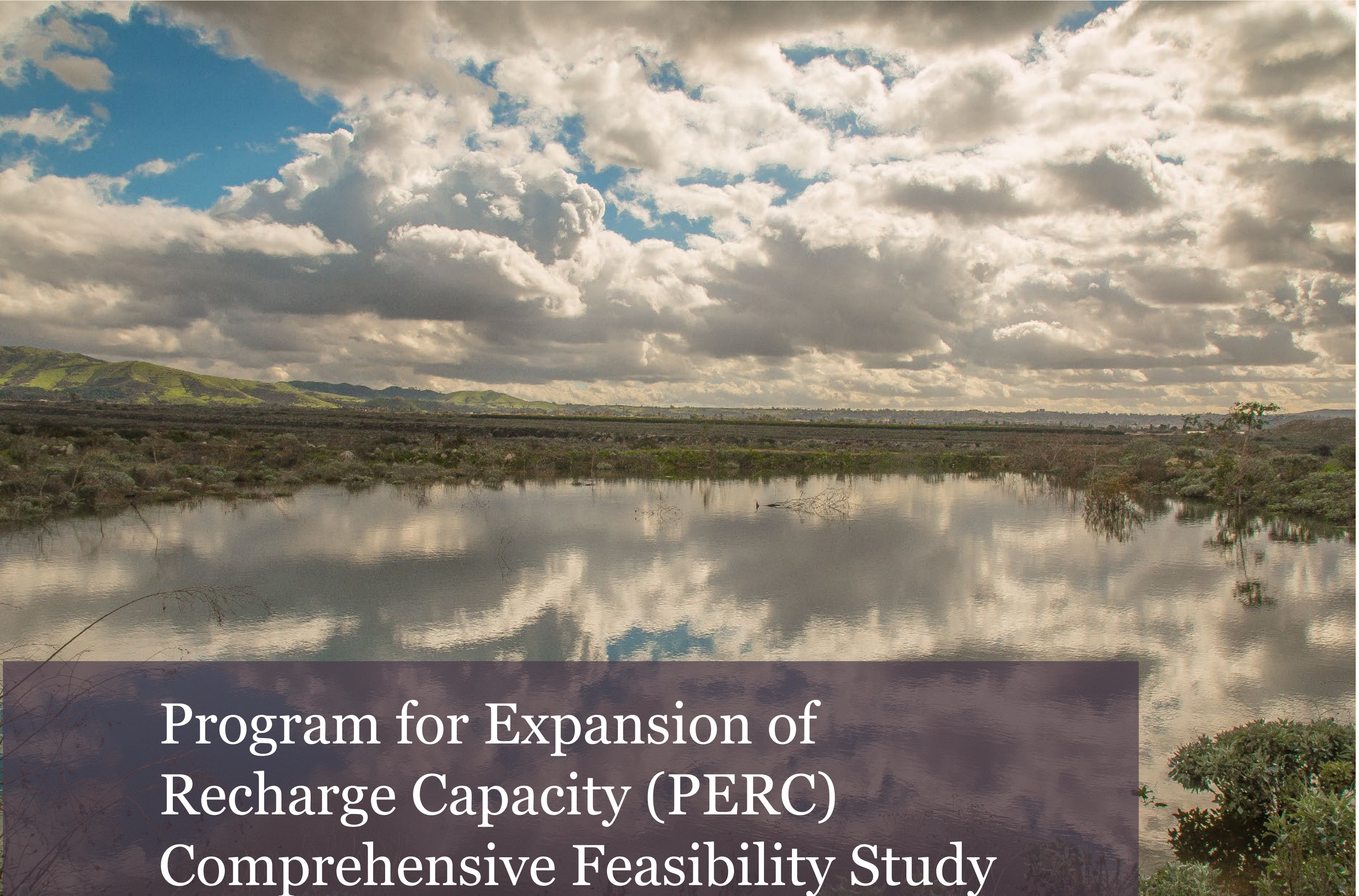

Program for Expansion of Recharge Capacity (PERC) Comprehensive Feasibility Study

Volume 2

Detailed Feasibility Analysis of PERC Project Alternatives for East Twin Creek Watershed

Waterman Recharge Basins

Twin Creek Recharge Basins

Lynwood Recharge Basins

November 2025

San Bernardino Valley
Water Conservation District
Helping Nature Store Our Water

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Introduction to Volume 2

Detailed Feasibility Analysis of Program for Expansion of Recharge Capacity (PERC) Project Alternatives in the East Twin Creek Watershed

Volume 2 of the *PERC Comprehensive Feasibility Study* includes Detailed Feasibility Analyses for the following *grading projects* as PERC Project Alternatives in the East Twin Creek Watershed:

- Waterman Recharge Basins
- Twin Creek Recharge Basins (two alternatives; small and large)
- Lynwood Recharge Basins

Table 1 lists all ten PERC Project Alternatives with the corresponding Study Volume, geographic location, and site for each.

Table 1. PERC Comprehensive Feasibility Study Alternatives

Volume/ Location	Site	PERC Alternative
Volume 2 East Twin Creek Watershed	Waterman Recharge Basins	Waterman Grading Alternative
	Twin Creek Recharge Basins (TCRB)	TCRB Small Grading Alternative
		TCRB Large Grading Alternative
	Lynwood Recharge Basins	Lynwood Operational Alternative
Volume 3 Plunge Creek Watershed	Oak Creek Recharge Basins (OCRB)	OCRB Construction Alternative
	Plunge Creek Recharge Basins (PCRB)	PCRB Interim Construction Alternative
		PCRB Ultimate Construction Alternative
Volume 4 Mill Creek	Mill Creek Recharge Basins (MCRB)	MCRB Grading Alternative 1
		MCRB Grading Alternative 2
		MCRB Grading Alternative 3

Technical details supporting Volume 2 can be found in the *Preliminary Design Report for Waterman Percolation Basins, Twin Creek Spreading Grounds, and Lynwood Basins,* provided as Appendix B.

About East Twin Creek Watershed

East Twin Creek Watershed is a source of water for three groundwater recharge locations: Waterman, Twin Creek, and Lynwood Recharge Basins. SBVWCD developed four PERC Project Alternatives to potentially expand recharge at the existing sites:

- Waterman Grading Alternative
- TCRB Small Grading Alternative
- TCRB Large Grading Alternative
- Lynwood Operational Alternative

Volume 2 of the *PERC Comprehensive Feasibility Study* includes Detailed Feasibility Analyses for each above-listed alternative.

PERC Cooperation and Joint Implementation

The East Twin Creek PERC Alternatives were developed with the understanding that SBCFCD's Operations and Maintenance Manual (Tetra Tech, 2014) requires peak stormflows to be bypassed for flood safety reasons. The Alternatives were reviewed with SBCFCD during technical studies supporting the PERC Comprehensive Feasibility Study from March 2022 to March 2025. The development process was supported by several cooperative agreements:

- Planning Memorandum of Understanding (MOU) between SBCFCD and SBVWCD entered February 9, 2021.
- San Bernardino County Board of Supervisors Resolution dated April 26, 2022 supported SBVWCD joint use of SBCFCD facilities for water conservation and groundwater recharge that is consistent with flood control operations and safety objectives.
- Contract No. 23-580, "Joint Groundwater Recharge and Facilities Planning Agreement," for SBVMWD and SBCFCD approved by the San Bernardino County Board of Supervisors on June 13, 2023:
    - Directed joint use of existing flood control facilities for engineered recharge by SBVMWD where it is compatible with safety objectives.
    - Established a Joint Implementation Committee between SBVMWD and SBCFCD with representatives of additional partner agencies.

SBVWCD participated in meetings of the Joint Implementation Committee which served as a forum for all partners to discuss PERC Project Alternatives.

Waterman Recharge Basins Alternative

1 Executive Summary

The **Waterman Recharge Basins PERC Project Grading Alternative** (Waterman Grading Alternative) modifies and enlarges existing recharge basins. It integrates the following features to improve control of inflows and inter-basin flows:

- Automating diversion of Waterman Canyon Creek native flows into enlarged basins.
- Controlling native Santa Ana River inflows from the San Bernardino Valley Municipal Water District (SBVMWD) Foothills Pipeline as a delivery source under Forecast Informed Reservoir Operations (FIRO).

The Waterman Grading Alternative is estimated to provide an additional **2,171 AFY of recharge** above the estimated 600 AFY from the existing facilities with the same water sources. It is estimated to provide an additional 83.89 cfs in infiltration-rate capacity. For the 50-year planning horizon, the 41.5-year period of operation would provide an estimated 92,264 AF of net groundwater recharge as forecast "firm yield" beyond what can be done with the current basins using the same native water sources.

The Waterman Grading Alternative is estimated to be able to be constructed in about 8 years. With a project decision date of July 1, 2025, this means projected operations are rated from July 1, 2033 to the end of the 50-year project planning horizon, December 31, 2075.

Waterman Grading Alternative Scores and Rank

Consideration (MAA Account)	Score
Groundwater Recharge Benefits	1.86
Cost Aspects	1.05
Other Technical Aspects	0.57
Social Aspects	0.08
Legal Aspects	0.40
Total Score	**3.95**
Rank (of 10)	**8th**

The projected capital cost (in present value) is $21,886,000. The annual Operations & Maintenance (O&M) cost, in 2025 value, is estimated to be $95,885.

Waterman Grading Alternative ranked 8th out of 10 potential PERC projects evaluated. It is a feasible and viable project but ranks lower on characteristics for near-term project prioritization to apply available human resources, financial resources, and political capital.

2 Introduction

In this document, the **Waterman Grading Alternative** is evaluated based on the five aspects identified by SBVWCD and project partners as important and relevant to ranking PERC Project Alternatives, which are:

- Groundwater Recharge Benefits
- Cost Aspects
- Other Technical Aspects
- Social Aspects
- Legal Aspects

A complete description of these aspects, their respective components, and the ranking methodology for PERC Project Alternatives is provided in **Volume 1**.

Sections 3 through 5 below provide information specific to the Waterman Grading Alternative, including the following:

- **Section 3 – Site and Features**: Descriptions of the Alternative's site location, existing facilities, geologic setting, and surrounding watershed.
- **Section 4 – Design and Analysis**: Descriptions of the Alternative's water sources, proposed design, and characteristics as they align with the five aspects (listed above).
- **Section 5 – Summary Results**: Tables presenting the Alternative's scores and rank.

3 Site and Features

The Waterman Recharge Basins are situated in an area of approximately 165 acres spread over three lots owned by SBCFCD. They are located upslope of a densely populated urban area near East 40th Street and North Waterman Avenue (i.e., CA Highway 18) in the City of San Bernardino. The Waterman Grading Alternative location, as well as the other PERC Project Alternative locations, is shown in **Figure 1**.

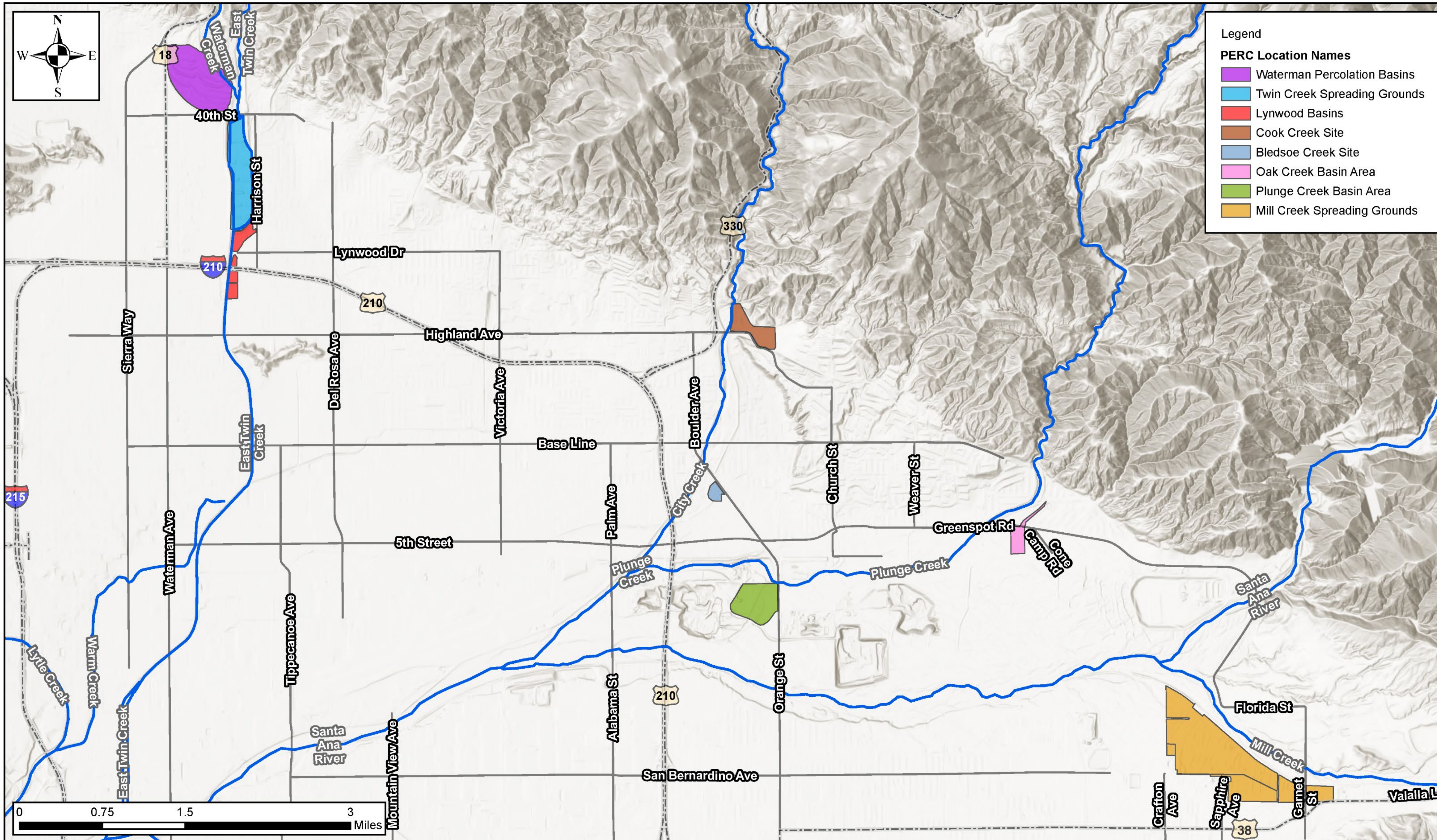

Figure 1. PERC Project Locations

3.1 Existing Facilities

The Waterman Recharge Basins extend approximately 0.5 miles north of East 40th Street and span between North Waterman Avenue on the west and North David Way on the east side of both Waterman Creek and East Twin Creek, above and below their confluence.

They are surrounded by levees, built by the U.S. Army Corps of Engineers (USACE) in the 1960s (USACE, 1960). USACE designed and built the current basin configuration for purposes of flood protection.[1] Construction was an improvement to protect areas southeast of Waterman Canyon Creek. Later, SBCFCD added internal berms and spillways to better control the flow of surface water and improve groundwater recharge. The Waterman Recharge Basins were operationally revised, sometime after 1962, to be used for groundwater recharge in addition to their flood detention capacity.

There are fourteen existing Waterman Recharge Basins, but one basin is no longer functional due to infill. The thirteen operable basins are depicted in **Figure 2** with designations ranging from Basin 1E to Basin 4. The non-functional Basin 1W is not depicted. Each basin is surrounded by earthen graded berms. Ostensibly the existing basins are on four elevation-grade levels; 1, 2, 3, and 4, with level 1 being the highest. The existing basins and berms are not precise; grade elevation between berms and basins on the same level are not the same, particularly on level 3. Hydraulic interties between the existing basins generally consist of ungated culverts that convey water downgrade between the basin levels in a largely serial fashion. For example, flow from Basin 1E goes to Basin 2E then to 2A and so on through to level 4 and the lowermost drop inlet leading to East Twin Creek. The culverts for interflow are set a few feet above the basin bottom elevation providing for shallow ponding of water. Some of the outflow culverts have slide gates to provide control of water stage and impoundment, but overall, there is very limited control of water stage elevation within and among the basins.

Along the centerline between the existing western and eastern basins there are two ogee-spillways (“Existing Weir”) that can pass very high flood flows out of the basins to an outlet channel, nominally Basin 4. Basin 4 (the lowermost basin) has a drop inlet at its eastern end that allows excess water flow to overflow into East Twin Creek via a regulated outflow to a 36-inch culvert under the access road along the eastern edge of the existing recharge basins (see Figure 2).

The perimeter levee around the western and southern sides of the facility is a FEMA accredited levee (Waterman Levee, FEMA ID 80A, 2-408-5A). The interior berms around each basin are neither levees nor jurisdictional dams. No evidence exists that the recharge basins were constructed for flood control purposes as depicted in the USACE designs of 1961.

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[1] SBCFCD Flood Control System Number [ID] 2-404-2A

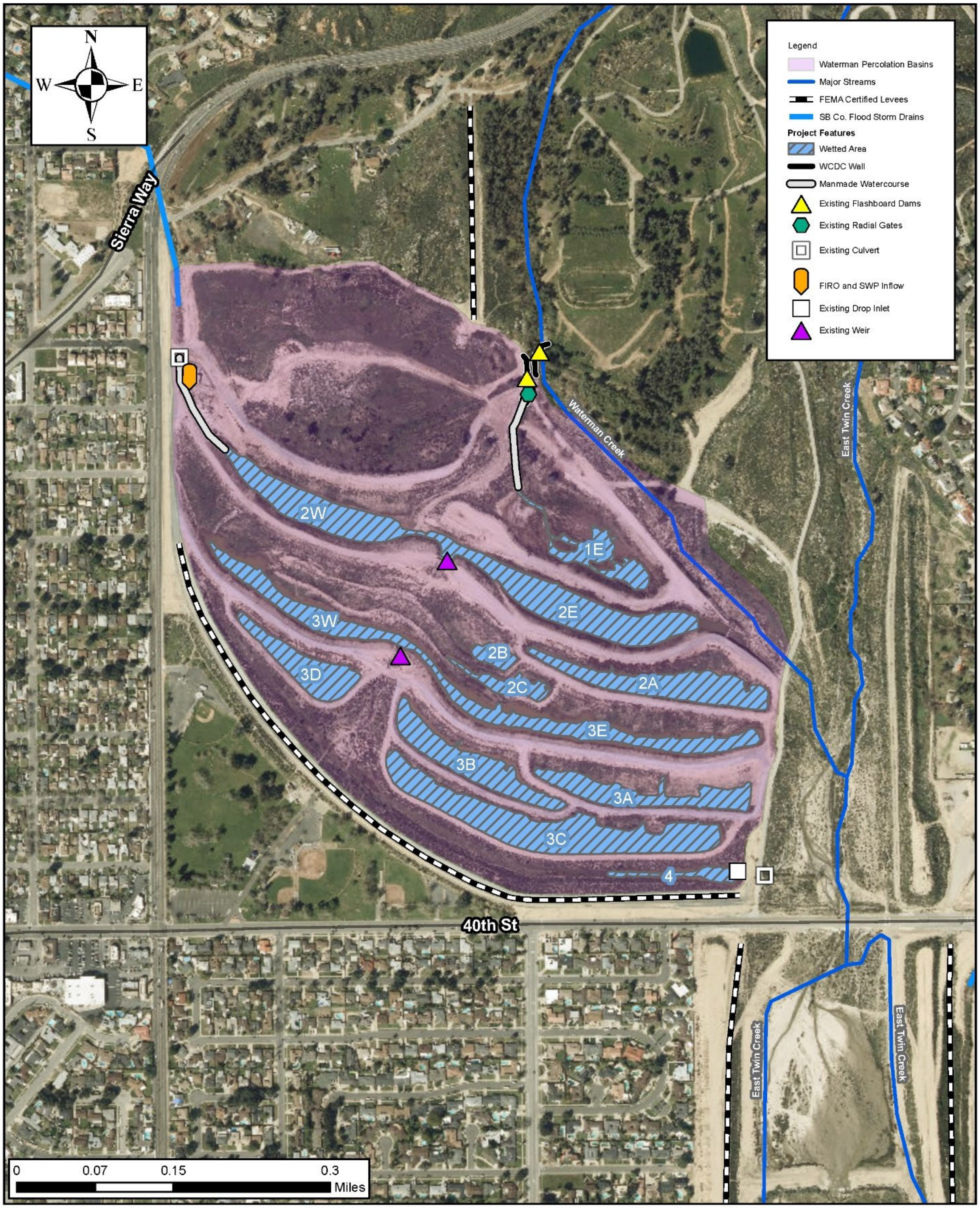

Figure 2. Waterman Recharge Basins Existing Conditions Overview

According to SBCFCD's Operation and Maintenance Manual (Tetra Tech, 2014):

- During the pre-storm flow phase of flood operations, when the National Weather Service forecasts rainfall in the area of ***more than 0.3- inches/hour*** or a total of ***more than 2-inches in a 24-hour period,*** protocol requires that the East Twin Creek and Waterman Levees headworks and diversion works (mechanical gates) be closed to keep storm flows from impairing the levee function.

- During non-rainy days, each of the two radial gates (also known as Tanner Gates) that allow inflow to Basin 1E can be opened.

During field inspection, the eastern radial gate was found to be in a frozen position at a height of 1.8 feet above the culvert floor (see photo, Appendix A). Repair was analyzed for the frozen/broken eastern radial gate at the top of the system, Heading 1C. Repairing it would enable the system to operate in conformance with the Operations and Maintenance Manual.

The repaired condition was used to evaluate flood conditions with and without the Waterman Grading Alternative. Flood modeling was conducted to analyze the duration of floodwater at the levee toe after grading for a new project alternative, compared to existing conditions (see Appendix B, Attachment II).

The following were identified as existing facilities that should be retained with a Waterman Grading Alternative:

- The existing grading for introduction of water from Brush Canyon and from the Foothill Pipeline would be retained and used in their current configuration of essentially serial flow.

- The existing drop inlet in the southeast corner to exhaust excess water into East Twin Creek would be retained.

- As it is not an operational recharge feature of the Waterman Recharge Basins, the existing flood control levee would not be altered or disturbed.

All other features of the existing conditions at the Waterman Recharge Basins were considered available for revision in the Waterman Grading Alternative.

3.2 Site Assessment

Preliminary site assessment at Waterman Recharge Basins included a topographic survey, site walk, and records review.

