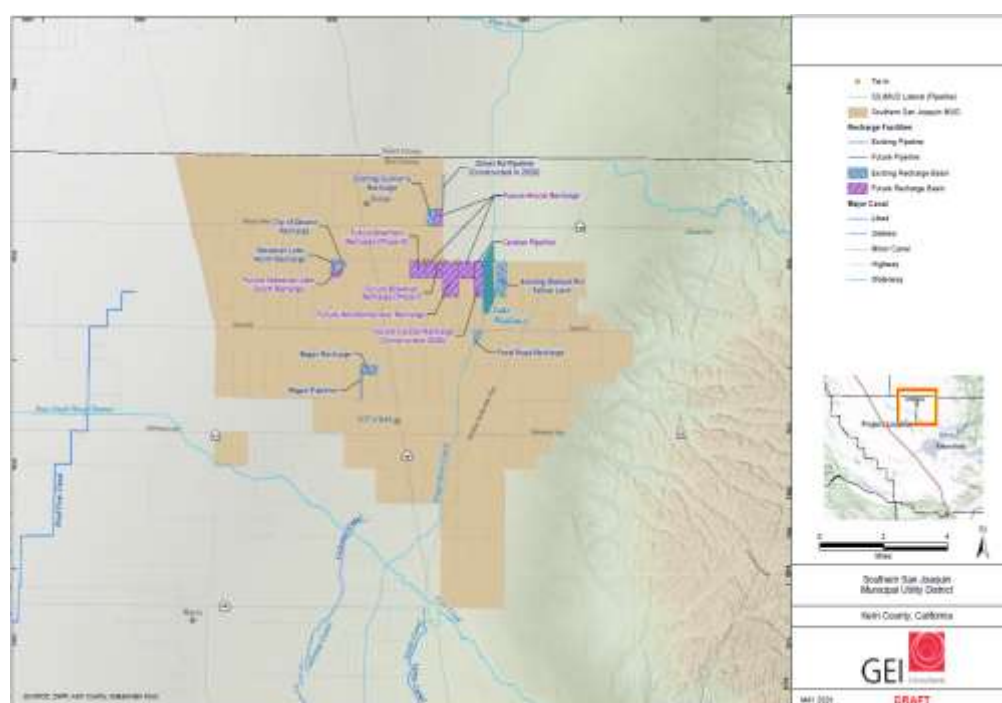


Figure 2. Location Southern San Joaquin Municipal Utility District with Existing and Future Recharge Facilities.

DESIGN PARAMETERS CONSIDERED FOR RECHARGE FACILITIES

In general, recharge facilities require supply, conveyance, and a recharge mechanism to deliver surface water into groundwater storage. Recovery needs in the District are met by growers' use of their wells with the addition of a few District owned wells that came with the land purchases which are now available for use if a growers' recovery well goes out of service.

The following design parameters were considered when designing recharge sites in the District for the two sites completed in 2022 and 2024. These design parameters are being refined as the District and engineering consultant work through the future recharge site developments.

- **Supply water source:** District contract water is delivered from the FKC. The conveyance and basin design considered constraints on available water sources, such as, how much time is water available and at what flow rate during a wet period? How many days or months is water available and at what frequency? Available water supply parameters are defined in the siting evaluation study as part of a decision to obtain land for recharge.
- **Soils recharge rates:** this information determined as part of local recharge study. For the District, a target recharge rate range of 0.09 to 0.15 m/day (0.3 to 0.5 ft/day) was chosen as an approximate range of recharge rates for land in the area.
- **Conveyance route:** The District's distribution system was designed and sized for irrigation deliveries at 0.014 cms (0.5 cfs) per 16 hectares (40 acres) ($0.5/40 = 0.0125$ cfs per acre), whereas the conveyance flow rate being used for recharge basin design is twenty times this original rate for irrigation (0.25 cfs per acre ($0.0125 \text{ cfs} \times 20$)). Locating future recharge basins near source water canals or main components of the existing distribution system helps minimize adding conveyance to the recharge sites. The District used their Water Management Planning to target areas to purchase land; once land was available, they were able to select the locations near larger existing mainline conveyance and near existing turnouts from the FKC.
- **Conveyance and turnout design flow rate:** This conveyance design flow rate is equivalent to 1.13 cms (40 cfs) for each 65-hectare (160 acre) area. Figure 2 illustrates the conveyance infrastructure needed to deliver FKC water to the example Caratan basin, including showing existing conveyance and primary diversion points and turnouts.
- **Conveyance size:** To match the 0.15 m/day (0.5 ft/day) recharge rate on a 65-hectare (160-acre) recharge basin requires 9.87 hectare-meters (80 acre-feet) per 24 hours, or 1.13 cms (40 cfs). Consider target of 1.13 cms (40 cfs) for each 65-hectares (160 acres) converted from cropland into recharge basins. (Gross area delivery to allow for filling of the basins and potential recharge rates higher than 0.15 m/day (0.5 ft/day) design parameter).
- **Gross and effective recharge area:** Typical gross area to net effective recharge area is 85-percent (~ 0.85) ratio once land is converted to recharge ponds.
- **Conveyance within site sizing:** Consider each basin area to size each turnout and Interbasin structures. Typical recharge rate of 0.15 m/day (0.5 ft/day ~ 0.25 cfs/acre).
- **Pond area sizing and layout:** Arrange ponds in a stairstep layout to reflect site elevation changes. Embankment spacing affects construction cost, so shorter looped haul routes for levee construction should be considered. Wind erosion should also be evaluated.
- **Compacted embankment parameters:** Embankments use interior slope 5:1 with exterior slope 4:1 for mowing and ease of maintenance. The maximum height inside of embankment is 1.52 meters (5 feet) with 0.6 meter (2 feet) of freeboard above the maximum water height; optimal height of 0.91 meter (3 feet) for the inside face of the levee holding water. Outside the

perimeter embankment can be 0.09 to 0.3 meters (0.5 to 1 foot) higher than interior to help protect against water leaving the site. Earthwork is a balanced cut/fill design with desire to export and remove material from the site if possible. When constructing the basins, consider high cut/fill compaction ratio of (~1:1.65) based on local experience in Kern County basin construction.

- **Top of embankment road base:** Aggregate base surfacing on top of embankment where needed for driving during operations. Width of 4.5 to 6.1 meters (15 to 20 feet), 2-percent slope with a crown, and depth of road base 15 centimeters (6 inches). Preferred to have an aggregate base surface to help with maintaining weed control and safe access during wet periods.
- **Consideration of clogging layer:** Clogging of soil in recharge basins is a complex phenomenon. Bouwer and Rice (1989) describe this as a consolidation process, with clogging-layer compression governed by water depth and other factors.
- **Pond water depth:** Minimum water depth is 0.15 meter (0.5 feet), maximum depth is 0.91 meter (3 feet); prefer to use shallow, minimum water depth in ponds to reduce the possible clogging layer and reduce the amount of time water is held in the ponds prior to recharging (holding time), Bouwer (2002)
- **Pond bottoms:** Flat bottoms with slight slope from high point to low about 0.15 meter (0.5 feet). Deep rip with slip plow following construction to enhance their recharge rate.
- **Pond filling and operation:** Use slightly lower elevation of the low channel in the pond bottom to direct water movement into and through the pond, let it fill up from the low elevation of the pond bottom to the higher elevation. Minimum operating depth is an advantage, however, District operators like seeing high water depth the ponds in a basin while in operation. This observation is based on operating feedback on the existing ponds; observing the field operator thinking, "keeping the basin at full depth will reach higher recharge capacity". The optimal operating at lower level is a design and operating parameter that requires some time in operation for acceptance.
- **Interbasin structures:** Preference is a corrugated, smooth interior wall, 61-centimeter (24-inch) diameter plastic pipe with tie-down ends to secure against floating. Concrete collar needs to be installed, and soil compacted around pipe to reduce piping seepage when operating.
- **Cut/fill balanced design:** In design, consider contour of existing site elevations and adjusting ponds by dropping elevation of the embankments as needed and bottom elevation to move water through to each pond. If a basin can operate with lower embankment height, it will be less in compacted quantity to construct, thus consider using lower embankment height of 0.91 meter (3 to 4 feet) instead of 1.5 meter (5 feet). Consider each pond cell as an individual decision as can adjust depth in the pond with use of diversion boards in the pre-cast inlet boxes if need a higher depth in pond to move water into it and through a series of connected ponds. Flexibility in the embankment height may save compacted fill if the site has high points in the middle or places where it rises in elevation.
- **Daylighting check:** It is prudent to check where a 10:1 slope from the highest water level on the inside of the embankment daylights on the exterior side of the embankment. The slope is not to daylight above ground or to any area that may influence adjacent land.
- **Material stockpiling:** Consider areas to stockpile or place material that could be removed from the site later and not needed for a compacted embankment. Stockpiling material and constructing the ponds lower can reduce the compacted embankment fill quantities and reduce likelihood of water leaving the site in an uncontrolled manner or by seepage.

RECHARGE BASIN LAYOUT

Figure 3 provides a layout of the Caratan 65-hectare (160-acre) recharge facility with 12 individual basins, including the general pond configuration, embankment design, interbasin structures, and access roads. The layout reflects the common design elements used across the District's recharge projects and illustrates how site conditions influence pond geometry and flow direction. This is a typical recharge basin layout used by the District, illustrating stairstep pond configuration based on site elevation, compacted embankments with 5:1 and 4:1 slopes, interior conveyance structures (interbasin pipes), and perimeter access roads.