3.2.1 Topographic Survey

The topographic survey was conducted by Tetra Tech and their survey contractor. A summary of the survey around Waterman Recharge Basins is reported in Appendix B, Exhibit A (Tetra

Tech, 2025) and the full survey details on the grades examined are reported in Appendix B, Exhibit B.

3.2.2 Site Walk

Site walk surveys by SBVWCD staff on January 17, 2024, June 5, 2024, and December 21, 2024, found existing site facilities in relatively good condition with all berms intact. The on-site radial gates are non-functional. Relevant site photos of infrastructure are provided in Appendix A.

3.2.3 Records Review

The records review of SBCFCD and USACE filings found:

- **Interior berms of the Waterman Recharge Basins** are not listed as flood control features (SBCFCD, 2023b).
- **USACE assessed that the FEMA-accredited flood levees are in good condition.** Further, they rated them as capable of managing a 200-year return frequency event using their standards of design (Standard Project Flood, SPF). USACE found the FEMA-accredited levees to be in good working condition during their last assessments in 2016 and 2019 (SBCFCD ID 2-408-5A & -5B, Waterman Levee and Twin Creek Levees). The layout and identification of the flood control features by SBCFCD are provided in Appendix B, Figure 1-1. The latest information on the levee conditions was updated by USACE in October 2024 to the National Levee Database under the following FEMA IDs: FEMA 80A, FEMA 80B, FEMA 52 and FEMA 65.

3.3 Geotechnical Assessment and Analysis

The surficial geology at the Waterman Recharge Basins is differentiated young “wash” and alluvial fan deposits (**Figure 3**). This differentiation means that the deposition occurred either in the general pathway of the watercourse (i.e., wash deposits) or on the surface of an alluvial fan built up at the boundary of flows. The sedimentary deposits beneath the Waterman Recharge Basins had routinely been subjected to flushing flows, but alluvial fan deposits grew around the northwestern edge and along their eastern boundary. These deposits would be expected to be relatively coarse-grained overall given their proximity to the canyon mouth and its grade line.

The engineering consulting team performed geotechnical testing and assessment of the Waterman Recharge Basins (Appendix B, Attachment II) including subsurface testing for infiltration properties of the near-surface sediments in Waterman Recharge Basins in November 2022. The on-site assessment via drilled boreholes and excavated test pits found favorable conditions for expanded groundwater recharge. On-site exploration by test pits also found sediment infill deposits accumulated within the existing basins.

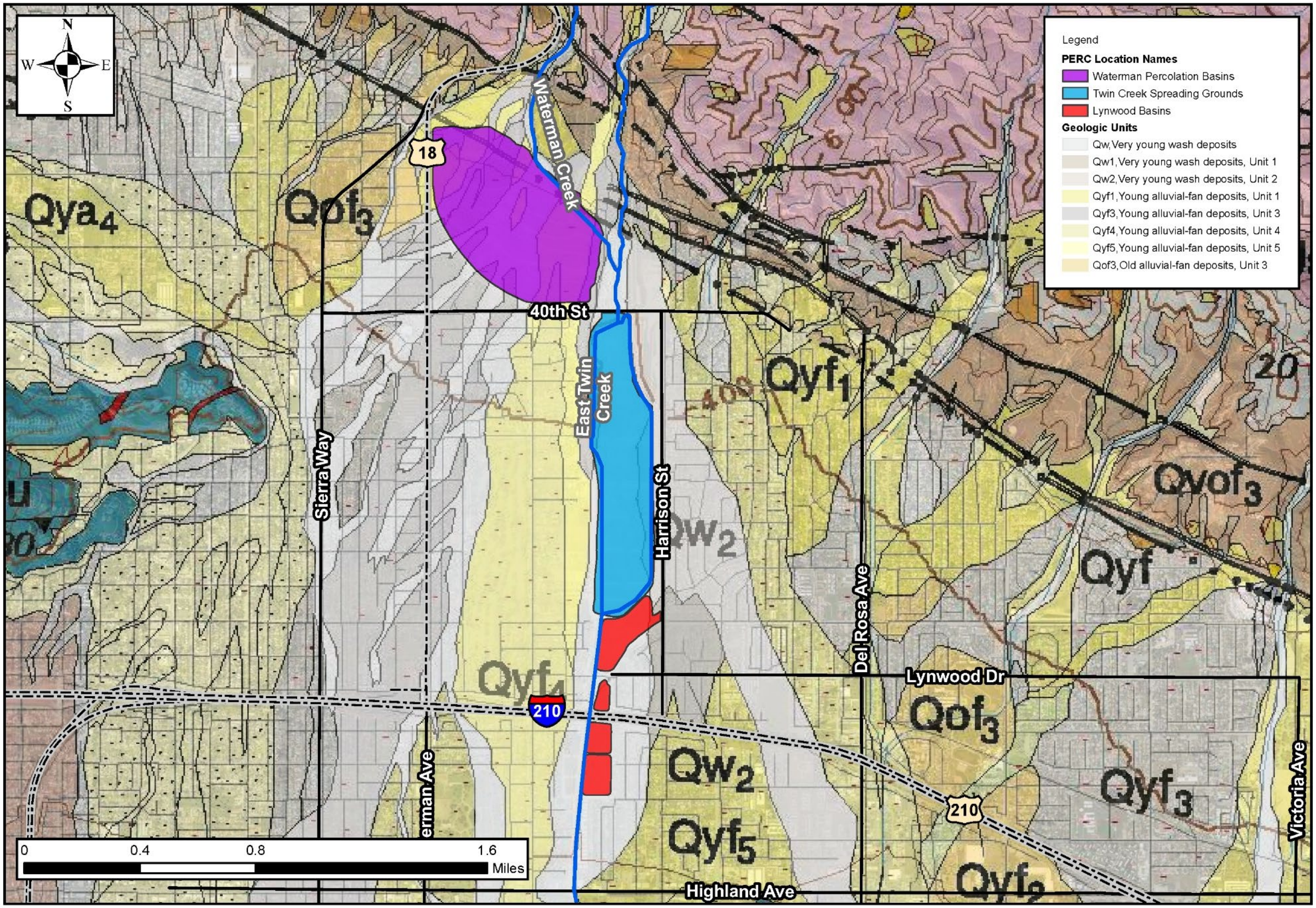

Figure 3. Sedimentary Geologic-Units Map of East Twin Creek Watershed PERC Project Sites

Infiltration testing data demonstrate that enlarging the existing detention basins and increasing the wetted area could constitute a PERC Project. The infiltration properties tested in the field and in the lab were consistent with other areas tested in the young wash deposits; these types of deposits were observed in the excavated test pits in Waterman Recharge Basins with notations of recent (Qal_2) and very recent (Qal_1) alluvial sediments.

There are many berms or non-flood levees within the Waterman Recharge Basins in their existing condition, as well as for the Waterman Grading Alternative. The geotechnical evaluations performed assessed land slope stability, the sustainable hydraulic slope (or water pressures) that could be safely sustained across the berms, and the seismic hazard potential. These analyses are reported in detail in Appendix B, Attachment II. The analyses provide meaningful recommendations to **avoid maximum water holds beyond 75 days** to reduce the potential for destabilization of berms by excess water slopes and pressures for extended periods.

There are no accredited flood-control levees within the Waterman Recharge Basin system and thus there are no flood-condition concerns for the inter-basin berms.

4 Design and Analysis

The objective for the Waterman Grading Alternative is to leverage existing infrastructure to increase the amount of recharge from the East Twin Creek watershed. A secondary objective is to enable evaluation of whether engineered groundwater recharge closer to the Pressure Zone can slow or stop the decline in the groundwater level within the Pressure Zone.

4.1 Proposed Design

The **Waterman Grading Alternative** includes structural improvement of the existing Waterman Creek Diversion Channel (WCDC) at the entrance of the basins and grading improvement of internal basins to promote groundwater recharge. The general project layout is shown in **Figure 4**.

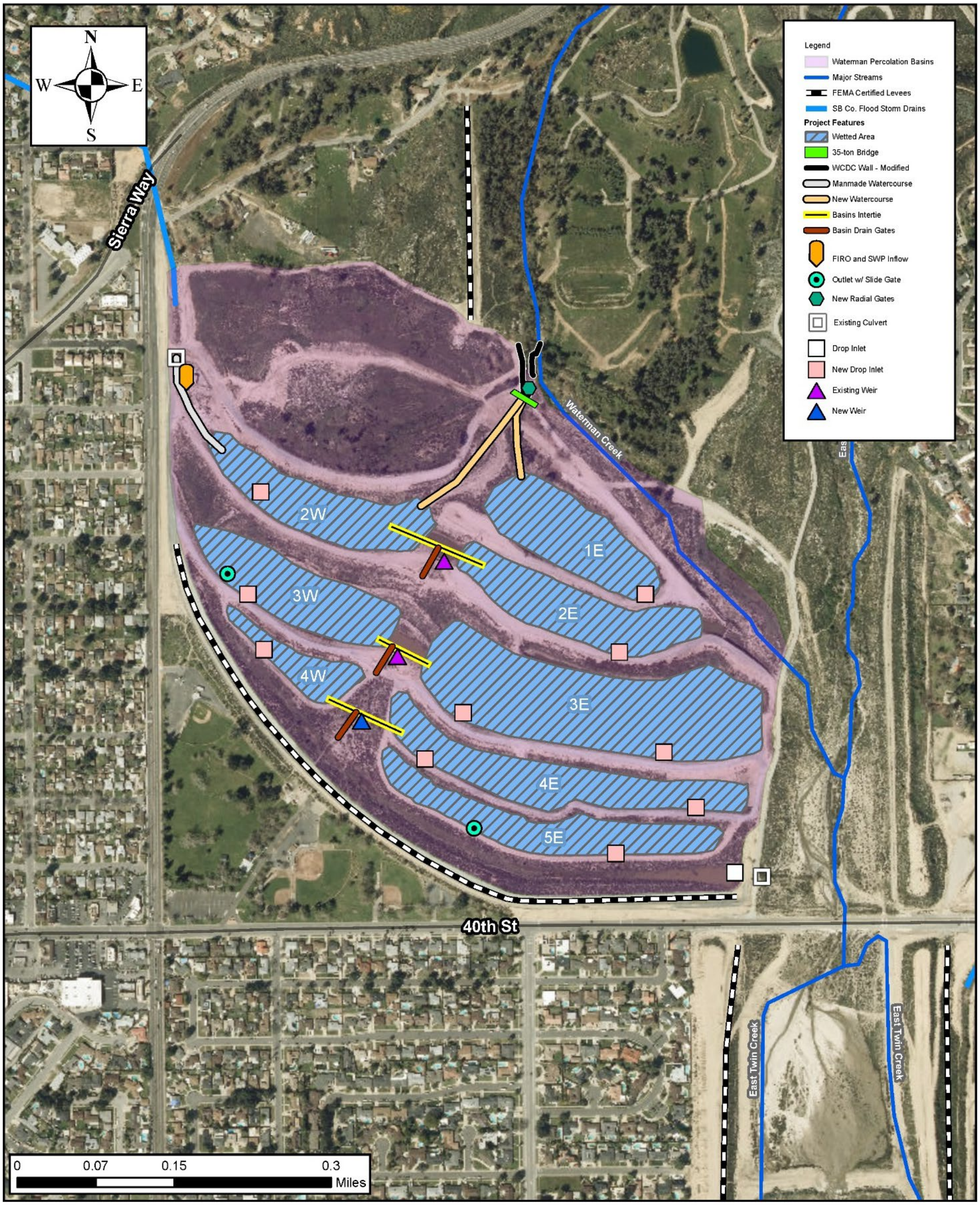

Figure 4. Waterman Recharge Basins Grading Alternative Design

A summary of the proposed modifications is provided below. Preliminary design details, including plan and profile views, are provided in Appendix B.

1. **Replace Channel Gates:** Remove gates at WCDC Headings 1A and 1B. Replace the two radial gates at Heading 1C with smaller radial gates.
2. **Install Diversion Control:** Split inflow from Heading 1C with a demising concrete wall between the radial gates continuing downslope 100+ feet. Regrade the land on either side to create a flow path away from each gate. One flow path is graded to the west into a regraded Basin 2W and the other flow path is graded to the east into a revised Basin 1E.
3. **Regrade Basin Areas:** Regrade existing basins to consolidate to 8 basins from the current 13. Regrade in accord with current top-of-berm elevations to generate five grade levels from top to bottom. The new footprint is approximately 61.2 acres.
4. **Control East to West Movement of Water:** Build piped interties east-west in the subsurface at grade levels 2, 3, and 4.[2] Outfit with slide gates for operational isolation to drain and clean basins while continuing to infiltrate water in the other basins.
5. **Control Water Level:** Control movement of water between grade levels via concrete drop inlets with piped outlets to the next level down, enabling operation of deeper and larger basins with passive level-control at the elevation of each drop inlet. Drop inlets in east-west basin pairs (e.g., Basins 2W and 2E) are built to the same elevation.

No modification to the USACE designed and built flood control features are proposed for the existing basins and flood levees.

The primary **water inflow** features to the regraded basins are:

- Two new radial gates at Heading 1C from Waterman Creek.
    - Two new box culverts behind the radial gates that adjoin to a concrete dividing wall to control flows from each gate to the west and east.
- Water inflow to Basin 2W from the Foothill Pipeline.
- Water inflow to Basin 2W from the Brush Canyon stormwater pipeline.

The **water volume** in maximum retention during operation would be 635 AF:

- The maximum water depths reach 25 feet in Level 2.
- The average depth of water in the basins overall is approximately 13.5 feet.

[2] There is a singular basin at grade levels 1 and 5 eliminating any need for east-west lateral interties.

The **water outflow** feature is an existing drop inlet in the bottom channel that exhausts water via a 36-inch corrugated metal pipe (CMP) culvert to East Twin Creek. That drop inlet is depicted in Figure 4 and in the design drafts in Appendix B. As noted on the design drawing, the outflow would be metered.

No metering of Waterman Creek is envisioned, as the existing USGS Gage provides influent data for divertible flow rates under 500 cfs. Inflows from the Foothill Pipeline are metered. No metering of Brush Canyon inflow is envisioned; those low frequency flows can be estimated from gage data.

4.1.1 Geotechnical Considerations on Project Design and Operations

The geotechnical engineering assessment of soils and sediments for lithology and engineering properties recommends the following considerations for design and operations (TetraTech, 2025):

- Slope of 3(H):1(V) for stability of earthen berms.
- Hydraulic slope across the berms not exceeding 75% for long periods of time (e.g., greater than 1 month) to avoid soil instability.
- During long-term infiltration periods, the maximum differential water elevation between adjacent basins should be maintained at no greater than 45% of the downstream slope height of the inter-basin berm.
    - This latter criterion can be met from the existing berm grades coupled with the respective water surface hold elevations proposed for the drop inlet structures in the preliminary conceptual design.

4.1.2 Project Operations

The day-to-day operations for Waterman Recharge Basins would be very low, as both operations and data collection would be designed for near-full automation. Basin cleaning and maintenance operations are projected to be sporadic at around 7.5-year intervals for scraping out sediment and a singular annual inspection of basin operating conditions.

4.1.3 Timeline

As described in Volume 1 of the Comprehensive PERC Feasibility Study Report, the timeline for project alternatives is calculated by estimating the time to design, permit, fund, and construct a project. Volume 1 summarizes these estimates alongside those for the other PERC Project Alternatives. Each timeline factor for the Waterman Grading Alternative is described below.

- **Design Time**: Design of the Waterman Grading Alternative to the 65+% level required for permitting consideration is estimated to take **12 months**.

- **Permit Time**: The permit time forecast for Waterman Grading Alternative is **36 months**. This is controlled by the expectation that a USACE 408 Permit will be required and may take up to 36 months to obtain. Even though the work does not physically contact or disturb a flood levee; the area of the work is within 500 feet of a flood-control levee. All other permit requirements are expected to be accomplished within that same overlapping one-year period. This is based on the preceding discussion, SBVWCD and SBVMWD experience, and programmatic expertise.

- **Funding Time**: The time forecast spanning from project decision-making to having a capital funding plan in place is estimated to be **36 months**. The funding timeline is thought to be initiated after the Design and Permitting Time. The timing of project funding then is **July 1, 2032**. This is the timeline used to generate a net present value factor for capital funding needs.

- **Construction Time**: The construction period includes the time needed to take project designs into biddable specifications and contract documents, conduct a public bidding process for contractor selection, the project construction period, and project works commissioning. For the Waterman Grading Alternative, this construction period is estimated to require **12 months**.

The project operational period is estimated to be **July 1, 2033, to December 31, 2075**. The project O&M costs are estimated over this period. Estimated groundwater recharge yield is predicated on a 42.5-year operating period.

4.2 Watershed Hydrology

Baseline hydrologic modeling for the Waterman Grading Alternative was performed to quantify the *volumes of water available from storm events* and to define those events.

SBCFCD coordinated with SBVWCD on the development of a low-frequency flood hydrograph (i.e., 100-year return frequency hydrograph or Q100) to use in the development of flood modeling for *flows into the basins*.

SBCFCD provided storm intensity of runoff and unit hydrographs from their simulation software, Advanced Engineering Software (AES) Hydrosoft v. 22 (Advanced Engineering Software). AES indicated a 3,366-acre area that was rated for stormwater flow at higher frequencies.

The full drainage area into the Waterman Recharge Basins is approximately 3,600 acres when including Brush Canyon (**Figure 5**). SBCFCD generated hydrographs using AES for 2-year, 5-year, 10- year, and 25-year events in this area.

Scaling the Waterman Recharge Basins Drainage Area to the 5,800-acre drainage area of East Twin Creek's watershed above the U.S. Geological Survey (USGS) gage (USGS

11058500) finds that it is ~58% the size of that area and model-rated at 59.2% on peak flows (**Table 2**).

Table 2. Watershed Evaluations for SBCFCD Facilities along the East Twin Creek Waterway

Watershed	SBCFCD Q100 (cfs)	Peak Flow Ratio to East Twin Creek	Watershed Area (Acres)	Watershed Area Ratio to East Twin Creek
Brush Canyon	779	8.9%	219	3.8%
Waterman Canyon	5,185	59.2%	3,366	57.9%
East Twin Creek Canyon above Waterman Creek	8,758	100.0%	5,811	100.0%

A scaled comparison of peak flows in a Q100 flood flow in the Brush Canyon Drainage Area to East Twin Creek finds that while the peak flow is 8.9%, the drainage area is only 3.8%, suggesting a very distinct flow pattern in the AES model hydrograph. Comparison of area ratios to peak flow ratios suggests that the estimated stormflows and the hydrology for the Waterman Recharge Basins are reasonably representative. Additionally, SBVWCD PERC consultants used these hydrographs to generate USACE Standard Project Flood (SPF) and FEMA flood flow hydrographs (Tetra Tech, 2023a).

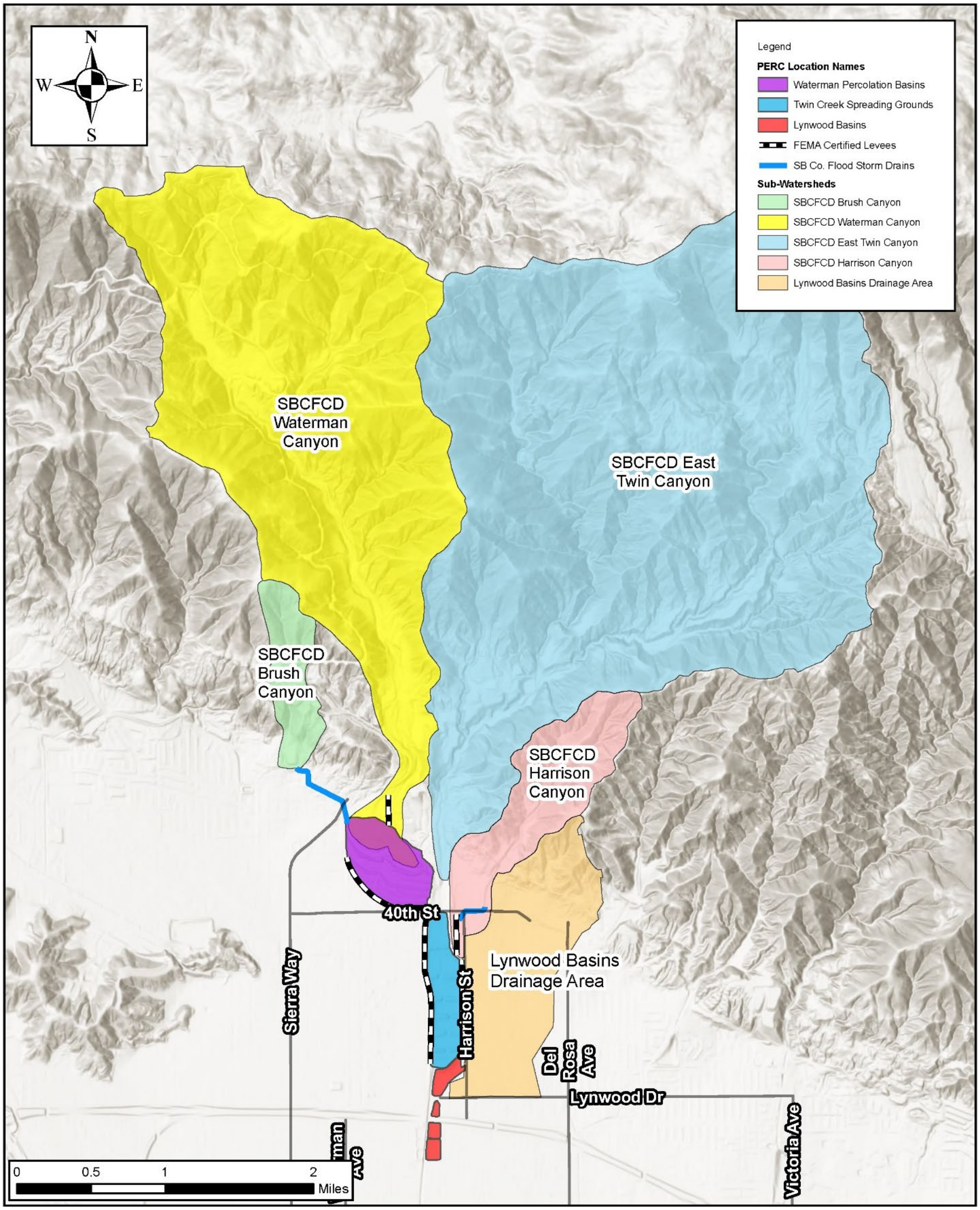

Figure 5. Watershed Areas above PERC Project Sites at SBCFCD Facilities

Initial hydraulic modeling was done of the Q100 using the AES hydrographs per SBCFCD's requests and direction. The initial modeling was done (Alden, 2024) over the Existing Conditions in each of four separate but hydraulically connected areas, listed from upstream to downstream below:

- WCDC
- Waterman Recharge Basins
- Twin Creek Recharge Basins
- Lynwood Recharge Basins

Subsequent hydraulic modeling of the proposed PERC Project Alternatives using these Q100 hydrographs from SBCFCD was performed. The comparison of existing conditions Q100 flow modeling to the Waterman Grading Alternative Q100 flow modeling is discussed in summary in Section 4.4, Groundwater Recharge Benefits.