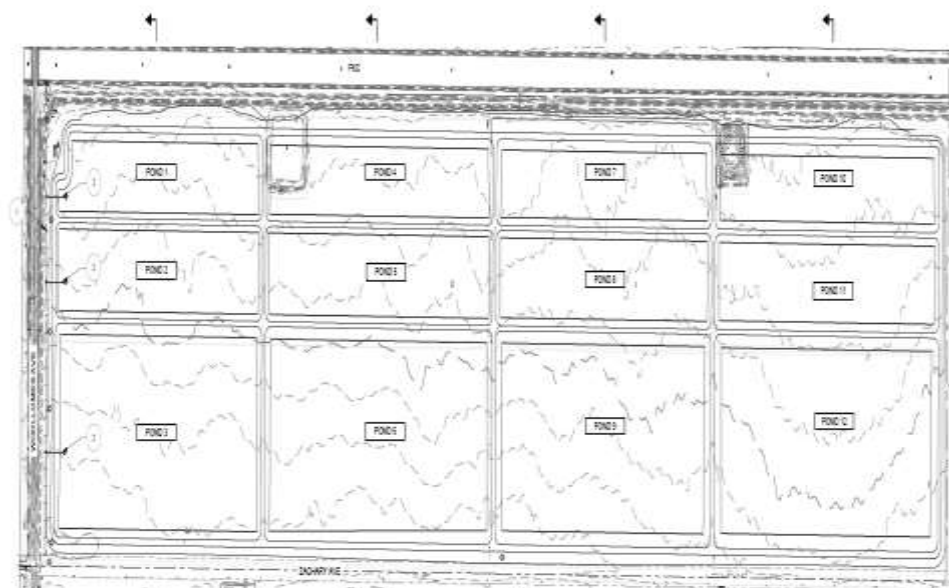


Figure 3. Caratan Recharge Facility Pond Layout

RECHARGE BASIN CONSTRUCTION

The schedule of values used for constructing the Caratan 65-hectare (160-acre) recharge facility shows nine bid items. The contract was awarded in April, 2026 with an anticipated completion of March, 2027.

Table 1. Recharge Basin Construction Costs

ITEM	DESCRIPTION OF WORK	SCHEDULED VALUE
1	Mobilization and Demobilization	\$75,000
2	Environmental Compliance and Permits	\$32,800
3	Demolish Old Irrigation Lines	\$45,650
4	Over Excavation and Compacting	\$85,100
5	Excavation	\$517,500
6	Levee Embankment	\$281,250
7	Aggregate Base Surfacing	\$404,991
8	Interbasin Structures	\$259,980
9	Deep Rip Pond Bottoms	\$64,965
	Contract Subtotal	\$1,767,236

DISTRICT PROGRESS ON RECHARGE BASINS

As shown in Figure 2, the District has completed several recharge basins prior to 2025 and has identified several more sites to complete to meet their target acres. The District set aside capital improvement funds for the purpose of buying and converting the land to recharge facilities. In 2024 the District was able to secure ownership of 275 hectares (680 acres) of land that prior use was raising table grapes and in 2026 identified additional crop land to convert to their existing and future recharge facilities. The District has secured supplemental grant funds for basin construction and will continue to pursue funding opportunities. Table 2 lists the existing and planned recharge projects which are identified in the District's SGMA Plan as they work toward reaching their target of 607 hectares (1,500 acres).

Table 2. SSJMUD Recharge Facilities Progress Summary

Recharge Site	Acreage [Hectares] (acres)	Status	Notes
Pond Road	[12.1] (30)	Constructed	In operation
Sebastian Lake	[12.9] (32)	Constructed	In operation
Giumarra/Driver Road Pipeline	[31.5] (78)	Constructed	Giumarra in operation / Driver Road Pipeline constructed.
Regan	[30.4] (75)	Constructed	In operation
Caratan	[65] (160)	Funded; Construction in 2026	Grant awarded; final design and bidding spring 2026.
Woollomes Avenue	[130] (320)	In Design and NEPA evaluation.	Grant Awarded; final design in 2026 and construct in 2027
Bowman – Site A	[16.2] (40)	Under Evaluation	Preliminary siting completed
Bowman – Site B	[65] (160)	Under Evaluation	Part of phased acquisition plan
Wallace Road (Fallow Land)	[72.8] (180)	Under Evaluation	Fallowed farmland; under review for infiltration rates
Giumarra	[32.5] (80)	Under Evaluation	Expansion of Giumarra site
Total Future Sites	[607] (1,500)	Under Evaluation	Existing plus Potential land identified

CONCLUSION

The District has initiated a long-term effort to increase in-district recharge capacity as part of its groundwater sustainability strategy under SGMA. The District's approach includes identifying suitable sites, acquiring land, and converting former agricultural parcels into recharge basins using locally funded capital improvements and available grant support. Design of the recharge basins considers water availability, soil infiltration capacity, topography, and construction efficiency. Features such as interbasin structures, compacted embankments, and access roads have been incorporated to support basin performance and operational needs. As the District continues to construct additional recharge sites in future phases, its efforts provide a practical example of how targeted groundwater recharge can be planned, designed, and implemented to support long-term basin sustainability.

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