4.3 Water Source Hydrology

Hydrology for groundwater recharge in the Waterman Recharge Basins consists of:

- Native inflows from **storm events**:
    - Waterman Canyon Creek flows (non-flood only)
    - Brush Canyon flows (flood and non-flood)
- **FIRO deliveries** of Santa Ana River water (via Foothill Pipeline)

Below is a description of the analysis that determined inflow volumes to expect from storm events and FIRO deliveries to the Waterman Grading Alternative.

4.3.1 Storm Events

Waterman Canyon Creek water availability for recharge follows the preliminary project hydrology identified in the *Final Hydrology Report* (Appendix B, Attachment IV). This report provides the real-time gage data from 2007 to 2023 that was used to identify the size and frequency of events exceeding 20 cfs. It identifies 63 events of that intensity or larger in a 16-year period or approximately 4 events per water year. The runoff hydrograph for capture, a project typical hydrograph (PTH), was developed for Waterman Creek native runoff using SBCFCD-provided hydrographs of 100-year runoff and then scaled using the gage data and the watershed drainage area above the gage to develop a 24-hour runoff hydrograph for consistency among the PTH.

Brush Canyon native runoff availability for recharge was determined similarly by developing hydrographs using the SBCFCD 100-year storm hydrograph and scaling. The developed hydrograph for Brush Canyon, as well as its analog for Waterman Canyon, are shown as

Figure 6. The return frequency of these small storm flows is the same at approximately 4 events per year.

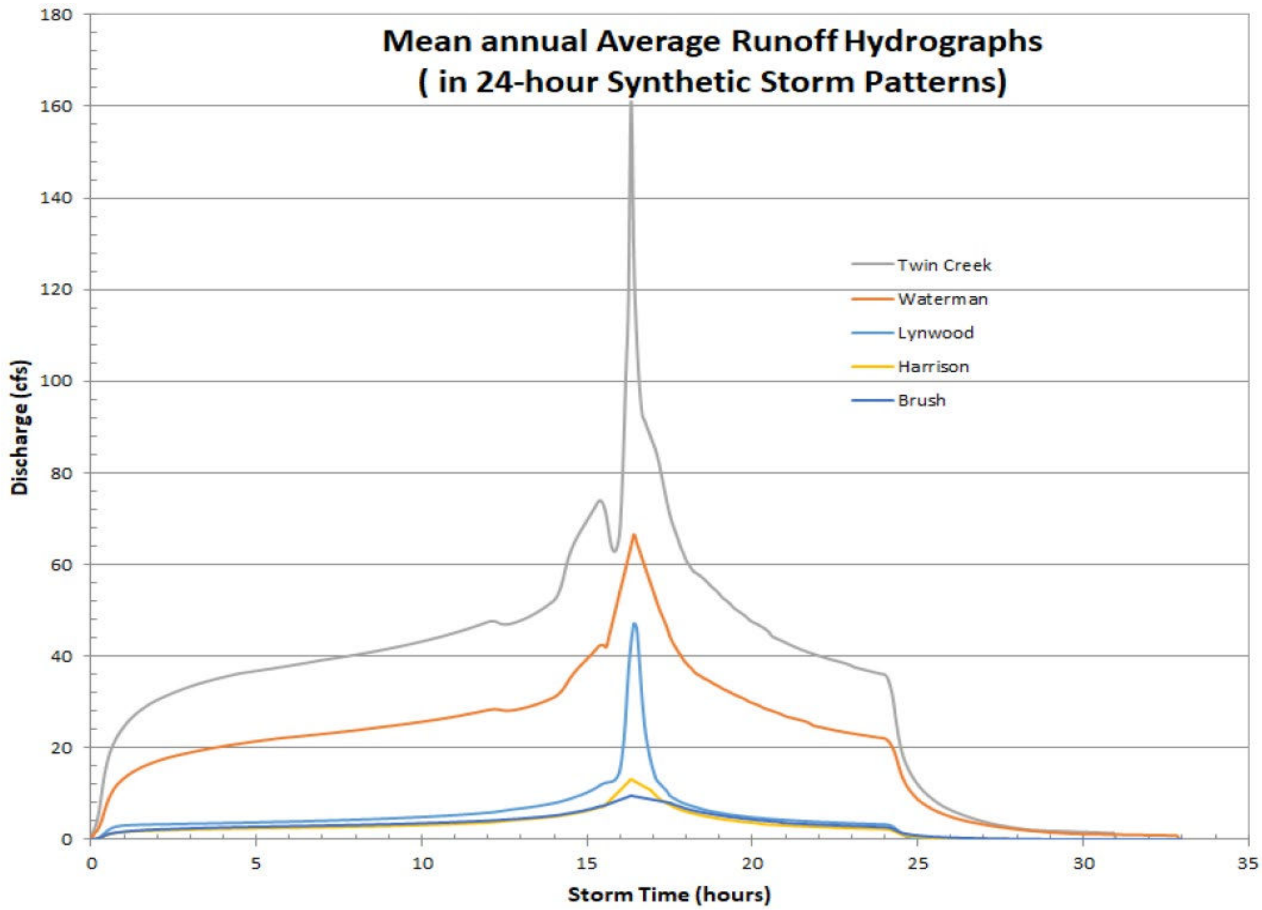

Figure 6. Synthetic Hydrographs for a 24-hour Storm using SBCFCD Forecasting Software (AES Hydrosoft)

4.3.2 FIRO Deliveries

The hydrology for FIRO water delivery to the Waterman Recharge Basins follows the forecast projection described in Volume 1 of this Feasibility Study.

Peak flows are estimated to be available in approximately 1 out of every 4 years to PERC Projects with access. For that hydrology, the estimate is a delivery over 52 days of a uniform flow rate. At the Waterman Recharge Basins there is existing infrastructure to deliver water out of the SBVMWD Foothill Pipeline at 78 cfs; 28 cfs can be delivered through a hydroelectric plant; and an additional 50 cfs can be delivered via flow bypass around the hydroelectric plant.

The analysis of FIRO hydrology to Waterman Recharge Basins beyond the Santa Ana River water delivery is the coincident native hydrology for a typical March flow in a wet water year using the Waterman Canyon Creek historic data (USGS Gage 11058600). Using the same wet ("exceedance") water years as found in the FIRO hydrologic analysis, the data from Waterman Canyon (shown in **Table 3**, with some record gaps) provided an estimated average flow rate of 20.1 cfs.

The sum of 78 cfs of FIRO water from the Santa Ana River coupled with 20.1 cfs from native Waterman average March flows (in a wet year) provided the FIRO hydrograph of 98.1 cfs. This flow rate was used for hydraulic modeling to develop infiltration hydrographs for the recharge yield analyses and the groundwater mounding analysis.

Table 3. March Average Flow Rate by Year at Waterman Canyon Creek Gage (USGS Gage 11058600)

Exceedance Water Year	March Average Flow Rate (cfs)
1914	14.7
1915	
1918	
1922	15.9
1927	8.19
1937	18.3
1938	57.1
1941	24.2
1958	10.2
1966	2.31
1967	6.35
1969	32
1970	4.13
1973	7.26
1978	37
1979	8.11
1980	56.8
1983	34.1
1993	
1995	
1998	
2005	
2011	8.27
2019	11.3
2023	30.4
2024	15.8
Average	**20.1**
Median	15.3

4.4 Groundwater Recharge Benefits

To estimate the increase in groundwater recharge potential under the Waterman Grading Alternative, it is necessary to calculate the flood detention volume of the basins in their revised condition.

4.4.1 Flood Detention Volume

As mentioned previously, flood conditions hydraulic modeling was performed using the AES-derived Q100 hydrographs, which have a higher peak flow than either a FEMA Q100 hydrograph or a USACE SPF hydrograph. The potential change in flood stage was examined over the existing conditions and over the Waterman Grading Alternative conditions to assess changes (Alden, 2025a) in both 1D and 2D models using the USACE HEC-RAS simulation codes and in the four developed model domains (Alden, 2024).

For the WCDC and Waterman Recharge Basins, the radial gate inlets at Heading 1C were simulated as **closed** per SBCFCD's Operations and Maintenance Manual (Tetra Tech, 2014). The changes in flood stage described in the 1D modeling from existing vs. proposed conditions could be characterized as small; they are fully described in the flood modeling Technical Memorandum presented to SBCFCD in March 2025 (Alden, 2025a). Subsequent discussions with SBCFCD indicated that additional flood conditions modeling using FEMA hydrographs would be needed if the Waterman Grading Alternative is moved forward to verify that the FEMA accreditation of the flood levees would be maintained with project implementation. The AES hydrographs do not conform to FEMA accreditation standards.

HEC-RAS 2D modeling indicates that peak stormflows in the WCDC enter the Waterman Recharge Basins via overland flow of water out of the existing diversion channel into the footprint of the existing basins. This allows the basins to provide a flood detention volume of approximately 338 AF in their existing condition (**Table 4**). Similarly, in the modified WCDC for the Waterman Grading Alternative, the Q100 2D modeling indicates that peak stormflows in the WCDC enter the Waterman Recharge Basins via overland flow and the regraded basins in the Waterman Grading Alternative would provide a **greater flood detention volume** of 635 AF of water (**Table 4**).

Table 4. Flood Detention Volume of Waterman Recharge Basins

With Existing Conditions	With Waterman Grading Alternative
338 AF	635 AF

In each simulation, the inflows into the Waterman Recharge Basins *that exceed their detention volume and infiltration-rate* outflow via the existing lower drop inlet into East Twin Creek via a 36-inch CMP culvert. This feature is not modified for the Waterman Grading Alternative, as it provides a multitude of key functions. A comparison of the duration of flood water at the toe of the Waterman Recharge Basins levee was used in the geotechnical study to assess whether any effects of those changed conditions may impair the levee's FEMA accreditation; that flood water retention evaluation is found in Appendix B, Attachment II.

The flood detention volume was used in conjunction with hydraulic modeling of inflow events to estimate the probable groundwater recharge yield for the Waterman Grading Alternative.

4.4.2 Estimated Groundwater Recharge

Below are descriptions of the three conditions that were analyzed to evaluate and estimate the probable groundwater recharge yield of a Waterman Grading Alternative:

- **Condition 1:** Analyzes the PTH from Waterman Canyon Creek and Brush Canyon entering the basins for recharge. This condition provides a flow of water for approximately *six days*.
- **Condition 2:** Analyzes a Forecast-Informed Reservoir Operations (FIRO) flow of 78 cfs operated at Waterman Recharge Basins outlet in conjunction with Waterman Canyon Creek flows.
- **Condition 3:** Analyzes the 6-day balanced hydrograph for a 50-year return low frequency storm with a volume of 1,605 AF based off the historic daily gage data for Waterman Canyon Creek.

Hydraulic modeling results for the three hydrologic conditions (PTH, FIRO, and Low Frequency Storm) are provided in Appendix B, Attachment V (Alden, 2025b). Summary results are presented in **Table 5** followed by written descriptions.

Table 5. Estimated Increase in Recharge with Waterman Grading Alternative

Condition 1 PTH Hydrology Infiltration to Groundwater Recharge	**Condition 2** FIRO Hydrology Infiltration to Groundwater Recharge	**Condition 3** 6-Day Balanced Hydrograph for Low Frequency Stormflow Events
~100 AFY	~2,070 AFY	~10 AFY

- **Condition 1 (PTH) Results:** The PTH hydrology is fully captured and infiltrated in the 2D model simulations of the Waterman Grading Alternative whereas the PTH hydrology *was not* fully captured in the simulations of the PTH in Existing Conditions whether the basins are clogged or clean. The rated bypassed flow for the Existing Conditions was estimated as the average of the clogged and clean basins at 25.4 AFY. The PTH occurs 4 times per year and this frequency was used to estimate that the increased yield in groundwater recharge of native flows is approximately **100 AFY**.

  The instantaneous infiltration rate capacity increase is quite large, increasing by ~84 cfs over Existing Conditions to a peak rate of ~135 cfs, enabling utilization of much greater inflow rates such as the 78 cfs available from existing water delivery infrastructure. Existing Conditions, when completely clean, have been measured at ~50 cfs infiltration rate capacity (Scheevel, 2018).

- **Condition 2 (FIRO) Results:** The median volume of FIRO water estimated to be available in a wet year (i.e., middle of the range of historic volumes) provides water for 52 days at the peak diversion rate of 500 cfs below Seven Oaks Dam. The flat FIRO hydrograph of 98.1 cfs was simulated for 6 days in the hydraulic models and extrapolated for 52 days. The extrapolation of FIRO water availability for Existing Conditions as compared to the Waterman Grading Alternative produces a net increase in the average annual yield for that facility of ~**2,070 AFY**; the single year increase is ~9,260 AF, but with an occurrence frequency of 1 in 4 years, the statistically informed forecast is the averaged annual yield.
- **Condition 3 (Low Frequency Storm) Results**: The 50-year return frequency storm volume was fully captured by the Waterman Grading Alternative by definition from its selection as the storm volume necessary to test Existing Conditions vs. the Proposed Alternative in a non-flood event. While the volume of such a storm is very large, its low frequency of occurrence means that it was rated as occurring 1 time in the 50-year project planning horizon, resulting in a modest increase in annual-average recharge yield over Existing Conditions of **~10AFY**. This is the statistical probability of this outcome based on historic stormflow measurements.

Hydrologic analysis of the Waterman Canyon Creek flows to determine groundwater recharge followed USACE methods for design sizing of reservoirs using flood frequency analysis to generate balanced hydrographs of a 6-day storm flow equivalent to a certain return frequency of large storm event using the USGS Gage 11058600 daily data (Appendix B, Attachment III). This volumetric analysis is suitable for the Waterman Recharge Basins because the basins control all non-flood flow and then exhaust water, beyond what they can hold and infiltrate, via an existing drop inlet to a culvert out to East Twin Creek.

The model results were used to determine the Waterman Grading Alternative's annual average recharge, infiltration rate capacity, and firm yield over the 50-year PERC planning horizon.

4.4.2.1 Annual Average Recharge

A PTH flow event in Waterman Creek occurs slightly less than 4 times per year. With a net recharge yield of an additional ~25 AF of recharge per stormflow event, this results in an estimated increase in annual average yield of 100 AFY from native PTH storms. FIRO-sourced Santa Ana River water flows are projected to be available approximately one in four years. The per-event volume for FIRO recharge over Existing Conditions is higher by 7,670 AF, but the return frequency for FIRO-sourced water from the Santa Ana River reduces the estimated net increase from FIRO to 2,070 AFY. The net groundwater recharge benefit increase on an annual basis is estimated to be the sum of PTH and FIRO water, totaling **2,171 AFY**.

4.4.2.2 Infiltration-Rate Capacity

The Waterman Recharge Basins infiltration-rate capacity is all net from a current capacity of zero. Hydraulic modeling identifies that at basin-full conditions, the net infiltration-rate capacity is estimated at **83.89 cfs**.

4.4.2.3 Firm Yield Over Planning Horizon

The Waterman Grading Alternative has a 42.5-year period of operation in the 50-year planning horizon (July 1, 2033 to December 31, 2075). Based on the increased average annual yield, a rated net increase in firm yield of **92,264 AF** of engineered recharge is calculated over the PERC Feasibility Study's planning horizon.

4.4.3 Groundwater Recharge Benefits Summary

Below are the Groundwater Recharge Benefits values associated with the Waterman Grading Alternative that were input to the MAA Model for final scoring.

Table 6. Waterman Grading Alternative Groundwater Recharge Benefits Summary

Groundwater Recharge Benefits Summary		
Annual Average New Recharge (AFY)	Infiltration Rate Capacity Increase (cfs)	Firm Yield over 50-Year Planning Horizon (AF)
2,171 AFY	83.89 cfs	92,264 AF

4.5 Cost Aspects

4.5.1 Capital Costs

The estimated capital costs are detailed in Appendix B, Attachment VIII and total $30,090,000 on a 2025 basis. But the timing of **the capital needed is July 1, 2032 to fund construction.** The discount rate used for capital is 4% with an expectation that the cost of money is 7% and inflation is 3%. A general contingency of 30-percent was added to each alternative. The Present Value of the capital needed in July 1, 2032, equates to **$21,886,000**.

4.5.2 Operations & Maintenance Costs

Waterman Recharge Basin maintenance would principally be for siltation management and basin clogging. Sediment transport data from the Preliminary Design Report (Appendix B) indicates an estimated 1,300 cubic yards/year of sediment loading would occur. This amount of sediment is projected to trigger a basin scraping and cleaning effort **once every 7.5 years**. Other maintenance measures are integrated to O&M costs via replacement cycles for meters and telecommunications equipment and would be addressed in a subsequent phase.

O&M Costs are forecast on an annual equivalent basis. The day-to-day operations for Waterman Recharge Basins would be very low, as both operations and data collection would be designed for near-full automation. Basin cleaning and maintenance operations are projected to be sporadic at around 7.5-year intervals for scraping out sediment and a singular annual inspection of basin operating conditions. Comparison of operating costs are made in present day dollars. The average annual costs of basin maintenance are estimated at **~$96,000 per year**. The O&M costs are not discounted for the sake of comparison since they will be incurred in the year that they occur. Therefore, projecting a borrowing cost for capital is not pertinent for operations. Similarly, inflationary factors are not material to comparing costs that would be similarly inflated over a similar period.

4.5.3 Cost Aspects Summary

Table 7 presents the Cost Aspects values associated with the Waterman Grading Alternative that were input to the MAA Model for final scoring.

Table 7. Waterman Grading Alternative Cost Aspects Summary

Cost Aspects Summary	
Capital Costs (2025$)	Annual O&M Costs (2025$)
$21,886,000	$96,000/year

4.6 Other Technical Aspects

Other aspects of the Waterman Grading Alternative are summarized here. For comparison among other PERC Alternatives in the Multiple Accounts Analysis (MAA), see Volume 1.

4.6.1 Groundwater Quality Improvements

Additional recharge into the Bunker Hill Basin Zone B is rated on its prospective annual average recharge for the equivalent in millions of gallons per day (MGD). That quantification is in keeping with the discussions and evaluations of Salt & Nutrient Management Planning. The Waterman Grading Alternative estimated average daily recharge rate based on a historic probability-based calculation of how often and how much water is materially available and the annual average groundwater recharge potential equates to **2.5 MGD**.

4.6.2 Conservation and Habitat Benefits

There are no species impacts forecast from the Waterman PERC Alternative, as the basins are existing features. If there is habitat restoration, it will likely be for the areas adjoining the WCDC which have developed into a vegetated area over the past 60 years.

The Waterman Recharge Basins are a part of the Upper Santa Ana River Habitat Conservation Plan (HCP) (ICF, 2020) as a component of *Waterman Basin Spreading Grounds Channel Maintenance (VD.2.12) – Phase 1.* The expected benefit to flows in the Santa Ana River is **2.9 cfs** as a chronic year-round rate.

4.6.3 Hydraulic Stress and Pressure Zone Influence

The value of relief to the hydraulic stress is described in Volume 1. It equates to the distance from the PERC Project Alternative to the center of the Pressure Zone near W. 5th Street and Waterman Avenue in the City of San Bernardino. Waterman Recharge Basins are measured as **7,050 yards** or approximately 4 miles.

4.6.4 Access to State Water Project Supply

The Waterman Recharge Basins can receive State Water Project supply, directly.

4.6.5 Groundwater Mounding

Groundwater modeling analyses for the combination of recharge conditions from a FIRO release were evaluated as the highest recharge rate condition to assess any reductions that may be necessary for groundwater mounding. Groundwater mounding results in the water levels forecast to potentially rise to within 100 feet of land surface. The geotechnical engineering evaluation found that the existing berms' stability is not affected by the estimated groundwater mounding at the property perimeter (Appendix B, Attachment II).

Groundwater modeling **does not indicate any reduction in the groundwater recharge rate** due to groundwater mounding. It is recommended that additional groundwater modeling be conducted during a design phase for the Waterman Recharge Basins using the San Bernardino Basins model (currently being developed by SBVMWD and focused on being better calibrated to local conditions).

4.6.6 Other Technical Aspects Summary

Table 8 presents a summary of the Other Technical Aspects values associated with the Waterman Grading Alternative that were input to the MAA Model for final scoring.

Table 8. Waterman Grading Alternative Other Technical Aspects Summary

Other Technical Aspects Summary				
Average Annual Recharge Rate (MGD)	Santa Ana River Contribution (cfs)	Proximity to Groundwater Pressure Zone (yds)	Access to SWP Supply	Groundwater Mounding
2.5	2.9	7,050	Direct access	No

4.7 Social Aspects

4.7.1 Job Creation

The Waterman Grading Alternative projected construction employment in FTE is equal to **70 full-time jobs for 12 months**. The total employment forecast for O&M for the OCRB Construction Alternative is **0.23 FTE** on a perpetual basis.

4.7.2 Ponded Water Depth

The Waterman Grading Alternative ponded water depth is **18 feet**. One social aspect that will be taken into consideration is prevention of drowning. Experience at SBVWCD basins demonstrates that water basins will attract unhoused individuals or passersby in hot weather to enter the basin. Access control will be a key consideration in design. Additionally, graded slopes for easy ingress and egress may reduce drowning and other safety hazards from sloped ground.

4.7.3 Social Aspects Summary

Table 9 presents the Social Aspects values associated with the Waterman Grading Alternative that were input to the MAA Model for final scoring.

Table 9. Waterman Grading Alternative Social Aspects Summary

Social Aspects Summary		
Construction Jobs (FTE/time period)	O&M Jobs (FTE)	Ponded Water Depth (ft)
70 /12 months	0.23	18

4.8 Legal Aspects

4.8.1 CEQA and Permitting Analysis

A brief review of the potential permit needs and issues for the Waterman Grading Alternative is provided in **Table 10** below.

Table 10. Review of Potential Permit Requirements for the Waterman Grading Alternative

Potential Permit	Preliminary Review Determination
California Environmental Quality Act (CEQA)	Given that the existing features perform the function of flood detention, and the use of these features for groundwater recharge extends the flood control function, this project has limited new potential for impacts that would be applicable under CEQA. It is anticipated that an Initial Study is necessary to identify the project and its potential impacts and that a Mitigated Negative Declaration for alterations that produce dust, noise

Potential Permit	Preliminary Review Determination
	and traffic is the probable CEQA need. The project itself is addressed under the programmatic EIR under development for the Upper Santa Ana River HCP.
U.S. Fish and Wildlife Service (USFWS)	Addressed under the Upper Santa Ana River HCP.
California Department of Fish and Wildlife (CDFW) CESA (2081)	Addressed under the Upper Santa Ana River HCP.
CDFW LSA /1600	Addressed under the Upper Santa Ana River HCP.
USACE 401/ Regional Water Quality Control Board (RWQCB)	Addressed under the Upper Santa Ana River HCP.
USACE 404	Required due alteration of the watercourse.
USACE 408	USACE 408 permit will be required, as the grading work is near a flood-control levee. Obtaining this permit may take more than a year based on typical timeframe of response on a 408-permit filing. However, no work is to disturb or alter the flood control features, and the hydraulic analysis shows no negative alteration of floodwater impoundment adjoining the flood levees.
California Division of Safety of Dams (DSOD) Jurisdictional Dam	Waterman Recharge Basins may not be considered jurisdictional dams due to the discrete nature of their water holds and their respective sizes, or due to their location within a flood control levee. They are assessed as being regulated under DSOD.
San Bernardino County Flood Control District (SBCFCB)	Waterman Recharge Basins would require a permit from SBCFCD. It is assumed that it will qualify as a "major construction permit" because segments of the flood watercourse will be inoperable for a brief period.

At this preliminary stage, no design considerations appear to be needed to provide for habitat impacts given that the Waterman Grading Alternative is an expansion of the existing facility and not a new area. However, final design should consider measures to mitigate against intrusion of non-native species.

The Waterman Recharge Basins are outside the Federal Aviation Administration (FAA) secondary buffer zone of 10,000 feet, Perimeter B, from San Bernardino International Airport (FAA, 2020). FAA has specific design and permitting review for water holds that could provide nesting habitat for waterfowl; a flight safety hazard. However, it is within Perimeter C, 5-miles, for San Bernardino International Airport which triggers notification recommendations for the project proponents to the airport operators and triggers the need for management actions by the airport operators such as providing assessment criteria for wildlife strike risks.

4.8.2 Land Availability

This land is NOT currently owned by a partner agency.

4.8.3 Support for Claimed Water Rights

The support for new Water Rights not yet perfected is equated to the maximum diversion rate to groundwater recharge. That is estimated at **83.89 cfs**. The annual yield could be as high as 6,062 AF in a very-wet water year.

4.8.4 Legal Aspects Summary

Table 11 presents the Legal Aspects values associated with the Waterman Grading Alternative that were input to the MAA Model for final scoring.

Table 11. Waterman Grading Alternative Legal Aspects Summary

Legal Aspects Summary		
CEQA/Permits Required	Land Availability	Support for Claimed Water Rights (cfs)
See Table 10	No	83.89

5 Summary Results

The PERC Comprehensive Feasibility Study looked at each Project Alternative's characteristics and viability over the following key considerations:

- **Groundwater Recharge Benefits**: How much water will be captured and stored as groundwater by the project each year? Over the next 50 years?
- **Cost Aspects:** Do the economics indicate the project's financial viability, including costs, benefits, and projected return on investment?
- **Technical Aspects:** Are the necessary technology, resources, and expertise available and sufficient to implement the project?
- **Social Aspects:** How well does the project align with the available human resources and how well can it align with existing operations?
- **Legal Aspects:** Are there legal or regulatory requirements that could impact the project?

In some respects, this amounts to a discovery process to identify whether any proposed project has fatal flaws that prevent its execution. The Waterman Grading Alternative **does not** have any apparent fatal flaws. More information can and would be developed for the project—if it is taken forward as a project for permitting, design, and construction—that may identify design considerations, but fatal flaws do not appear likely. Operationally, the Waterman Grading Alternative is judged to be a very good fit to the dual objectives of a

SBCFCD flood control facility with flood control functionality that can be fully maintained, or improved upon, while groundwater recharge is greatly enhanced.

5.1 MAA Indicator Values

PERC and its regional partners chose an integrated multiple accounts analysis (MAA) method to consistently assess PERC Alternatives against what they chose as the most important feasibility considerations. The MAA developed for PERC is described in Volume 1. **Table 12** shows the MAA Indicators and their respective Waterman Grading Alternative Values.

Table 12. Waterman Grading Alternative MAA Indicator Values

Account	Subaccounts	Indicators	Waterman Grading Alternative Values
Groundwater Recharge Benefits	Groundwater Recharge-Benefit (Net AFY)	AFY	2,171
	Infiltration-rate-capacity increase (cfs)	Net Increase in Infiltration Rate Capacity (cfs)	83.89
		Ease of Maintenance (FTE)	0.10
		Timeline to Implement (years)	7.50
	Recharge benefit on a “firm yield” 50-year horizon (AF)	AF	92,264
Cost Aspects	Capital Costs	Capital Costs NPV	$21,886,000
		Grant Sources	0%
	O&M	O&M in 2025 $	$95,885
Other Technical Aspects	Groundwater Quality Improvements *(Salt & Nutrient Management Planning)*	Volume of Annual Recharge (MGD)	2.5
	Conservation and Habitat Benefits	Santa Ana River Contribution	2.90
		Habitat Restoration	0.00
		Species/ Habitat Impacts	0.00

Account	Subaccounts	Indicators	Waterman Grading Alternative Values
	Proximity to Groundwater Pressure Zone	Distance to Pressure Zone (yds)	7,050
	Access to State Water Project Supply	Direct, Indirect, or No Access	Direct
	Groundwater Mounding	Rate Limiting Mounding *(Liquefaction Issue)*	No
Social Aspects	Project Job Creation	Number of Jobs Forecast for Construction	70.0
		Number of Jobs Forecast for Operational Needs	0.00
	Public Safety Hazards of Project	Ponded Water Depth (ft)	18.0
Legal Aspects	CEQA	CEQA Filing Type (e.g. NOE)	IS-MND1
	Permits Required/ Requirements	U.S. FWS Permit Requirements	River-HCP
		CDFW CESA 2081 Permit Requirements	River-HCP
		CDFW LSA 1600 Permit Requirement	River-HCP
		USACE/RWQCB 401 Permit Required	River-HCP
		USACE 404 Permit Required	Typical
		USACE 408 Permit Required	Typical
		CA DOSD Jurisdictional Dam	Typical
		City of San Bernardino Consent Decree Area Permit	Typical

Account	Subaccounts	Indicators	Waterman Grading Alternative Values
		SBCFCD	Major
	Land Availability	Property Ownership by Partner Agencies (Y/N)	N
	Water Rights	Support for utilization of water rights not yet Licensed	83.89

5.2 Score and Rank

The MAA Summary Scoring prioritizes the **Waterman Grading Alternative as the 8th priority project out of 10 potential PERC projects**. The MAA takes into consideration the stakeholder developed characteristics, criteria, and their weighted importance in meeting regional goals. The Waterman Grading Alternative is a feasible and viable project but ranks lower on those characteristics for near-term project prioritization to apply available human resources, financial resources, and political capital.

The Waterman Grading Alternative MAA summary scores are shown in **Table 13**.

Table 13. Waterman Grading Alternative MAA Scoring Summary

Account	Waterman Grading Alternative MAA Summary Score
Groundwater Recharge Benefits	1.86
Cost Aspects	1.05
Other Technical Aspects	0.57
Social Aspects	0.08
Legal Aspects	0.40
Total	**3.95**
Priority Rank (of 10)	**8th**

Twin Creek Recharge Basins Alternatives

1 Executive Summary

There are two potential PERC Project Alternatives within the Twin Creek Recharge Basins (TCRB): 1) **Small Grading Alternative**, and 2) **Large Grading Alternative**. The overarching objective for both TCRB PERC Alternatives is to recharge more water than can be done under Existing Conditions. An additional objective for the TCRB Large Grading Alternative is self-maintenance to remain unclogged to maintain a high rate of groundwater recharge and eliminate sediment handling expenses and manhours. New and different detention of water under each of the two TCRB PERC Project Alternatives would increase the "wetted area" and thereby generate more groundwater recharge.

TCRB Small Grading Alternative

The TCRB Small Grading Alternative is a proposed modification within the existing TCRB footprint aimed at increasing engineered groundwater recharge from East Twin Creek flows. The project focuses on leveraging and restoring existing infrastructure without modifying surrounding USACE flood-control features (i.e., flood levees and associated gates).

The Small Grading Alternative involves regrading Hold 2 and repairing Berm 2, removing a non-functional low-flow culvert, and reinforcing the flow diffuser at Berm 1. The revised grades are designed to promote more effective water impoundment and sediment movement to maintain infiltration capacity.

TCRB Small Grading Alternative Scores and Rank

Consideration (MAA Account)	Score
Groundwater Recharge Benefits	1.32
Cost Aspects	1.45
Other Technical Aspects	0.45
Social Aspects	0.20
Legal Aspects	0.53
Total Score	**3.95**
Rank (of 10)	**9th**

- **Footprint**: 9.3 acres
- **Maximum Water Depth**: 2 feet
- **Detention Volume**: ~14 acre-feet

Recharge modeling found a net infiltration rate capacity increase of approximately +12.6 cfs (total: 20.1 cfs) and an average annual net recharge increase of ~480 AFY. Over the 46.7-year operational period (May 1, 2029 – Dec 31, 2075), the net **firm yield** (i.e., increase over Existing Conditions) is estimated at **22,405 acre-feet**.

The projected capital cost (in present value) is $2.46 million. The annual O&M cost, in 2025 value, is estimated to be $54,000.

The TCRB Small Grading Alternative is a technically feasible, cost-effective enhancement of existing recharge infrastructure. It offers a significant increase in groundwater recharge (~183% over existing conditions), aligns with long-term regional groundwater sustainability goals, and maintains compliance with flood control and environmental regulations. However, it is a lower priority project using the Multiple-Accounts Analysis developed for prioritizing the PERC Project Alternatives, **ranking 9th out of 10**.

TCRB Large Grading Alternative

The TCRB Large Grading Alternative revises the grade lines and base elevations within the Flood-Leveed area for East Twin Creek to enhance groundwater recharge. The proposed design focuses on creating sheet flow into and across water Holds, improving infiltration-rate capacity, with self-maintenance of that infiltration-rate capacity without the need for routine sediment removal.

- **Footprint**: 120 acres
- **Maximum Water Depth**: 2.6 feet (i.e., waist high)
- **Detention Volume**: up to 46.6 acre-feet

Flood flow conditions modeling indicates improved flow through the TCRB but with a probable increase in base flood elevation due to elevated bottom grade that may be problematic for FEMA-accredited levees. Additional hydraulic modeling of base flood would be needed during the design phase. The annual groundwater recharge increases by 1,900 AFY on average. Over a 35-year operational period, 2040 to 2075, the Large Grading Alternative has an estimated **firm yield of 67,915 AF**.

TCRB Large Grading Alternative Scores and Rank

Consideration (MAA Account)	Score
Groundwater Recharge Benefits	1.57
Cost Aspects	0.86
Other Technical Aspects	0.51
Social Aspects	0.25
Legal Aspects	0.28
Total Score	**3.46**
Rank (of 10)	**10th**

The projected capital cost (in present value) for the TCRB Large Grading Alternative is $57.8M. The annual O&M cost, in 2025 value, is estimated to be the lowest of all PERC Alternatives, at $27,600 due to minimal maintenance, with only annual inspections and no forecast sediment removal.

The TCRB Large Grading Alternative offers a significant increase in groundwater recharge (~700% over existing conditions), aligns with long-term regional groundwater sustainability goals, and maintains compliance with flood control and environmental regulations. However, it is a lower priority project using the Multiple-Accounts Analysis developed for prioritizing the PERC Project Alternatives, **ranking 10th out of 10**.

2 Introduction

There are two potential PERC Project Alternatives for the TCRB:

1) **Small Grading Alternative**
2) **Large Grading Alternative**

The objective for both is to detain more water than is or can be done via the existing features. Additional detention of water will increase the wetted area and thereby promote additional groundwater recharge under both alternatives. *A secondary objective for the Large Grading Alternative is self-maintenance to remain unclogged*.

In this document, the TCRB Grading Alternatives are evaluated based on the five aspects identified by SBVWCD and project partners as important and relevant to ranking PERC Project Alternatives, which are:

- Groundwater Recharge Benefits
- Cost Aspects
- Other Technical Aspects
- Social Aspects
- Legal Aspects

A complete description of these aspects, their respective components, and the ranking methodology for PERC Project Alternatives is provided in Volume 1.

Sections 3 through 5 below provide information specifically for the two TCRB Grading Alternatives, including the following:

- **Section 3–Site and Features**: Descriptions relevant to both alternatives including site location, existing facilities, geologic setting, and surrounding watershed.

- **Section 4– TCRB Small Grading Alternative**: Descriptions of the Small Alternative's water sources, proposed design, and characteristics as they align with the five aspects; as well as tables presenting the Alternative's scores and rank.
- **Section 5– TCRB Large Grading Alternative**: Descriptions of the Large Alternative's water sources, proposed design, and characteristics as they align with the five aspects; as well as tables presenting the Alternative's scores and rank.

3 Site and Features

TCRB are located on ~120 acres spread over five lots owned by SBCFCD. They are upslope and adjacent to a densely populated urban area beginning at East 40th Street and continuing downslope below Marshall Boulevard in the City of San Bernardino (Figure 1). The basins extend approximately 1 mile south of East 40th Street and span between Harrison Street on the eastern side and Valencia Avenue North on the west. They are below the confluence of Waterman Creek and East Twin Creek and receive additional flow from Harrison Canyon via stormwater infrastructure.

The TCRB are surrounded by flood-control levees which were built by USACE from 1960 to 1962 (USACE, 1960). USACE designed and built these levees in their current configuration solely for purposes of flood protection. The levees are operated and maintained by SBCFCD in accordance with an agreement with USACE. The SBCFCD 1980 designs of berms, spillways, and lateral roads inside the vintage 1962 flood levees appear to have been done to manage sediment from major flooding and chronic debris flows from WY1979 through WY1980 (Chin et al, 1991). It appears these interior earthen berms may have been intended to control the flow of surface water and improve groundwater recharge, but they were clearly not designed for the high peak flow rates of lower return frequency storm events like the one of December 25, 2003, that severely damaged them. **Figure 7** depicts the Holds in their current condition.

Figure 7. TCRB Existing Conditions Overview

3.1 Existing Facilities

After a series of debris flow events in 1980, SBCFCD created a series of seven basins, or “Holds” in the flood-leveed footprint (SBCFCD, 1980). Six of the Holds were constructed with internal berms. The earthen berms were designed with 1-foot deep, 100-foot wide saddle weirs across modest low points; the earthwork also included filling within the leveed area and on top of the levees. At the southern downstream end, the seventh Hold was created with the concrete edge of the reinforced concrete channel (RC Channel) Floodway for East Twin Creek. Roughly 23 years after these 6 berms were built, on December 25, 2003, a peak storm flow of 6,000 cfs[3] breached the six berms between the Holds.

The SBCFCD design from 1980 largely developed the present day TCRB hardscape features. The six berms appear, in several locations, to have extended existing concrete cross-sectional walls, depicted in the USACE 1960 Design and As-Builts of the current East Twin Creek flood levee system (USACE, 1960) as an existing condition and termed “stabilizers”. Their vintage is not well documented, but review of aerial photos indicates that many of the stabilizers were in place prior to the March 1938 flood event. Their design is unknown, but they appear to have been placed with the intent of directing the flow of East Twin Creek and the morphology away from an incised channel. Per the USACE 1961 As-Built Sheet, they were left in place (USACE, 1961b). The remaining berm portions placed by SBCFCD likely contain portions of the historic concrete cross-sectional walls within them today.

After the 2003 flood, the berm between Holds 1 and 2 was repaired. Aerial photos demonstrate that this upper berm was largely obliterated by flood flows. A grouted rip-rap spillway was built circa 2005 near the centerline of the berm repair, presumably to sustain against chronic erosion or a future high storm flow. Additionally, SBCFCD installed a bottom-of-berm flow culvert through the berm near its western end. This culvert can convey low flows through the single intact berm which can impound a limited volume of water within Hold 1. The slidegate over this culvert is manually operable and was observed in a fully open position during a field tour in June 2024. The other five breached berms have not been repaired and Holds 2 through 7 impound no water. These SBCFCD earthen berms that define the outlines of the six Holds are neither levees nor jurisdictional dams based on their size and current condition.

In addition to the original six berms, there is a notable and large peninsula of sediment built out into the former Hold 7. It is of unknown origin as it is not shown in either the 1980 or 1961 design. As can be seen in Figure 7, the incised flow channel for East Twin Creek passes around its eastern end.

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[3] An historic stormflow of record measured on the USGS Gage 11058500 bottom end of East Twin Creek Canyon.

The TCRB currently receive direct **inflows** of surface water from three water sources:

1. **East Twin Creek Canyon** (SBCFCD ID 2-405-1A)
2. Storm drain conveying runoff from Harrison Basin (SBCFCD ID 2-415-6A) and the mouth of **Harrison Canyon** (SBCFCD ID 2-414-4A)
3. **Waterman Canyon** runoff through the WCDC that has bypassed the Waterman Recharge Basins (SBCFCD ID 2-404-2A)

The primary inflow of water to the TCRB is East Twin Creek passing under or over 40th Street. USACE designed and installed a 4-foot wide by 8-foot tall box culvert to convey the surface water flowing southward in East Twin Creek below the asphalt concrete roadway of 40th Street. Flows can pass through this culvert within most storms; however, the USACE in its designs recognized that there would be storm flows too high to keep within this culvert and therefore they developed or designed a "Dip"[4] in the 40th Street profile that is approximately 1,000-feet wide from east to west that acts as the flow way into the TCRB during very high stormflows. USACE designed and built a barricade at either end of the Dip; a three-segment articulating gate section to swing out from north and south side of 40th Street at either end to be locked off during routine road closure of the street for flood water (USACE, 1961c). These existing conditions impact the design of the grading alternatives developed in this feasibility study.

The primary **outflows** of water from the TCRB are the reinforced concrete channel (RC Channel) for East Twin Creek (SBCFCD ID 2-409-1A) and the gated 48-inch culvert into Lynwood Basin No. 1 (2-420-4A). Each of these two outflow features were designed and built by USACE around 1961 for controlling flood water and managing detained water and are schematically depicted in Figure 7.

Analysis of runoff, sedimentary materials in the TCRB, and the shape and length of the watercourse in the TCRB indicates that there is some minor groundwater recharge occurring from the existing condition. The repaired berm for Hold 1 and its rip-rap weir hold some water but the low-flow culvert through the existing berm is routinely in a closed position (based on field observations); as a result no impoundment of water occurs. Furthermore, Hold 1 has been infilled with sediment by routine high flows transporting sediment into it. This means that without basin clearing the infiltration rate for the surface materials may be at the lower end of the range and, without the low-flow culvert being closed, then little if any groundwater recharge can occur within the small, narrow, deeply incised channel within the Existing Conditions of TCRB as observed in the field.

[4] Literally called out as a Dip in the title of Plan Sheets 33 to 36 of 36 (USACE, 1961c).

According to the SBCFCD's *Operation and Maintenance Manual East Twin Creek and Waterman Levees* (Tetra Tech, Inc. 2014) the pre-storm phase of flood operations, when the National Weather Service forecasts rainfall in the area of ***more than 0.3- inches/hour*** or a total of ***more than 2-inches in a 24-hour period*** requires that the East Twin Creek Levee drain gate (mechanical slidegate) be closed to keep storm flows from impairing the levee function. This enables flood water to gather on the levee and exhaust the RC Channel for the flood protection it affords. The slidegate at the drain gate was observed to be buried in sediment up to the top of its structural backwall and while the slidegate appears to be functional, the system is non-functional today. This however is neither material to the flood protection of the levees nor to materially reducing the amount of groundwater infiltration generated under Existing Conditions, as this may be the area of the most useful current impoundment of water at low flows. The operational use of this drain gate is integral to a Lynwood Recharge Basins PERC Project Alternative and is discussed in that chapter of the Feasibility Report here in Volume 2.

The following were identified as existing facilities that should be retained with a TCRB Grading Alternative:

- The existing grading for introduction of water from Harrison Canyon Flood Detention Basin would be retained and used in their current configuration.
- The existing drain gate through the east side levee would be retained.
- The existing flood control levees and RC Channel for East Twin Creek watershed outflows would not be altered or disturbed.

All other features of the existing conditions at TCRB were considered available for revision in the Small and Large Grading Alternatives.

3.2 Site Assessment

Preliminary site assessment for the TCRB Grading Alternatives included a topographic survey, site walk, and records review.

3.2.1 Topographic Survey

The topographic survey was conducted by Tetra Tech and their survey contractor. A summary of the survey around TCRB is reported out in Appendix B, Exhibit A (TetraTech, 2025) and the full survey details on the grades examined are reported out in Appendix B, Exhibit B.

3.2.2 Site Walk

A site walk survey by SBVWCD staff on January 17, 2024, June 5, 2024, and December 21, 2024 found existing site facilities in relatively good condition with all berms intact. Relevant site photos of infrastructure are provided in Appendices D and E.

3.2.3 Records Review

The records review of SBCFCD and USACE filings found:

- **Berms around the interior of TCRB** are not listed as federal, state, or county flood control features (SBCFCD, 2023b).
- **USACE has assessed the FEMA-accredited flood levees are in good condition.** Further, they rated them as capable of managing a 200-year return frequency event using their standards of design (Standard Project Flood, SPF). USACE found the FEMA-accredited levees to be in good working condition during their last assessments in 2016 and 2019 (SBCFCD ID 2-408-5A & -5B, Waterman Levee and Twin Creek Levees). The layout and identification of the flood control features by SBCFCD are provided in Appendix B , Figure 1-1 (TetraTech, 2025). The related latest information on the Levee conditions were updated by USACE in October 2024 to the National Levee Database under the following IDs: East Twin Creek 1 – 3805010082, East Twin Creek 2 – 380501709, also as FEMA 80A, FEMA 80B, FEMA 52, and FEMA 65.

3.3 Geotechnical Assessment and Analysis

The surficial geology at the TCRB is differentiated young "wash" and alluvial fan deposits (Figure 3). This differentiation means that the deposition occurred either in the general pathway of the watercourse (i.e., wash deposits) or on the surface of an alluvial fan built up at the boundary of flows. The sedimentary deposits beneath the TCRB had routinely been subjected to flushing flows, but alluvial fan deposits grew around the northwestern edge and along their eastern boundary. These deposits would be expected to be relatively coarse-grained overall given their proximity to the canyon mouth and its grade line.

The engineering consulting team performed geotechnical testing and assessment of the existing TCRB (Appendix B, Attachment II). The on-site assessment via drilled boreholes and excavated test pits found favorable conditions for expanded groundwater recharge. On-site exploration by test pits also found sediment infill deposits accumulated within the existing basins.

Subsurface testing for infiltration properties of the near-surface sediments in TCRB was performed in November 2022. The infiltration properties tested in the field and in the lab were consistent with other areas tested in the young wash deposits; these types of deposits were observed in the excavated test pits in TCRB with notations of recent (Qal_2) and very recent (Qal_1) alluvial sediments. Infiltration testing data demonstrate that enlarging the existing detention basins and increasing their wetted area could constitute a PERC Project.

The berms and non-flood levees within the TCRB Existing Condition were appraised and tested for material properties. They were noted in their current conditions in the photographs in Appendix C. The geotechnical evaluations performed assess land slope stability, the sustainable hydraulic slope (or water pressures) that could be safely sustained across the berms, and the seismic hazard potential. These analyses are reported in detail in Appendix B, Attachment II.

3.4 Watershed Hydrology

Baseline hydrologic modeling for the East Twin Creek watershed was performed to quantify the volumes of water available in certain return frequency storm events and to define those stormflow hydrographs. SBCFCD coordinated with SBVWCD on the development of their low-frequency flood hydrograph (i.e., 100-year return frequency hydrograph or Q100) to use in the development of flood modeling for flows into the TCRB. SBCFCD provided storm intensity of runoff and unit hydrographs from their Advanced Engineering Software (AES) Hydrosoft v. 22 (Advanced Engineering Software). SBCFCD's AES, used for rating stormwater runoff, indicated a 3,366-acre area that was rated for stormwater flow at higher frequencies. SBCFCD generated hydrographs using their AES program for 2-year, 5-year, 10- year, and 25-year events in this area.

The full drainage area into the TCRB is approximately 9,773 acres (Figure 4) when including the natural drainages above the basins plus Brush Canyon as it is routed through the Waterman Recharge Basins and thereby tributary to the TCRB.

- The 5,811-acre drainage area of East Twin Creek's watershed above the USGS gage (USGS 11058500) finds that it is model rated on peak flows.
- A scaled comparison of peak flows in a Q100 flood flow in the Harrison Canyon Drainage Area to East Twin Creek finds that while the peak flow is 8.0%, the drainage area is only 6.5% (**Table 14**), suggesting a relatively similar flow pattern in the AES model hydrograph.

Table 14. Watershed Evaluations for SBCFCD Facilities along the East Twin Creek Waterway

Watershed	SBCFCD Q100 (cfs)	Peak Flow Ratio to East Twin Creek	Watershed Area (Acres)	Watershed Area Ratio to East Twin Creek
Brush Canyon	779	8.9%	219	3.8%
Waterman Canyon	5,185	59.2%	3,366	57.9%
East Twin Creek Canyon above Waterman Creek	8,758	100.0%	5,811	100.0%
Harrison Canyon	697	8.0%	377	6.5%

Comparison of area ratios to peak flow ratios suggests that the estimated stormflows and the hydrology for the TCRB is reasonably representative.

Additionally, SBVWCD PERC consultants used these hydrographs to generate USACE Standard Project Flood (SPF) and FEMA flood flow hydrographs (Tetra Tech, 2023a).

Initial hydraulic modeling was done of the Q100 using the AES hydrographs per SBCFCD's requests and direction. The initial modeling was done over the Existing Conditions in each of four separate but hydraulically connected areas (Alden, 2024). Moving from upstream to downstream, those are: WCDC, Waterman Recharge Basins, TCRB, and Lynwood Recharge Basins. Subsequent hydraulic modeling of the proposed PERC Project Alternatives using these Q100 hydrographs from SBCFCD was performed. The comparison of existing conditions Q100 flow modeling to PERC Project Alternative Q100 flow modeling is discussed in the Groundwater Recharge Benefits sections for the Small and Large Alternatives.

3.5 Water Source Hydrology

The hydrology for groundwater recharge in the TCRB consists of three water sources.

- **East Twin Creek** native flows (non-flood only)
- **Harrison Canyon** native flows (flood and non-flood)
- Surplus **Santa Ana River** water delivered under FIRO

3.5.1 East Twin Creek Hydrology

Native East Twin Creek water availability for groundwater recharge in the TCRB follows the preliminary project hydrology identified in the *Final Hydrology Report* (Appendix B, Attachment IV). Studies presented in the report evaluated the real-time gage data from 2007 to 2023 to identify the size and frequency of events exceeding 30 cfs in the East Twin Creek watershed. The study identified 33 events of that intensity or larger in a 16-year period. This equates to approximately **2.1 events per water year**. From the size of the storm, an equivalent 24-hour runoff hydrograph was developed using AES software (Hydrosoft) for generating a Unit Hydrograph in the East Twin Creek watershed and a project typical hydrograph (PTH). This was developed for East Twin Creek native water runoff using SBCFCD provided hydrographs for 100-year return frequency runoff and then scaled using the gage data and the watershed drainage area above the gage to develop a 24-hour runoff hydrograph for consistency among the different PTH.

3.5.2 Harrison Canyon Hydrology

Similarly for the Harrison Canyon runoff into the TCRB the synthetic hydrograph of the SBCFCD 100-year storm hydrograph was scaled to generate an equivalent 24-hour hydrograph. The developed hydrograph for Harrison Canyon as well as its analog for East Twin Creek. The return frequency of these small storm flows is assumed to be the same at approximately 2.1 events per year in each of these two native inflows to and through the TCRB Of note the Waterman Recharge Basins.

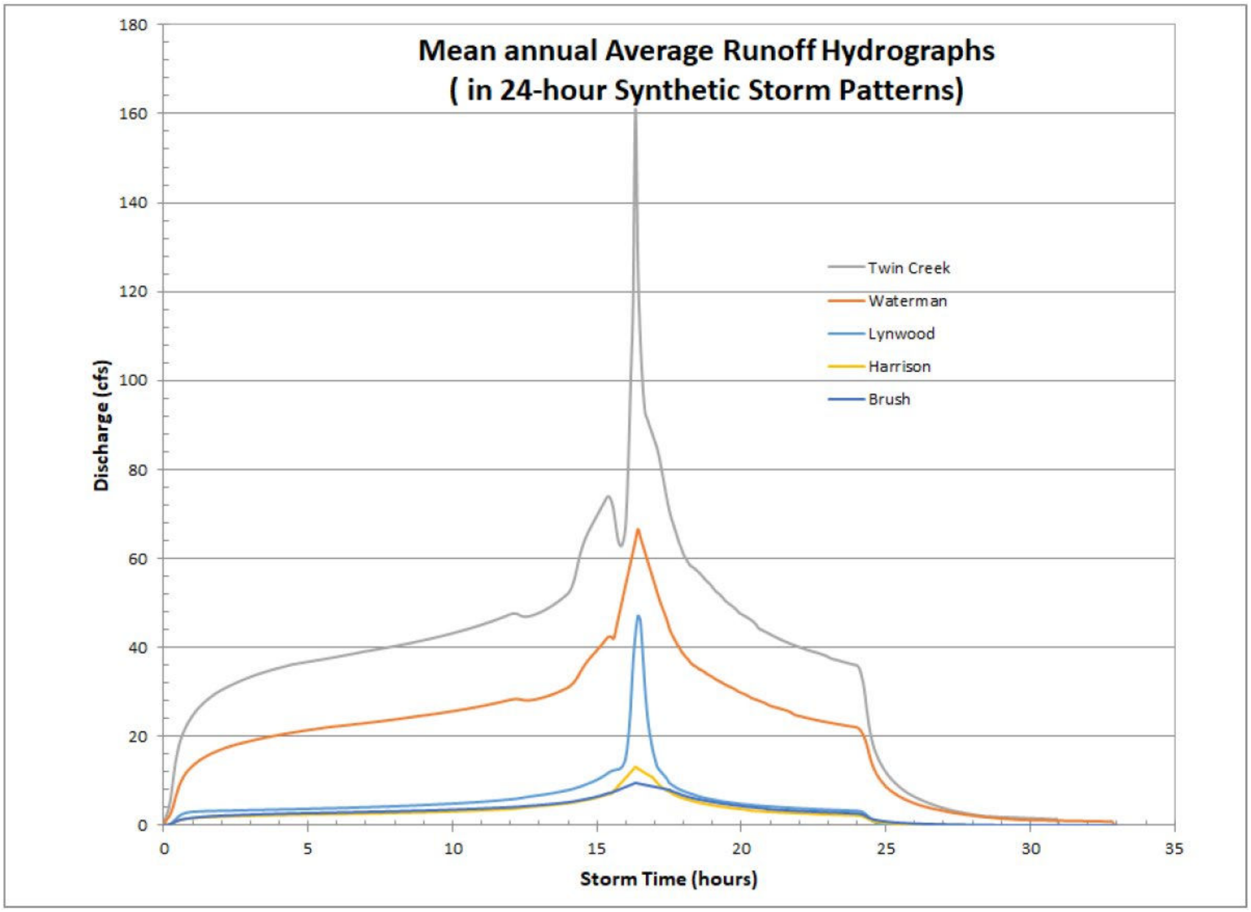

Figure 8. Synthetic Hydrographs for a 24-hour Storm using SBCFCD Forecasting Software (AES Hydrosoft)

3.5.3 FIRO Hydrology

The FIRO hydrology for TCRB consists of two component sources of water: (1) Santa Ana River water delivered to the area and received to the TCRB indirectly, and (2) the co-incident native flow in East Twin Creek in (by FIRO definition) a wet water year.

The hydrology for FIRO water delivery to the TCRB follows the overall forecast projection described in Volume 1. Under that FIRO hydrologic analysis, water from the Santa Ana River stored at Seven Oaks Dam is estimated to be available in approximately 1 out of every 4 years, a wet water year. There are PERC Project Alternatives that can receive FIRO water indirectly. For TCRB, this is water flowing downstream from its release into Waterman Recharge Basins in excess of their infiltration-rate capacity. For the FIRO hydrology, the estimate is a delivery over 52 days of a uniform flow rate, in this case 78 cfs of FIRO water out of the Foothill Pipeline to the Waterman Recharge Basins in their current conditions. Hydraulic modeling of those Waterman existing conditions with a FIRO inflow produces an outflow hydrograph that is the FIRO water inflow to the TCRB. Added to that is the second source of water to the FIRO hydrology and hydrograph, the contemporaneous and coincident native hydrology of East Twin Creek for a typical March flow in a wet water year.

Table 15. March Average Flow Rate at East Twin Creek Gage (USGS 11058500)

East Twin Creek Gage (USGS 11058500)	
Exceedance Water Year	March Average Flow Rate (cfs)
1922	27.4
1927	10.6
1937	27.0
1938	91.6
1941	43.9
1958	20.3
1966	3.2
1967	7.3
1969	42.0
1970	6.7
1973	15.7
1978	57.0
1979	14.8
1980	78.0
1983	51.5
1993	33.5
1995	58.1
1998	20.1
2005	23.2
2011	15.1
2019	11.2
2023	29.9
2024	16.2
Average	**30.6**
Median	23.2

Using the same wet water years as found in the FIRO hydrologic analysis, the gage data from East Twin Creek (**Table 15**) provided an estimated average flow rate of 30.6 cfs (average monthly data as computed by USGS for Gage 11058500). The sum of the FIRO Santa Ana River water exhausting from Waterman Recharge Basins and this 30.6 cfs average flow in East Twin Creek for March in a wet year produced the FIRO hydrograph used. This surface water hydrograph was the inflow to the 2D HEC-RAS hydraulic modeling of water spreading in the TCRB area and over each of the two TCRB PERC Project Alternatives to develop infiltration hydrographs for each of the alternatives on their groundwater recharge characteristics. This FIRO hydrograph was also hydraulically modeled in 2D HEC-RAS over the TCRB in their Existing Condition to infiltrate water there and then produce a downstream FIRO inflow hydrograph for the Lynwood Recharge Basins PERC Project Altenative analyses.

4 Small Grading Alternative

The TCRB PERC Project Alternatives were developed with the understanding that the TCRB are passively operated but that the drainage produces a great deal of sand and other sediments that fill the TCRB. One key determinant is to maintain or minimize any encroachment of peak stormflows water-surface elevation on the flood-control levees or flood water duration on the toe of the flood-control levees for flood safety reasons.

In a technical cooperation meeting on June 6, 2024 between engineering consultants for SBVWCD and technical staff at SBCFCD, the maintenance issues of removal of very large quantities of sand from TCRB Existing Conditions was described by SBCFCD. That maintenance issue, in part, led to the formulation of the Large Grading Alternative. Other relevant information shared by SBCFCD in that meeting regarding the development of PERC Project Alternatives in the TCRB was a plan and request from the San Manuel Indian Nation for a 40th Street Connector Project to the residential development planned at Arrowhead Springs that would skirt the Waterman Recharge Basins but end on 40th Street within the flood gated-off area built by USACE. An area zoned for residential development at Arrowhead Springs is depicted in the Summary Hydrology Report when considering future land uses on the hydrology of the watershed (see Appendix B, Addendum 1, Figure 18). Arrowhead Springs as a residential area is a high-hazard area for fire and floods and that will require a secondary emergency route of access. The TCRB Large Grading Alternative would improve flood conditions at 40th Street but would require modifications to current transportation infrastructure. Those modifications to roadway infrastructure are not part of the PERC scope of work, so no analysis of necessary revisions to current infrastructure have been done. The TCRB Small Grading Alternative does not require modification to current transportation infrastructure; instead this Feasibility Study identifies in the hydrologic analyses how frequently stormwater flows exceed the hydraulic capacity of the culvert beneath 40th Street and thereby how often road closure using the USACE-built road closure infrastructure is required.

The objective for the TCRB Small Grading Alternative is to leverage existing infrastructure to increase the amount of recharge from the East Twin Creek watershed.

4.1 Proposed Design

The natural regrading that has taken place since the flood levees were built currently directs flow to the RC Channel for East Twin Creek and the stormflows or released inflows would exit the TCRB Small Grading Alternative via the RC Channel for East Twin Creek in the project estimated non-flood flows. Project design does not include modification to the USACE-designed and built flood control features surrounding the TCRB (such as the flood levees). The lower drain gate for the East Twin Creek flood-levee-controlled area would not change operational plan. Regrading around the drain gate would not be necessary, even though it is presently non-operational.

The TCRB Small Grading Alternative is principally a revision of the grade elevation and slope of Hold 2 within the Recharge Basins and the lower berm, Berm 2, that would impound water within Hold 2. The overall layout of the TCRB Small Grading Alternative project design is provided in **Figure 9**. The detailed preliminary conceptual design sheets developed by SBVWCD are found in Appendix B, Attachment 1C.

Several forms of grading modification are required for the TCRB Small Grading Alternative.

1. **Improve Saddle Weir in Berm No. 1:** The existing reinforced riprap in the weir of Berm 1 would be revised with minimal regrading.
2. **Remove Low-Flow Culvert in Berm No. 1:** The existing low-flow culvert would be removed.
3. **Repair Berm 2:** Berm 2 is currently breached and requires repair (see photos in Appendix C).
4. **Regrade Berm 2 and Hold 2:** The regrading of Hold 2 and Berm 2 is proposed to avoid raising the base flood elevation.

The planned revisions to the existing riprap saddle weir in Berm 1 would enhance impoundment of water for wetted area and recharge. Other revisions to the weir in Berm 1 are to reinforce its downstream flow diffuser into Hold 2, and thereby reduce erosion of sediment base elevation at the upstream end of the entirely regraded bottom of Hold 2 .

The low-flow culvert through Berm 1 would be removed as it has no functional value to flood protection nor to project recharge benefits. Its removal would enable water to spread out in Hold 1 with outflowing water converging to the bottom of the riprap spillway and out of Hold 1.

Minor improvements would be made to the top of Berm 1 to bring it to a more uniform grade line. This would improve passage of an extreme flood flow passing through the TCRB in a Small Grading Alternative and would improve overall durability of Berm 1 against damage from large flood flows.

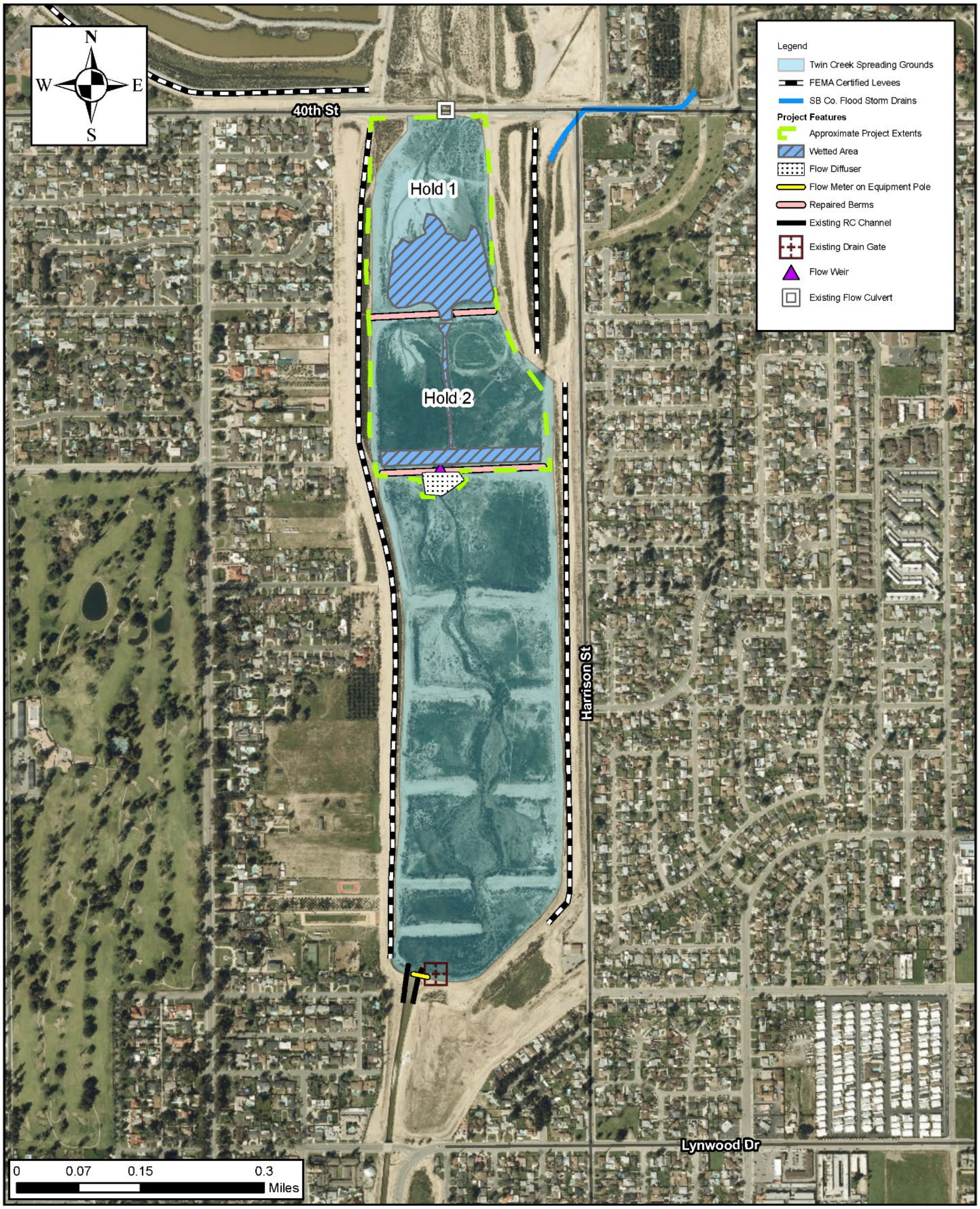

Figure 9. TCRB Small Grading Alternative Overview

Regrading Hold 2 to achieve a uniform downslope from north to south would enable water spreading. The lowered grade elevation in Hold 2 enables a saddle-shaped flow weir that would be 2 feet above the revised grade and would impound water within Hold 2 at a depth of 2 feet along Berm 2. Berm 2 would have a reinforced spillway (the black and white hatched polygon as a 'flow diffuser in Figure 9). It is anticipated that water flows would converge in Hold 2 to this saddle weir and that water movement would move sediments and regrade this area routinely. This would necessitate routine basin cleanout not only for clogging but also to maintain recharge capacity. This is a chronic maintenance challenge for the TCRB.

The preliminary design details for the TCRB Small Grading Alternative, including plan and profile views, are provided as Appendix B, Attachment IC.

The footprint of the two regraded Holds for the TCRB Small Grading Alternative would be approximately 9.3 acres. The water volume in maximum retention during operation would be 14 AF.

- The maximum water depths reach 2 feet in Hold 2.
- The average depth of water in the basins overall is approximately 1.5 feet.

The primary **water inflow** features are:

- Existing 4-foot by 8-foot concrete box culvert below 40th Street.
- Graded waterway for Harrison Canyon inflow that would be outfitted with an "Arizona Crossing" on the perimeter road to limit erosion induced by the lowered grade line of Hold 2 from Existing Conditions.

No metering of the box culvert inflows from East Twin Creek is envisioned, as the existing USGS gage provides this influent data broadly. No metering of Harrison Canyon inflow is envisioned; those low frequency flows can be estimated from gage data.

The **water outflow** feature is the floodway RC Channel at the southern end of the TCRB. As noted on the design drawings (Appendix B, Attachment 1B), the RC Channel outflow would be metered to enable estimates of net recharge across the TCRB Small Grading Alternative. Operationally, any excess spill of FIRO supplied water measured at that metered location could inform reduction of a FIRO release rate at the Waterman Recharge Basins, if that is desirable for recharge optimization.

4.1.1 Geotechnical Considerations on Project Design and Operations

The geotechnical engineering assessment of soils and sediments for their lithology and engineering properties (TetraTech, 2025) recommends the following (see Appendix B, Attachment II):

- Slope of 3(H):1(V) for stability of earthen berms

- Armored downslope areas in active spillway areas

4.1.2 Project Operations

Project operations could occur at virtually any time of year depending on flood considerations and SBCFCD requirements on FIRO releases. During the winter rainy season, PTH flows are the expected hydrology and neither induce nor require any change in operations. Project operations for FIRO water rely upon releases to the Waterman Recharge Basin 2W. FIRO releases may be limited to non-storm periods or the dry season depending on SBCFCD requirements or the operational flexibility available at Waterman Recharge Basins to enable pre-storm evacuation of water from those basins. Use of FIRO water would be governed by SBCFCD requirements for timing of use of Waterman Recharge Basins for FIRO releases.

4.1.3 Timeline

As described in Volume 1 of the Comprehensive PERC Feasibility Study Report, the timeline for project alternatives is calculated by estimating the time to design, permit, fund, and construct a project. Volume 1 summarizes these estimates alongside those for the other PERC Project Alternatives. Each of these factors is described below for the TCRB Small Grading Alternative.

- **Design Time**: Design of the TCRB Small Grading Alternative to the 65+% level required for permitting consideration is estimated to take **6 months**.
- **Permit Time**: The permit time forecast for TCRB Small Grading Alternative is **36 months**. This is controlled by the expectation that a USACE 408 Permit will be required and may take up to 36 months to obtain, even though the work being conducted does not physically contact or disturb a flood levee; the area of the work is within 500 feet of a flood control levee. All other permit requirements are expected to be met within that same overlapping three-year period. This is based on the preceding discussion, SBVWCD and SBVMWD experience and programmatic expertise.
- **Funding Time**: The time forecast from project decision-making to having a capital funding plan in place is estimated to be **0 months** since the current PERC Capital Account has sufficient funds to cover the Present Value cost estimate. The funding timeline is thought to be initiated after the Design and Permitting Time. The timing of project funding then is **May 1, 2028**. This is the timeline used to generate present value for capital funding needs.
- **Construction Time**: The construction period includes the time needed to take project designs into biddable specifications and contract documents, conduct a public bidding process for contractor selection, the project construction period, and

project works commissioning. For TCRB Small Grading Alternative, this construction period is estimated to be **4 months**.

The project operational period is estimated to be **May 1, 2029 to December 31, 2075**. The project O&M Costs are estimated over this period. Estimated groundwater recharge yield is predicated on a 46.7-year operating period.

4.2 Groundwater Recharge Benefits

Three conditions were analyzed to evaluate and estimate the probable groundwater recharge yield of the TCRB PERC Project Alternatives:

- **Condition 1:** Analyzes the PTH from East Twin Creek and Harrison Canyon entering into the TCRB for recharge. This condition provides a flow of water for approximately six days.
- **Condition 2:** Analyzes a FIRO flow of 78 cfs operated into Waterman Recharge Basins Existing Conditions (clogged) exhausting excess water into East Twin Creek and combining with East Twin Creek wet year base flows. As described in the Waterman PERC Alternative, FIRO water can be delivered into the west side of Waterman Recharge Basin 2W, using existing infrastructure. In addition, the hydrograph for native March runoff from East Twin Creek of 30.6 cfs in a wet year is available at the box culvert under 40th Street at the upstream end of the TCRB. This is a relatively flat hydrograph.
- **Condition 3:** Analyzes the 6-day balanced hydrograph for a 4-year return frequency storm with a volume of 745 AF based off the historic daily gage data for East Twin Creek (USGS Gage 11058500).

Hydraulic modeling results are provided in Appendix B, Attachment V (Alden, 2025b). Summary results are presented in **Table 16** and followed by written descriptions.

Table 16. Estimated Increase in Average Annual Recharge with TCRB Small Grading Alternative

Condition 1 PTH Hydrology Infiltration to Groundwater Recharge	**Condition 2** FIRO Hydrology Infiltration to Groundwater Recharge	**Condition 3** 6-Day Balanced Hydrograph for 4-Year Return Frequency Stormflow Events
~92.6 AFY	~351AFY	~36.5 AFY

- **Condition 1 (PTH) Results**: The TCRB Small Grading Alternative PTH hydrograph was hydraulically modelled and produced a predicted infiltration rate of 20.1 cfs in the 2D model simulations out of the peak flow rate of 180 cfs in the PTH hydrograph. The instantaneous infiltration-rate capacity increase (the net increase) in the infiltration-rate capacity is 12.6 cfs above Existing Conditions. The net annual average recharge yield over TCRB Existing Conditions is estimated **92.6 AFY** based on the 2.1 stormflow events of a PTH over time.

- **Condition 2: (FIRO) Results**: The FIRO-hydrograph described in Section 3.5.3 was simulated for 6 days in the HEC-RAS hydraulic models and extrapolated for 52 days per the FIRO probable availability of flows in wet water years. The extrapolation of FIRO water availability for Existing Conditions as compared to the TCRB Small Grading Alternative produces a net increase in average annual yield of ~**351 AFY**; the single year increase is 2,080 AF, but with an occurrence frequency of 1 in 4 years the statistically informed forecast is the average annual yield.
- **Condition 3 (4-Year Return Frequency) Results**: The 4-year return frequency storm volume was assessed and provides a good estimate of infiltration in a non-flood event producing a net increase in infiltration volume of ~145AF per event. This 6-day event with a 4-year frequency results in a modest increase in annual-average recharge yield over Existing Conditions of **~36.5 AFY**. This is a probable outcome based on historic gage flow measurements.

Hydraulic modeling was performed using the SBCFCD's AES-derived Q100 hydrograph, which has a higher peak flow than either a FEMA Q100 hydrograph or a USACE SPF hydrograph. The potential changes in flood stage were examined over existing conditions and TCRB Small Grading Alternative conditions to assess changes (Alden, 2025a). This assessment was performed in both 1D and 2D models using the USACE HEC-RAS simulation codes and in the four developed model domains (Alden, 2024).

For the WCDC and TCRB, the radial gate inlets at Heading 1C were simulated as closed per SBCFCD's Operations and Maintenance Manual (Tetra Tech, 2014). The changes in flood stage described in the 1D modeling from existing vs. proposed conditions could be characterized as small; those changes are fully described in the flood modeling Technical Memorandum presented to SBCFCD in March 2025 (Alden, 2025a) and the accompanying model and output files. Subsequent discussions with SBCFCD indicated that additional flood conditions modeling using FEMA hydrographs would be needed if the TCRB Small Grading Alternative for the TCRB is moved forward to verify that the FEMA accreditation of the flood levees would be maintained with proposed conditions. The AES hydrographs do not conform to the FEMA accreditation standards; they are larger at peak flow.

HEC-RAS 2D modeling indicates that peak stormflows out of the WCDC and upper East Twin Creek enter the existing TCRB by flowing over 40th Street; as the box culvert beneath cannot convey the AES model's synthetic peak stormflow of ~14,700 cfs. Inflows to the TCRB below 40th Street were modeled using the AES model's synthetic peak stormflow from Harrison Canyon of approximately 700 cfs.

The TCRB Small Grading Alternative provides <u>no meaningful flood detention volume</u> for extreme flow conditions simulated. Its total water detention volume, estimated at 14 AF, is simply immaterial in low-frequency stormflows that produce large volumes in a split-second. Thus, in each Q100 simulation with the TCRB Small Grading Alternative, the flood flows through the TCRB as the hydraulic surface crests onto the surrounding FEMA accredited levees and out the floodway for East Twin Creek at the downstream end of the TCRB (the wide and deep RC Channel designed by the USACE for an SPF). A comparison of the duration of flood water at the toe of the East Twin Creek levee system was used in the geotechnical study to assess any effects of those changed conditions. There is no flood water retention found (Appendix B, Attachment II).

Hydrologic analysis to assess the net recharge yield followed USACE methods for design sizing of reservoirs using a balanced hydrograph of a 6-day storm. This was generally suitable to the TCRB because it receives all non-flood flows and this smoothed hydrograph is representative of baseflow events in the TCRB as compared to the very steep-sided hydrographs of the watershed in stormflow developed as the PTH. The criterion for selection of this hydrograph was to find a storm volume of a lower frequency that it would overfill the TCRB Large Grading Alternative's static volume + infiltrated volume over a 6-day period. This was done as a hydrologic condition to more completely analyze the potential TCRB PERC Alternatives recharge yields when compared to the TCRB Existing Conditions. The estimated volume of the grading alternative detention hold at 46 AF and its estimated 6-day infiltration volume is 710 AF. That total volume of 756 AF of water is exceeded by a 4-year return frequency storm in East Twin Creek, a relatively high-frequency event that would happen on the order of 10 to 12 times in a 50-year planning horizon. This 6-day balance hydrograph was modeled for the two PERC Project Alternatives.

The model results were used to determine the TCRB Small Grading Alternative's annual average recharge, infiltration rate capacity, and firm yield over the 50-year PERC planning horizon.

4.2.1 Annual Average Recharge

A PTH flow event in East Twin Creek occurs slightly more than 2 times per year. With a net recharge yield of an additional ~45 AF of recharge per stormflow event, this results in an estimated <u>increase in annual average yield of 92.5 AFY</u> from native PTH storms. And an additional 36.5 AFY from baseflows in wet-water-year flow events simulated using a 6-day balanced hydrograph with a 4-year return.

FIRO-sourced Santa Ana River water flows are projected to be available approximately one in four years. The per-event volume for FIRO recharge over Existing Conditions is higher by 1,300 AF, but the return frequency for FIRO-sourced water from the Santa Ana River reduces the estimated net increase from FIRO to <u>351 AFY</u>.

The net groundwater recharge benefit increase on an annual basis is estimated to be the sum of the three hydrologic sources of water, **totaling ~480 AFY**. The total estimated groundwater recharge benefit for the TCRB Small Grading Alternative is ~745 AFY indicating that the PERC project produces an 183% increase in recharge compared to Existing Conditions from the same source water availability.

4.2.2 Infiltration-Rate Capacity

The TCRB Small Grading Infiltration rate capacity is estimated to be 20.1 cfs with a net of **12.55 cfs** over the Existing Conditions infiltration-rate capacity of 7.5 cfs (basin full conditions).

4.2.3 Firm Yield Over Planning Horizon

The TCRB Small Grading Alternative has a 46.7-year period of operation in the 50-year planning horizon (July 1, 2033 to December 31, 2075). Based on the increased average annual yield, the rated net increase in firm yield is **22,405 AF** of engineered recharge over the 50-year planning horizon.

4.2.4 Groundwater Recharge Benefits Summary

Below are the Groundwater Recharge Benefits values associated with the TCRB Small Grading Alternative that were input to the MAA Model for final scoring.

Table 17. TCRB Small Grading Alternative Groundwater Recharge Benefits Summary

Groundwater Recharge Benefits Summary		
Annual Average New Recharge (AFY)	Infiltration Rate Capacity Increase (cfs)	Firm Yield over 50-Year Planning Horizon (AF)
480 AFY	12.55 cfs	22,405 AF

4.3 Cost Aspects

4.3.1 Capital Costs

The estimated capital costs are detailed in Appendix B, Attachment VIII and total $12,787,000 on a 2025 basis. But the timing of **the capital needed is May 1, 2028 to fund construction.** The discount factor used for capital is 4% with an expectation that the cost of money is 7% and inflation is 3%. A general contingency of 30-percent was added to each alternative. The Present Value of the capital needed today to fund in May 1, 2028 equates to **$10,822,000**.

4.3.2 Operations & Maintenance Costs

TCRB Small Grading Alternative maintenance would be for siltation management and basin clogging. Using data from the Preliminary Design Report on sediment transport, it is estimated that a modest 45 cubic yards per year of sediment retention would occur. This amount of sediment is projected to trigger a basin scraping and cleaning effort **once every 15 years**. Other maintenance measures and upkeep matters are integrated to O&M costs via replacement cycles for meters and telecommunications equipment and would be addressed in a subsequent phase. The day-to-day operations for TCRB Small Grading Alternative would be very low, as operations and data collection are either passive (e.g., native inflow and outflow) or would be nearly completely automated.

O&M Costs are forecast on an annual equivalent basis. Comparison of operating costs are made in present day dollars. The average annual costs of basin maintenance are estimated at **~$29,000 per year**. The O&M costs are not discounted for the sake of comparison since they will be incurred in the year that they occur. Therefore, projecting a borrowing cost for capital is not pertinent for operations. Similarly, inflationary factors are not material to comparing costs that would be similarly inflated over a similar period of time.

4.3.3 Cost Aspects Summary

Table 18 presents the Cost Aspects values associated with the TCRB Small Grading Alternative that were input to the MAA Model for final scoring.

Table 18. TCRB Small Grading Alternative Cost Aspects Summary

Cost Aspects Summary	
Capital Costs (2025$)	Annual O&M Costs (2025$)
$10,822,000	$29,048

4.4 Other Technical Aspects

Other aspects of the TCRB Small Grading Alternative are summarized here. For comparison among other PERC Alternatives in the MAA, see Volume 1.

4.4.1 Groundwater Quality Improvements

The addition of recharge into the Bunker Hill Basin Zone B is rated on its prospective annual average recharge for the equivalent MGD. That quantification is in keeping with the discussions and evaluations of Salt & Nutrient Management Planning. TCRB estimated average daily recharge rate based on a historic probability based calculation of how often and how much water is materially available in the annual average groundwater recharge potential equates to **0.7 MGD**.

4.4.2 Conservation and Habitat Benefits

There are no species impacts forecast from TCRB Small Grading Alternative as they are existing features with no regrading planned. Nor is there any habitat restoration.

The TCRB Project Alternatives are a part of the Upper Santa Ana River Habitat Conservation Plan (ICF, 2020) as a component of *Twin Creek Spreading Grounds (VD.2.13) – Phase 2*. The expected benefit to flows in the Santa Ana River is **0.5 cfs** as a chronic year-round rate.

4.4.3 Hydraulic Stress and Pressure Zone Influence

The value of relief to hydraulic stress is described in Volume 1. It equates to the distance from the PERC Project Alternative to the center of the Pressure Zone near West 5th Street and Waterman Avenue in the City of San Bernardino. TCRB Small Grading Alternative features are measured as **6,270 yards** or approximately 3.5 miles.

4.4.4 Access to State Water Project Supply

The TCRB Small Grading Alternative has indirect access to receive State Water Project supply.

4.4.5 Groundwater Mounding

Groundwater modeling analyses for the combination of recharge conditions from a FIRO release were evaluated in Appendix B, Attachment VII as the highest recharge rate conditions. Analysis of the groundwater modeling for groundwater mounding results did not recommend any further geotechnical engineering evaluation (Appendix B, Attachment II). Further, groundwater modeling **does not indicate any reduction in the groundwater recharge** rates due to groundwater mounding.

4.4.6 Other Technical Aspects Summary

Table 19 presents a summary of the Other Technical Aspects values associated with the TCRB Small Grading Alternative that were input to the MAA Model for final scoring.

Table 19. TCRB Small Grading Alternative Other Technical Aspects Summary

Other Technical Aspects Summary				
Average Annual Recharge Rate (MGD)	Santa Ana River Contribution (cfs)	Proximity to Groundwater Pressure Zone (yds)	Access to SWP Supply	Groundwater Mounding
0.7 MGD	0.5 cfs	6,270 yds	Indirect	No

4.5 Social Aspects

4.5.1 Job Creation

The projected construction employment in FTE equates to **40 full-time jobs for one-year**. The total employment forecast for O&M of the TCRB Small Grading Alternative is **0.05 FTE** on a perpetual basis.

4.5.2 Ponded Water Depth

The Waterman Grading Alternative ponded water depth is **3 feet**. One social aspect that will be taken into consideration is prevention of drowning. Experience at SBVWCD basins demonstrates that water basins will attract unhoused individuals or passersby in hot weather to enter the basin. Access control will be a key consideration in design. Additionally, graded slopes for easy ingress and egress may reduce drowning and other safety hazards from sloped ground.

4.5.3 Social Aspects Summary

Table 20 presents the Social Aspects values associated with the TCRB Small Grading Alternative that were input to the MAA Model for final scoring.

Table 20. TCRB Small Grading Alternative Social Aspects Summary

Social Aspects Summary		
Construction Jobs (FTE/time period)	O&M Jobs (FTE)	Ponded Water Depth (ft)
40 /12 months	0.05	3

4.6 Legal Aspects

4.6.1 CEQA and Permitting Analysis

A brief review of the potential permit needs and issues for the TCRB Small Grading Alternative is provided in **Table 21** below.

Table 21. Potential Permit Requirements for the TCRB Small Grading Alternative

Potential Permit	Preliminary Review Determination
CEQA	Given the existing features, the modifications can be classified as repair (to provide the function for which they were originally built), potentially qualifying the project for a categorical exemption under CEQA. Regardless, the project itself is addressed under the

Potential Permit	Preliminary Review Determination
	programmatic EIR under development for the Upper Santa Ana River HCP.
USFWS	Addressed under the Upper Santa Ana River HCP.
CDFW CESA 2081	Addressed under the Upper Santa Ana River HCP.
CDFW LSA /1600	Addressed under the Upper Santa Ana River HCP.
USACE 401/ RWQCB	Addressed under the Upper Santa Ana River HCP.
USACE 404	Required due to alteration of the watercourse.
USACE 408	USACE 408 permit will be required, as the grading work is near a flood control levee. Obtaining this permit may take more than a year based on typical timeframe of response on a 408-permit filing. However, no work is to disturb or alter the flood control features and the hydraulic analysis shows no negative alteration of floodwater impoundment adjoining the flood levees.
CA DOSD Jurisdictional Dam	TCRB berms are not jurisdictional dams due to their respective sizes, and due to their location within a flood control levee.
SBCFCD	TCRB Small Grading Alternative would require a permit from SBCFCD. It is assumed that it will qualify as a “major construction permit” because segments of the flood watercourse will be inoperable for a brief period.

At this preliminary stage, no design considerations appear to be needed to provide for habitat impacts in the project footprint given that the project is a repair of existing facilities to restore and improve their function. It does not utilize any new land area. Final design, however, should consider measures to mitigate against creating habitat within the project that would foster intrusive species of flora and fauna.

The TCRB footprint is outside the Federal Aviation Administration (FAA) secondary buffer zone of 10,000 feet, Perimeter B, from San Bernardino International Airport (FAA, 2020). The FAA has specific design and permitting review for water holds that could provide nesting habitat for waterfowl; a flight safety hazard. The TCRB are, however, within the FAA Perimeter C requirements area of 5-miles for the San Bernardino International Airport. Perimeter C triggers notification recommendations for the project proponents to the San Bernardino Airport operators. This buffer zone of 5-miles is intended to trigger the airport operators to evaluate potential management actions.

4.6.2 Land Availability

This land is NOT currently owned by a partner agency.

4.6.3 Support for Claimed Water Rights

The support for new Water Rights not yet perfected is equated to the maximum diversion rate to groundwater recharge, estimated at **12.55 cfs** for the TCRB Small Grading Alternative. The annual yield could be as high as 2,385 AF in a very-wet water year.

4.6.4 Legal Aspects Summary

Table 22 presents the Legal Aspects values associated with the TCRB Small Grading Alternative that were input to the MAA Model for final scoring.

Table 22. TCRB Small Grading Alternative Legal Aspects Summary

Legal Aspects Summary		
CEQA/Permits Required	Land Availability	Support for Claimed Water Rights (cfs)
See Table 21	No	12.55

4.7 Summary Results

The PERC Comprehensive Feasibility Study looked at each Project Alternative's characteristics and viability over the following key considerations:

- **Groundwater Recharge Benefits**: How much water will be captured and stored as groundwater by the project each year? Over the next 50 years?
- **Cost Aspects:** Do the economics indicate the project's financial viability, including costs, benefits, and projected return on investment?
- **Technical Aspects:** Are the necessary technology, resources, and expertise available and sufficient to implement the project?
- **Social Aspects:** How well does the project align with the available human resources and how well can it align with existing operations?
- **Legal Aspects:** Are there legal or regulatory requirements that could impact the project?

In some respects, this amounts to a discovery process to identify whether any proposed project has fatal flaws that prevent its execution. The TCRB Small Grading Alternative **does not have any apparent fatal flaws**, albeit the infrastructure for the project could be compromised in a low-frequency storm, like the one experienced in December 25, 2003, potentially necessitating reconstruction of the majority of the grading features. More information can and would be developed for the TCRB Small Grading Alternative if it is taken forward as a PERC project for permitting, design, and construction. Operationally, the TCRB Small Grading Alternative is a judged to be a **good fit** to the dual objectives in a SBCFCD flood control facility; flood control functionality is fully maintained and groundwater recharge is enhanced.

4.7.1 MAA Indicator Values

PERC and its regional partners chose an integrated multiple accounts analysis (MAA) method to consistently assess PERC Alternatives against what they chose as the most important feasibility considerations. The MAA developed for PERC is described in Volume 1. **Table 23** shows the MAA Indicators and their respective TCRB Small Grading Alternative Values.

Table 23. TCRB Small Grading Alternative MAA Indicator Values

Account	Subaccounts	Indicators	TCRB Small Grading Alternative Values
Groundwater Recharge Benefits	Groundwater Recharge-Benefit (Net AFY)	AFY	480
	Infiltration-rate-capacity increase (cfs)	Net Increase in Infiltration Rate Capacity (cfs)	12.55
		Ease of Maintenance (FTE)	0.05
		Timeline to Implement (years)	5.40
	Recharge benefit on a "firm yield" 50-year horizon (AF)	AF	22,405
Cost Aspects	Capital Costs	Capital Costs NPV	$10,822,000
		Grant Sources	0%
	O&M	O&M in 2025 $	$29,048
Other Technical Aspects	Groundwater Quality Improvements *(Salt & Nutrient Management Planning)*	Volume of Annual Recharge (MGD)	0.7
	Conservation and Habitat Benefits	Santa Ana River Contribution	0.50
		Habitat Restoration	0.00

Account	Subaccounts	Indicators	TCRB Small Grading Alternative Values
		Species/ Habitat Impacts	0.00
	Proximity to Groundwater Pressure Zone	Distance to Pressure Zone (yds)	6,270
	Access to State Water Project Supply	Direct, Indirect or No Access	Indirect
	Groundwater Mounding	Rate Limiting Mounding *(Liquefaction Issue)*	No
Social Aspects	Project Job Creation	Number of Jobs Forecast for Construction	40.0
		Number of Jobs Forecast from Operational Needs	0.04
	Public Safety Hazards of Project	Ponded Water Depth (ft)	2.5
Legal Aspects	CEQA	CEQA Filing Type (e.g. NOE)	Categorical
	Permits Required/ Requirements	USFWS Permit Requirements	River-HCP
		CDFW CESA (2081) Permit Requirements	River-HCP
		CDFW LSA /1600 Permit Requirement	River-HCP
		USACE/RWQCB 401 Permit Required	River-HCP
		USACE 404 Permit Required	Typical
		USACE 408 Permit Required	Time-Consuming
		CA DOSD Jurisdictional Dam	None-Required

Account	Subaccounts	Indicators	TCRB Small Grading Alternative Values
		City of San Bernardino Consent Decree Area Permit	None-Required
		SBCFCD	Major
	Land Availability	Property Ownership by Partner Agencies (Y/N)	N
	Water Rights	Support for utilization of water rights not yet Licensed	12.55

4.7.2 Score and Rank

The MAA Summary Scoring prioritizes the TCRB Small Grading Alternative very low with a **9th priority** ranking (out of 10) when considering the stakeholder-developed characteristics, criteria, and their weighted importance in meeting regional goals. It is a feasible and viable project **but does not warrant near-term prioritization** for applying human resources, financial resources, and political capital.

The summary scoring under the MAA for the TCRB Small Grading Alternative is shown in **Table 24**.

Table 24. TCRB Small Grading Alternative MAA Scoring Summary

Account	TCRB Small Grading Alternative MAA Summary Score
Groundwater Recharge Benefits	1.32
Cost Aspects	1.45
Other Technical Aspects	0.45
Social Aspects	0.20
Legal Aspects	0.53
Total	**3.95**
Priority Rank	**9th**

5 Large Grading Alternative

The objective for the TCRB Large Grading Alternative is a complete revision of the grade lines and elevations within the Twin Creek Flood Leveed area south of 40th Street, west of Harrison Street in the City of San Bernardino.

5.1 Proposed Design

The fundamental design concept is to construct the project to induce and maintain sheet flow of water into and across water Holds. No modification to the USACE-designed and built flood control features surrounding the TCRB is necessary. The stormflows or the FIRO-released inflows would exit the TCRB via the RC Channel for East Twin Creek for both flood and non-flood flows.

The design of the Large Grading Alternative matches the grade line of the surrounding area, a land surface slope of approximately 1.7%. This would eliminate grade transitions at the top, middle, and bottom of the TCRB footprint.

To maintain sheet flow of water over the long term, the conceptual design utilizes long-crested weirs that are concrete-clad earthen berms for durability. They span across the width of the TCRB to inhibit or prevent the incision of a watercourse by both low and high flows. The flow patterns are "reset" by the low-profile crested weir to a downstream and upstream sheet flow due to their uniform elevation and flow-durable construction. The weir designs are 3 feet tall with an upstream grade of 8:1 and a downstream grade of 5:1, both fairly gradual slopes for the water to rise up and flow down.

To initiate the desired sheet flow of water in the TCRB, the entry of water is guided across a newly designed and built 450-foot-wide flat-bottomed culvert set between the side berms (non-flood features) on the south side of East 40th Street. The existing infrastructure for passing flowing water in East Twin Creek below 40th Street would need to be revised but this is not contemplated as a part of the PERC project in this conceptual design phase[5]. The entering water is guided to spread out laterally and flow downslope to the 1st of 10 of these three-foot-tall, long-crested weirs. These weirs are spaced approximately 500 feet apart, north to south, over the 5,000 length of the TCRB in the flow direction.

The overall layout of the TCRB Large Grading Alternative design is provided in **Figure 10**. The detailed preliminary conceptual design sheets developed by SBVWCD are found in Appendix B, Attachment 1D.

[5] This needed infrastructure should be built to keep East 40th Street open at all times by utilizing the hydraulic capacity made possible by a wide flat-bottomed culvert or series of box culverts.

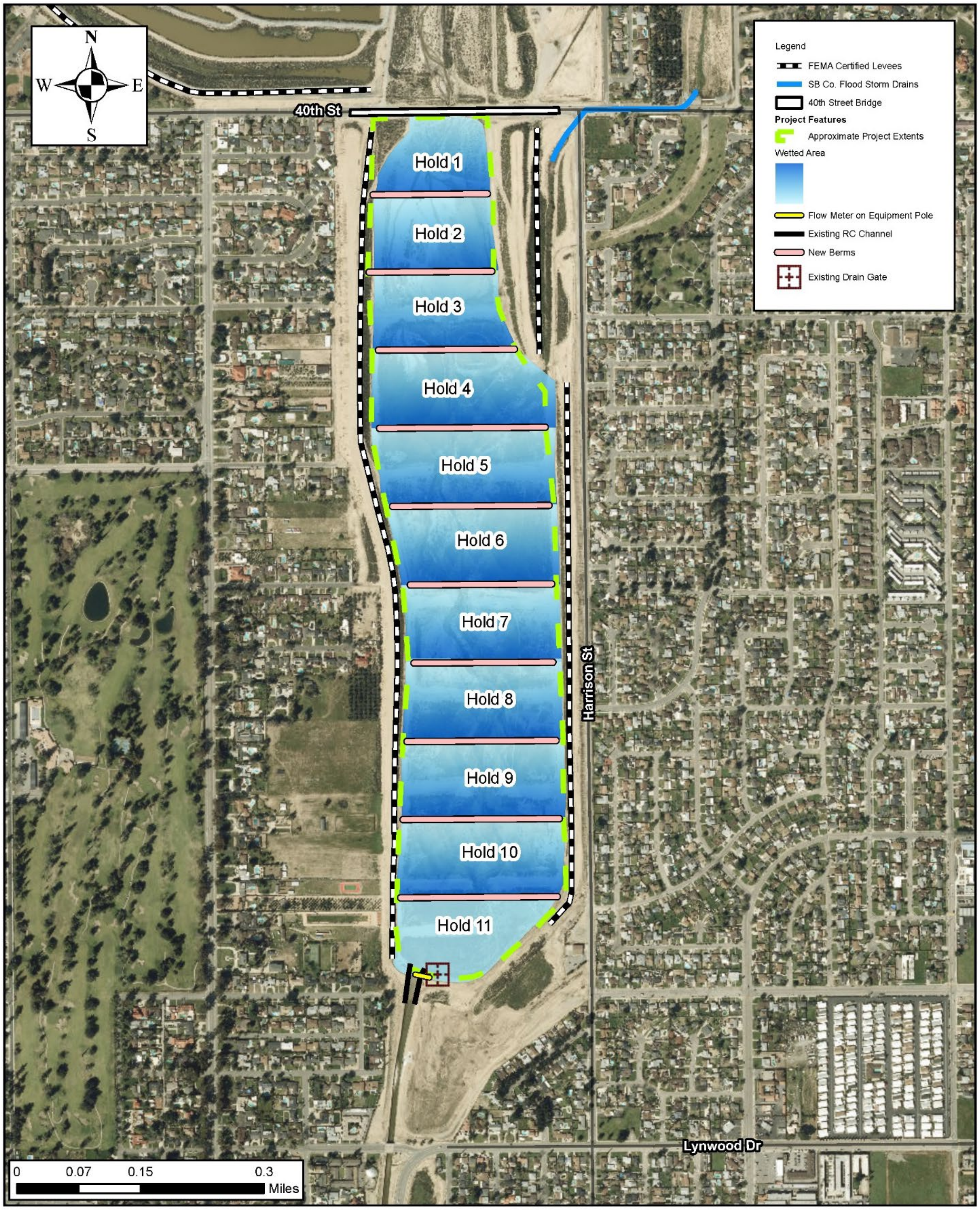

Figure 10. TCRB Large Grading Alternative Overview

The smoothly graded design of the TCRB Large Grading Alternative is intended to ***eliminate the need for routine basin cleanout*** as the Holds would be self-cleaning to maintain recharge capacity. Basin cleaning is currently an expensive, time-consuming, chronic challenge for SBCFCD in the TCRB. They are running out of places to put the sediments requiring removal. The preliminary design details for the TCRB Large Grading Alternative, including plan and profile views, are provided as Appendix B in Attachment ID.

The **footprint** of the 11 regraded Holds in TCRB would be approximately 120 acres, or virtually the entire footprint of the TCRB.

The **water volume** in maximum retention during operation would be 46.6 AF.

- The maximum water depths reach a maximum of 2.6 feet. Due to the broad low slope to the top of the weirs, the maximum depth of water is less than the height of the weirs.
- The average depth of water in the basins overall is approximately 0.5 feet.

The primary **water inflow** features are:

- Revised broad culvert below 40th Street.
- Existing graded waterway for Harrison Canyon inflow will be regraded near its south end to match the revised grade line and outfitted with an “Arizona Crossing” on the perimeter road to enable water to enter while limiting erosion.

There is no metering of the new culverts inflow from East Twin Creek because the existing USGS gage provides this influent data broadly. Water outflowing from the Waterman Recharge Basins, whether revised or operationally altered, would be metered. No metering of Harrison Canyon inflow is envisioned; those low frequency flows can be estimated from gage data.

The **water outflow** feature is the floodway RC Channel at the southern end of the TCRB. As noted on the design drawings (Appendix B, Attachment 1D), that outflow would be metered to enable estimates of net recharge across the TSCG Large Grading Alternative.

5.1.1 Geotechnical Considerations on Project Design and Operations

The geotechnical engineering assessment of soils and sediments for their lithology and engineering properties (TetraTech, 2025) recommends the following (Appendix B, Attachment II):

- Slope of 3(H):1(V) for stability of earthen berms.
- Armored downslope areas in active spillway areas.

5.1.2 Project Operations

Project operations could occur at virtually any time of year depending on flood considerations and SBCFCD requirements on FIRO releases. During the winter rainy season, PTH flows are the expected hydrology and neither induce nor require any change in operations.

Project operations for FIRO water rely upon releases to Waterman Recharge Basin 2W. FIRO releases may be limited to non-storm periods or the dry season depending on SBCFCD requirements and/or the operational flexibility available at Waterman Recharge Basins to enable pre-storm evacuation of water from those basins. Use of FIRO water would be governed by SBCFCD requirements for timing of use of Waterman Recharge Basins for FIRO releases.

5.1.3 Timeline

As described in Volume 1 in the Comprehensive PERC Feasibility Study Report, the timeline for project alternatives is calculated by estimating the time to design, permit, fund, and construct a project. Table A in Volume 1 summarizes these estimates alongside those for the other PERC Project Alternatives. Each of these factors is described below for the TCRB Large Grading Alternative.

- **Design Time**: Design of the TCRB Large Grading Alternative to the 65% level required for permitting consideration is estimated to take **15 months**.
- **Permit Time**: The permit time forecast for TCRB Large Grading Alternative is **36 months**. This is controlled by the expectation that a USACE 408 Permit will be required and may take up to 36 months to obtain. All other permit requirements are expected to be accomplished within that same overlapping three-year period due in large part to the umbrella of the River HCP. This is based on the preceding discussion, SBVWCD and SBVMWD experience, and programmatic expertise.
- **Funding Time**: The time forecast from project decision-making to having a capital funding plan in place is estimated to be **108 months** since the current PERC Capital Account does not have sufficient funds to cover the Present Value cost estimate. The funding timeline is thought to be initiated after the Design and Permitting Time. The timing of project funding then is **April 1, 2039**. This is the timeline used to generate present value for capital funding needs.
- **Construction Time**: The construction period includes the time needed to take project designs into biddable specifications and contract documents, conduct a public bidding process for contractor selection, the project construction period, and project works commissioning. For the TCRB Large Grading Alternative, this construction period is estimated to be **18 months**.

The project operational period is estimated to be **April 1, 2040 to December 31, 2075**. The project O&M Costs are estimated over this period. Estimated groundwater recharge yield is predicated on a 46.7-year operating period.

5.2 Groundwater Recharge Benefits

The three hydrologic conditions analyzed for the TCRB Small Grading Alternative (PTH, FIRO, and 6-Day Balanced) as described in Section 4.2 were also hydraulically modeled to evaluate the recharge infiltration estimated from the spreading of the water over the proposed TCRB *Large* Grading Alternative.

Hydraulic modeling results are provided in Appendix B, Attachment V (Alden, 2025b). Summary results are presented in **Table 25** and followed by written descriptions.

Table 25. Estimated Increase in Average Annual Recharge with TCRB Large Grading Alternative

Condition 1 PTH Hydrology Infiltration to Groundwater Recharge	**Condition 2** FIRO Hydrology Infiltration to Groundwater Recharge	**Condition 3** 6-Day Balanced Hydrograph for 4-Year Return Frequency Stormflow Events
~260 AFY	~1,515 AFY	~125 AFY

- **Condition 1 (PTH) Results**: The PTH hydrograph produces a predicted infiltration rate of 62.1 cfs in the 2D model simulations of the TCRB Large Grading Alternative out of the peak flow rate of 180 cfs in the PTH hydrograph. The instantaneous infiltration rate capacity increase (the net increase) is 54.5 cfs above Existing Conditions. The net annual average recharge yield over TCRB Existing Conditions is approximately **260 AFY** based on the 2.1 stormflow events of a PTH over time.
- **Condition 2: (FIRO) Results**: The FIRO-hydrograph described in Section 3.5.3 was simulated for 6 days in the HEC-RAS hydraulic models and extrapolated for 52 days per the FIRO probable availability of flows in wet water years. The extrapolation of FIRO water availability for Existing Conditions as compared to the TCRB Large Grading Alternative produces a net increase in the average annual yield for that facility of ~**1,515 AFY**; the single year increase is 6,400 AF, but with an occurrence frequency of roughly 1 in 4 years, the statistically informed forecast is the average annual yield.
- **Condition 3 (4-Year Return Frequency) Results**: The 4-year return frequency storm volume was assessed and provides a good estimate of infiltration in a non-flood event producing a net increase in infiltration volume of ~600 AF per event. This 6-day event with a 4-year frequency results in a modest increase in annual-average recharge yield

over Existing Conditions of **~125 AFY**. This is a probable outcome based on historic gage flow measurements.

Flood conditions hydraulic modeling was performed using SBCFCD's AES-derived Q100 hydrographs. The potential changes in base-flood elevation were examined over the TCRB Existing Conditions and the TCRB Large Grading Alternative conditions to assess changes (Alden, 2025a) in both 1D and 2D models using the USACE HEC-RAS simulation codes and in the four developed model domains (Alden, 2024).

For the WCDC and TCRB the radial gate inlets at Heading 1C were simulated as closed per the SBCFCD's Operations and Maintenance Manual (Tetra Tech, 2014). The changes in flood stage described in the 1D modeling from existing vs. proposed conditions could be characterized as **large**. The extensive regrading in the TCRB Large Grading Alternative would elevate the land surface within the TCRB considerably. However, the smooth grading profile and low berms reduce some of the flow-turbulence effects induced by Existing Conditions, improving flood stage in some areas. Simulated changes in an AES Q100 flood hydrograph are fully described in the flood modeling Technical Memorandum presented to SBCFCD in March 2025 (Alden, 2025a) with the associated model and output files. Subsequent discussions with SBCFCD indicated that additional flood conditions modeling using FEMA hydrographs would be needed if the TCRB Large Grading Alternative moves forward. This additional flood modeling would need to model a FEMA Q100 hydrograph, which has a smaller peak flow than the SBCFCD AES hydrograph. It is assumed for now that FEMA accreditation would be maintained with the TCRB Large Grading Alternative, avoiding the need for USACE evaluation.

HEC-RAS 2D modeling indicates that peak stormflows out of the WCDC and upper East Twin Creek enter the TCRB into the footprint under TCRB Existing Conditions by flowing over 40th Street, as the box culvert beneath cannot convey the AES model's synthetic peak stormflow of ~14,700 cfs. Conversely, the HEC-RAS 2D modeling indicates that those same peak stormflows are conveyed within the conceptual 450-foot wide culvert.

Additional inflows to the TCRB below 40th Street were modeled using the AES model's synthetic peak stormflow from Harrison Canyon of ~700 cfs over the existing grade and the modified grade at the entry of Harrison Canyon floodwater flowing downslope into the TCRB between flood levees.

In a Q100 flood, the TCRB Large Grading Alternative provides **no meaningful flood detention** volume for these extreme flow conditions simulated. Its total water detention volume, estimated of 46.6 AF, is simply immaterial in low-frequency stormflows that produce these large volumes in a split-second. Thus, in each Q100 simulation, the flood flows through the TCRB with the TCRB Large Grading Alternative as the hydraulic surface, crest onto the surrounding flood levees and out the floodway for East Twin Creek at the downstream end of the TCRB, through the wide and deep RC Channel designed by USACE for an SPF. A comparison of the duration of flood water at the toe of the East Twin Creek levee system was used in the geotechnical study to assess any effects of those changed conditions. No flood water retention is found (Appendix B, Attachment II).

Surface water exiting the TCRB Large Grading Alternative would be metered at the RC Channel per the conceptual design (Appendix B, Attachment 1D). Operationally, any excess spill of FIRO-supplied water measured at that metered location could inform reduction of a FIRO release rate at the Waterman Recharge Basins, if desirable for recharge optimization.

The model results were used to determine the TCRB Large Grading Alternative's annual average recharge, infiltration rate capacity, and firm yield over the 50-year PERC planning horizon.

5.2.1 Annual Average Recharge

A PTH flow event in East Twin Creek occurs slightly more than 2 times per year. With a net recharge yield of an additional ~125 AF of recharge per stormflow event, this results in an estimated increase in annual average yield of approximately 260 AFY from native PTH storms. An additional 125 AFY was calculated as available from baseflows in wet-water-year flow events simulated using a 6-day balanced hydrograph with a 4-year return.

FIRO-sourced Santa Ana River water flows are projected to be available approximately one in four years. The per-event volume for FIRO recharge over Existing Conditions is higher by 5,600 AF, but the return frequency for FIRO-sourced water from the Santa Ana River reduces the estimated net increase from FIRO to 1,515 AFY.

The net groundwater recharge benefit increase on an annual basis is estimated to be the sum of the three hydrologic sources of water, **totaling ~1,900 AFY**. The total estimated groundwater recharge benefit for the TCRB Large Grading Alternative is ~2,160 AFY, indicating a **723% increase in recharge** compared to Existing Conditions from the same source water availability.

5.2.2 Infiltration-Rate Capacity

The TCRB Large Grading Alternative infiltration-rate capacity is estimated to be 62.1 cfs with a net of **54.5 cfs** over the Existing Conditions infiltration-rate capacity of 7.5 cfs (basin full conditions).

5.2.3 Firm Yield Over Planning Horizon

The TCRB Large Grading Alternative has a 46.7-year period of operation in the 50-year planning horizon (July 1, 2033 to December 31, 2075). The increased average annual yield (described above) results in a **rated net increase in firm yield** of **67,914 AF** of engineered recharge over the 50-year planning horizon.

5.2.4 Groundwater Recharge Benefits Summary

Below are the Groundwater Recharge Benefits values associated with the TCRB Large Grading Alternative that were input to the MAA Model for final scoring.

Table 26. TCRB Large Grading Alternative Groundwater Recharge Benefits Summary

Groundwater Recharge Benefits Summary		
Annual Average New Recharge (AFY)	Infiltration Rate Capacity Increase (cfs)	Firm Yield over 50-Year Planning Horizon (AF)
1,900 AFY	54.53 cfs	67,914 AF

5.3 Cost Aspects

5.3.1 Capital Costs

The estimated capital costs are detailed in Appendix B, Attachment VIII and total \$99,841,000 on a 2025 basis. But the timing of **the capital needed is April 1, 2039, to fund construction.** The discount factor used for capital is 4% with an expectation that the cost of money is 7% and inflation is 3%. Using this discount factor, the Present Value of the capital needed today to fund in April 1, 2039, equates to **\$57,834,000**.

5.3.2 Operations & Maintenance Costs

TCRB Large Grading Alternative maintenance would be minimal with inspection of equipment and grading conditions expected once per year, the **lowest maintenance of any potential PERC Project Alternative**. No sediment retention is estimated to occur as stormflow in the TCRB are expected to reach sweeping velocities on the order of 1.5 feet per second (fps) at least once per year, thereby effectively sweeping the Hold bottoms clear of fine sediment. Other maintenance measures and upkeep matters are integrated into O&M costs via replacement cycles for meters and telecommunications equipment for expected equipment lifetimes of 5 to 10 years based on the equipment type.

O&M Costs are forecast on an annual equivalent basis. The day-to-day operations for TCRB Large Grading Alternative would be **very low** as operations and data collection are either passive (e.g., native inflow and outflow) or would be nearly completely automated. The basin cleaning and maintenance operations are projected to be limited to a singular annual inspection of basin operating conditions, as the sweeping stormflow velocities will automatically clean the basins.

Comparison of operating costs are done in present day dollars. The average annual costs of basin maintenance are estimated at **~\$27,621 per year**. The O&M costs are not discounted for the sake of comparison or for budgeting since they will be incurred in the year that they occur. Therefore, projecting a borrowing cost for capital is not pertinent for operations. Similarly, inflationary factors are not material to comparing costs that would be similarly inflated over a similar period.

5.3.3 Cost Aspects Summary

Table 27 presents the Cost Aspects values associated with the TCRB Small Grading Alternative that were input to the MAA Model for final scoring.

Table 27. TCRB Large Grading Alternative Cost Aspects Summary

Cost Aspects Summary	
Capital Costs (2025$)	Annual O&M Costs (2025$)
$57,834,000	$27,621

5.4 Other Technical Aspects

Other aspects of the TCRB Large Grading Alternative are summarized here for use in comparison among the other PERC Alternatives in the MAA, as presented in Volume 1.

5.4.1 Groundwater Quality Improvements

The addition of recharge into the Bunker Hill Basin Zone B is rated on its prospective annual average recharge for the equivalent in MGD. That quantification is in keeping with the discussions and evaluations of Salt & Nutrient Management Planning. TCRB Large Grading Alternative estimated average daily recharge rate based on a historic probability-based calculation of how often and how much water is materially available in the annual average groundwater recharge potential equates to **1.9 MGD**.

5.4.2 Conservation and Habitat Benefits

There are no species impacts forecast from TCRB Large Grading Alternative as they are existing features with no regrading planned. Nor is there any habitat restoration.

The TCRB Project Alternatives are a part of the Upper Santa Ana River Habitat Conservation Plan (ICF, 2020) as a component of *Twin Creek Spreading Grounds (VD.2.13) – Phase 2*. The expected benefit to flows in the Santa Ana River is **2.1 cfs** as a chronic year-round rate.

5.4.3 Hydraulic Stress and Pressure Zone Influence

The value of relief to the hydraulic stress is described in Volume 1. It equates to the distance from the PERC Project Alternative to the center of the Pressure Zone near West 5th Street and

Waterman Avenue in the City of San Bernardino. The TCRB Large Grading Alternative features are measured as **5,150 yards** or approximately 3 miles.

5.4.4 Access to State Water Project Supply

The TCRB Large Grading Alternative can **indirectly** receive State Water Project supply.

5.4.5 Groundwater Mounding

Groundwater modeling analyses for the combination of recharge conditions from a FIRO release were evaluated in Appendix B, Attachment VII as the highest recharge rate conditions. Analysis of the groundwater modeling for groundwater mounding results did not recommend any further geotechnical engineering evaluation (Appendix B, Attachment II). Further, the groundwater modeling **does not indicate any reduction in the groundwater recharge rates** due to groundwater mounding.

5.4.6 Other Technical Aspects Summary

Table 28 presents a summary of the Other Technical Aspects values associated with the TCRB Large Grading Alternative that were input to the MAA Model for final scoring.

Table 28. TCRB Large Grading Alternative Other Technical Aspects Summary

Other Technical Aspects Summary				
Average Annual Recharge Rate (MGD)	Santa Ana River Contribution (cfs)	Proximity to Groundwater Pressure Zone (yds)	Access to SWP Supply	Groundwater Mounding
1.9 MGD	2.1 cfs	5,150 yds	Indirect	No

5.5 Social Aspects

5.5.1 Job Creation

The projected construction employment in FTE equates to **190 full-time jobs for one year**. The total employment forecast for O&M of the TCRB Large Grading Alternative is **0.03 FTE** on a perpetual basis.

5.5.2 Ponded Water Depth

The TCRB Large Grading Alternative ponded water depth is **3 feet**. One social aspect that will be taken into consideration is prevention of drowning. Experience at SBVWCD basins demonstrates that water basins will attract unhoused individuals or passersby in hot weather to enter the basin. Access control will be a key consideration in design. Additionally, graded slopes for easy ingress and egress may reduce drowning and other safety hazards from sloped ground.

5.5.3 Social Aspects Summary

Table 29 presents the Social Aspects values associated with the TCRB Large Grading Alternative that were input to the MAA Model for final scoring.

Table 29. TCRB Large Grading Alternative Social Aspects Summary

Social Aspects Summary		
Construction Jobs (FTE/time period)	O&M Jobs (FTE)	Ponded Water Depth (ft)
190 /12 months	0.03	3

5.6 Legal Aspects

5.6.1 Permitting Analysis

A brief review of the potential permit needs and issues for the TCRB Large Grading Alternative is provided in **Table 30** below.

Table 30. Review of Potential Permit Requirements for TCRB Large Grading Alternative

Potential Permit	Preliminary Review Determination
CEQA	The project is addressed under the programmatic EIR under development for the Upper Santa Ana River HCP. It is anticipated that a full project-specific EIR would be necessary but aided by the Programmatic EIR.
USFWS	Addressed under the Upper Santa Ana River HCP.
CDFW CESA 2081	Addressed under the Upper Santa Ana River HCP.
CDFW LSA /1600	Addressed under the Upper Santa Ana River HCP.
USACE 401/ RWQCB	Addressed under the Upper Santa Ana River HCP.
USACE 404	Required due to alteration of the watercourse.
USACE 408	USACE 408 permit will be required, as the grading work is near flood control levees. Obtaining this permit may take more than a year based on typical timeframe of response on a 408-permit filing. Depending on a future evaluation of a FEMA hydrograph and/or a USACE SPF Hydrograph, the project may require further work. The

Potential Permit	Preliminary Review Determination
	estimate made for this feasibility study is that the accreditation will not be in jeopardy, and a 408 permit can readily be obtained since the flood control features themselves are not being altered.
CA DOSD Jurisdictional Dam	TCRB berms are not jurisdictional dams due to their respective sizes, and due to their location within a flood control levee.
SBCFCD	The TCRB Large Grading Alternative would require a permit from SBCFCD. It would qualify as a "major construction permit" because segments of the flood watercourse will be inoperable for a lengthy period.

At this preliminary stage, no design considerations appear to be needed to provide for habitat impacts in the project footprint. The TCRB Large Grading Alternative does not utilize any new land area. Final design may need to consider measures to mitigate against creating habitat within the project that would foster intrusive species of flora and fauna, but little to no free water is forecast to be at the surface given the high infiltration-rate capacity estimated by the hydraulic modeling.

The TCRB footprint is outside the Federal Aviation Administration (FAA) secondary buffer zone of 10,000 feet, Perimeter B, from San Bernardino International Airport (FAA, 2020). The FAA has specific design and permitting review for water holds that could provide nesting habitat for waterfowl (a flight safety hazard). The TCRB are, however, within the FAA Perimeter C requirements area of 5-miles for the San Bernardino International Airport; Perimeter C triggers notification recommendations for the project proponents to the San Bernardino Airport operators. This buffer zone of 5-miles is intended to trigger the airport operators to evaluate potential management actions.

5.6.2 Land Availability

This land is NOT currently owned by a partner agency.

5.6.3 Support for Claimed Water Rights

The support for new Water Rights not yet perfected is equated to the maximum diversion rate to groundwater recharge, estimated at **54.53 cfs**. The annual yield could be as high as 6,395 AF in a very-wet water year.

5.6.4 Legal Aspects Summary

Table 31 presents the Legal Aspects values associated with the OCRB Construction Alternative that were input to the MAA Model for final scoring.

Table 31. OCRB Construction Alternative Legal Aspects Summary

Legal Aspects Summary		
CEQA/Permits Required	Land Availability	Support for Claimed Water Rights (cfs)
See Table 30	No	54.53

5.7 Summary Results

The PERC Comprehensive Feasibility Study looked at each Project Alternative's characteristics and viability over the following key considerations:

- **Groundwater Recharge Benefits**: How much water will be captured and stored as groundwater by the project each year? Over the next 50 years?
- **Cost Aspects:** Do the economics indicate the project's financial viability, including costs, benefits, and projected return on investment?
- **Technical Aspects:** Are the necessary technology, resources, and expertise available and sufficient to implement the project?
- **Social Aspects:** How well does the project align with the available human resources and how well can it align with existing operations?
- **Legal Aspects:** Are there legal or regulatory requirements that could impact the project?

In some respects, this amounts to a discovery process to identify whether any proposed project has fatal flaws that prevent its execution. The TCRB Large Grading Alternative **does not have any apparent fatal flaws**, albeit the hydraulic modeling of low-frequency storms could necessitate a Conditional Letter of Map Revision (CLOMR) analysis and revision by the USACE. If a CLOMR is not likely to be possible, then this project would become fatally flawed. This is not considered to be a likely outcome, given that levee freeboard was maintained in the hydraulic modeling using the more extreme SBCFCD AES hydrograph. More information can and would be developed for the TCRB Large Grading Alternative if it is taken forward as a PERC Project for permitting, design, and construction. Operationally, the TCRB Large Grading Alternative is judged to be a **good fit** to the dual objectives in a SBCFCD flood control facility; flood control functionality is fully maintained, and groundwater recharge is enhanced.

5.7.1 MAA Indicator Values

PERC and its regional partners executed an integrated multiple accounts analysis (MAA) by assessing their key considerations and weighting them. The MAA developed for PERC as a comprehensive analytical tool and the weighted scoring method are described in Volume 1. **Table 32** shows the MAA Indicators and their respective TCRB Large Grading Alternative Values.

Table 32. TCRB Large Grading Alternative MAA Indicator Values

<table>
<tr><th>Account</th><th>Subaccounts</th><th>Indicators</th><th>TCRB Large Grading Alternative Values</th></tr>
<tr><td rowspan="5">Groundwater Recharge Benefits</td><td>Groundwater Recharge-Benefit (Net AFY)</td><td>AFY</td><td>1,900</td></tr>
<tr><td rowspan="3">Infiltration-rate-capacity increase (cfs)</td><td>Net Increase in Infiltration Rate Capacity (cfs)</td><td>54.53</td></tr>
<tr><td>Ease of Maintenance (FTE)</td><td>0.05</td></tr>
<tr><td>Timeline to Implement (years)</td><td>16.30</td></tr>
<tr><td>Recharge benefit on a “firm yield” 50-year horizon (AF)</td><td>AF</td><td>67,914</td></tr>
<tr><td rowspan="3">Cost Aspects</td><td rowspan="2">Capital Costs</td><td>Capital Costs NPV</td><td>$57,834,000</td></tr>
<tr><td>Grant Sources</td><td>0%</td></tr>
<tr><td>O&M</td><td>O&M in 2025 $</td><td>$27,621</td></tr>
<tr><td rowspan="6">Other Technical Aspects</td><td>Groundwater Quality Improvements (Salt & Nutrient Management Planning)</td><td>Volume of Annual Recharge (MGD)</td><td>1.9</td></tr>
<tr><td rowspan="3">Conservation and Habitat Benefits</td><td>Santa Ana River Contribution</td><td>2.10</td></tr>
<tr><td>Habitat Restoration</td><td>0.00</td></tr>
<tr><td>Species/ Habitat Impacts</td><td>0.00</td></tr>
<tr><td>Proximity to Groundwater Pressure Zone</td><td>Distance to Pressure Zone (yds)</td><td>5,150</td></tr>
<tr><td>Access to State Water Project Supply</td><td>Direct, Indirect or No Access</td><td>Indirect</td></tr>
</table>

Account	Subaccounts	Indicators	TCRB Large Grading Alternative Values
	Groundwater Mounding	Rate Limiting Mounding *(Liquefaction Issue)*	No
Social Aspects	Project Job Creation	Number of Jobs Forecast for Construction	190.0
		Number of Jobs Forecast from Operational Needs	0.03
	Public Safety Hazards of Project	Ponded Water Depth (ft)	3
Legal Aspects	CEQA	CEQA Filing Type (e.g., NOE)	EIR
	Permits Required/ Requirements	USFWS Permit Requirements	River-HCP
		CDFW CESA 2081 Permit Requirements	River-HCP
		CDFW LSA /1600 Permit Requirement	River-HCP
		USACE/RWQCB 401 Permit Required	River-HCP
		USACE 404 Permit Required	Typical
		USACE 408 Permit Required	Very-Time-Consuming
		CA DOSD Jurisdictional Dam	None-Required
		City of San Bernardino Consent Decree Area Permit	None-Required
		SBCFCD	Barriers
	Land Availability	Property Ownership by Partner Agencies (Y/N)	N

Account	Subaccounts	Indicators	TCRB Large Grading Alternative Values
	Water Rights	Support for utilization of water rights not yet Licensed	54.53

5.7.2 Score and Rank

The MAA Summary Scoring prioritizes the TCRB Large Grading Alternative very low, with a **10th priority** ranking (out of 10), when taking into consideration the stakeholder-developed characteristics, criteria, and their weighted importance in meeting regional goals. The TCRB Large Grading Alternative has the **lowest overall score in the MAA**. It is a feasible and viable project but does not warrant near-term prioritization for applying human resources, financial resources, and political capital.

The summary scoring under the MAA for the TCRB Large Grading Alternative is shown in **Table 33**.

Table 33. TCRB Large Grading Alternative MAA Scoring Summary

Account	TCRB Large Grading Alternative MAA Summary Score
Groundwater Recharge Benefits	1.57
Cost Aspects	0.86
Other Technical Aspects	0.51
Social Aspects	0.25
Legal Aspects	0.28
Total	**3.46**
Priority Rank	**10th**

Lynwood Recharge Basins Alternative

1 Executive Summary

Lynwood Operational Alternative Scores and Rank

Consideration (MAA Account)	Score
Groundwater Recharge Benefits	1.49
Cost Aspects	1.48
Other Technical Aspects	0.48
Social Aspects	0.12
Legal Aspects	0.55
Total Score	4.12
Rank (of 10)	**4th**

The **Lynwood Recharge Basins PERC Project Operational Alternative** (Lynwood Operational Alternative) modifies existing facilities owned and operated by SBCFCD to automate control of storm water detention and release.

The Lynwood Operational Alternative is estimated to provide 687 AFY of recharge. It is estimated to provide 23.4 cfs in infiltration-rate capacity. For the 50-year planning horizon, the Lynwood Operational Alternative's 48.75-year period of operation would provide 33,850 AF of groundwater recharge as forecast "firm yield."

The Lynwood Operational Alternative is estimated to be able to be constructed in about 15 months. With a project decision start date of July 1, 2025, this means its projected operations are rated from October 1, 2026, to the end of the 50-year project planning horizon, December 31, 2075.

The projected capital cost in present value is $2,303,000. Annual O&M Cost is estimated to be $47,500 in 2025 USD.

Lynwood Operational Alternative ranked as the 4th highest priority project when taking under consideration the partner-developed characteristics, criteria, and their weighted importance in meeting regional goals. It is a feasible and viable project that likely warrants near term prioritization for applying human resources, financial resources, and political capital.

2 Introduction

The objective for the Lynwood Operational Alternative is to leverage existing infrastructure to increase the amount of recharge from the East Twin Creek watershed. A secondary objective is to enable evaluation of whether engineered groundwater recharge closer to the Pressure Zone can slow or stop the decline in the groundwater level within the Pressure Zone.

In this document, the **Lynwood Operational Alternative** is evaluated based on the five aspects identified by SBVWCD and project partners as important and relevant to ranking PERC Project Alternatives, which are:

- Groundwater Recharge Benefits
- Cost Aspects
- Other Technical Aspects
- Social Aspects
- Legal Aspects

A complete description of these aspects, their respective components, and the ranking methodology for PERC Project Alternatives is provided in **Volume 1**.

Sections 3 through 5 below provide information specific to the Lynwood Operational Alternative, including the following:

- **Section 3–Site and Features**: Descriptions of the Alternative's site location, existing facilities, geologic setting, and surrounding watershed.
- **Section 4–Design and Analysis**: Descriptions of the Alternative's water sources, proposed design, and characteristics as they align with the five aspects (listed above).
- **Section 5–Summary Results**: Tables presenting the Alternative's scores and rank.

3 Site and Features

The Lynwood Recharge Basins are in a densely populated urban area near Lynwood Drive and Harrison Street in the City of San Bernardino.

The Lynwood Recharge Basins full surface area is 34 acres. The area is situated within a large number of tax lots owned separately by either San Bernardino County or City of San Bernardino. Each basin is surrounded by earthen graded berms.

3.1 Existing Facilities

There are four Basins, numbered north to south, divided by Interstate 210 between Basins No. 2 and 3, as shown on **Figure 11.**

Figure 11. Lynwood Operational Alternative Overview

The Lynwood Recharge Basins have three primary water sources:

1. **East Twin Creek** can provide water into the Lynwood Recharge Basins via a "drain gate" built into the system of flood levees constructed system in 1961 by USACE (USACE, 1960).
2. **Stormwater runoff** from the nearby urban areas is conveyed by the City of San Bernardino and CalTrans stormwater systems into the Lynwood Recharge Basins.
3. **Surface water** from a mountain foothill area naturally collects from the Lynwood Recharge Basins Drainage Area (Figure 4).

The Lynwood Recharge Basins as currently configured and operated are principally fed by urban storm water runoff.

- Lynwood Basin No. 1 receives inflow from the Lynwood Recharge Basins Drainage Area during rainfall events with its outlet gate closed to rely upon an emergency spillway to the west (Figure 11) into the RC Channel for East Twin Creek.
- Lynwood Basin Nos. 2 and 3 appear to receive stormwater runoff from the adjacent sections of Interstate 210; outflows are regulated by the height of existing drop inlets with the outflow from Basin No. 3 providing the inflow to Basin No. 4.
- Basin No. 4 has a drop inlet along with a drain gate to enable stormwater to exit to the RC Channel.

Figure 11 illustrates the water hold with the drop inlets in service in Basin Nos. 2, 3, and 4 and their respective drain gates in the closed position.

The Lynwood Recharge Basins were built by SBCFCD in August 1961 (SBCFCD, 1961) next to and interconnected to the East Twin Creek flood levee system. USACE incorporated a drain gate (USACE, 1961) at the lowest point inside the levees that may be opened to divert East Twin Creek storm flows into a 48-inch diameter concrete pipe that leads to Lynwood Basin No. 1. This drainage out of East Twin Creek and the TCRB is integral to the Lynwood Operational Alternative because it enables excess water from East Twin Creek post storm surge to be diverted into the Lynwood Recharge Basins for groundwater recharge.

The Lynwood Recharge Basins and slide gates were historically used to manage the stormwater runoff from the urbanized area. The uppermost basin, Basin No. 1, has a concrete spillway on its western edge, leading into the RC Channel.[6] When the slide gate at the bottom of Basin No. 1 is closed, then stormwater collects until it reaches the top of the spillway and the excess storm water safely overflows into the RC Channel. Figure 11 depicts

[6] RC Channel was built by USACE in 1960 to contain East Twin Creek outflows from the Twin Creek Spreading Grounds and other urban drainage.

this existing spillway, which requires no modification for the Lynwood Operational Alternative.

During rainy days, per the SBCFCD O&M Manual (Tetra Tech, 2014), the slidegate out of Basin No. 1 is to remain closed when the National Weather Service forecasts rainfall in the area of ***more than 0.3-inches/hour*** or a total of ***more than 2-inches in a 24-hour period***. Similarly, the drain gate in the Twin Creek levees must remain closed for this same forecast rainfall to prevent a storm surge of water in the larger system from entering the much smaller Lynwood Recharge Basins system.

During non-rainy days, each of the four internal slidegates to Basin Nos. 1 through 4 can be open and have been documented in that position in Appendix D. Similarly, the drain gate out of East Twin Creek's leveed area can be open to remove potential nuisance water and sustain flood detention capacity within the leveed area ahead of a subsequent stormflow; however, it is currently buried in sand (see photo, Appendix D) and presumably will operate as designed if excavated. When these slide gates are all open, baseflows in East Twin Creek will exit the levee-controlled area and flow through each Lynwood Recharge Basin, from north to south, and reach the 36-inch outlet to the RC Channel from Basin No. 4 as depicted in Figure 11. This, however, is <u>not</u> the Lynwood Operational Alternative planned configuration for slidegates at Basin Nos. 2, 3, and 4.

Basin Nos. 2, 3, and 4 have existing drop inlet structures at various elevations which will be retained for the Lynwood Operational Alternative. The drop inlet structures are vertical openings designed to detain water up to a fixed elevation. Once the water exceeds that elevation, it flows into the drop inlet that connects to a water-routing outlet.

Lynwood Basin No. 4 has a unique drop-inlet structure that is rectangular concrete column measuring 7.5 feet tall with an opening of 3-feet long by 6-feet wide. The drop inlet has a 36-inch diameter culvert connected to a 36-inch CMP outlet to the RC Channel. When the slidegate on the upstream side of this rectangular drop inlet is closed, water in Basin No. 4 will collect to a depth of 7.5 feet and spread across the basin over the area outlined in Figure 11 while maintaining 5.5 feet of freeboard.

Lynwood Basin Nos. 2 and 3 were revised in 1975 by SBCFCD to add drop inlet structures at the downstream ends. These drop inlets may be used to regulate the storage of water for infiltration. Closure of the slide gates allows stormwater to infiltrate and to be retained to the height of the wingwalls of the drop inlet. Water entering these drop inlets is directed through dual 36-inch-diamter RCP culverts, one set from Basin No. 2 to Basin No. 3, and another set from Basin No. 3 into Basin No. 4 (SBCFCD, 1975).

Below is a construction history of the drop inlet structures at Lynwood Basin Nos. 2 and 3:

- The two open dual-pipe systems appear to have been built during the construction of Interstate 210 (circa 1967) since they are not found for construction in 1961 but are found as an existing condition in SBCFCD's 1975 As-Built drawings.
- In 1975, SBCFCD built smaller slide gates affixing them to new front walls 9.7-feet tall and attaching those front walls to the existing wing walls off the headwall for the dual-pipe outflow culverts.
- The 1975 design, which is the current existing condition, enables a very high flow rate of water into either of these two basins to be regulated by detention of water up to the height of the wing walls, thereby creating the drop inlet at the downstream end of each basin.
- In 1975, the existing wing wall tops were rounded to crests and joined to the new front wall at a height of 7.3 feet, leaving 2.4 feet of freeboard to the top of these front walls.
- Further, the 1975 construction also extended the walk ways to their current positions in order that they hold these newer slide gates.

Currently, if the slide gates in Basin Nos. 2 and 3 are closed, then water is retained to the elevation of the wing walls, enabling greater spreading and infiltration. The water elevations for the current drop inlets in Basin Nos. 2 and 3 as surveyed (Appendix B, Exhibit B, Sheets 11 and 12) provide over 5.5 feet of freeboard on the surrounding basin berms.

During operation, when stormwater flow rates exceed the infiltration-rate capacity of each basin, excess water would cascade into the drop inlet and outflow to the next downstream basin.

Lynwood Basin No. 1 does not have a drop inlet. Therefore, the Lynwood Operational Alternative requires the Basin 1 slide gate to be open, allowing non-peak or non-critical rate flows to enter the downstream basins. Basin No. 1 has a single slide gate over a 48-inch diameter RCP outflow culvert. Thus, it is either open to allow all flow downstream to other basins for infiltration (recommended), or it holds water up to the elevation of the overflow spillway. Basin No. 1 has a low infiltration rate and small volume water detention hold. Basin No. 1 with its slidegate closed over its 48-inch culvert during rainfall events is not considered a component of the Lynwood Operational Alternative. Instead, the Basin 1 slidegate remaining closed is a safety operational requirement for flood control per the SBCFCD Operations Manual for the Lynwood Basins (HDR, 2013).

3.2 Site Assessment

Preliminary site assessment at Lynwood Recharge Basins included topographic survey, a site walk, and records review.

3.2.1 Topographic Survey

The topographic survey was conducted by Tetra Tech and their survey contractor and is provided in Appendix A, Exhibit A (TetraTech, 2025). Full survey details are provided in Appendix B, Exhibit B. The field survey of existing facilities was not fully completed in Lynwood Basin Nos. 3 and 4 due to worker safety concerns from encampments of unhoused people.

3.2.2 Site Walk

The site walk survey by SBVWCD staff on November 20, 2024, found all existing site facilities in relatively good condition with all berms intact and surrounding fences with functional gates. Relevant site photos of infrastructure are provided in Appendix C. As noted previously, the TCRB Drain Gate is buried in sediment. Similarly, the culvert from Basin No. 1 to Basin No. 2 is filled with sediment but still allows flow. Basin maintenance actions by SBCFCD in spring of 2024 removed nuisance growth and left a well-graded and clean sedimentary surface.

3.2.3 Records Review

The records review of SBCFCD and USACE filings found:

- **Berms around Basin No. 1** are listed as non-accredited levees controlling only flow into and out of Basin No. 1, principally into the accredited flood levees for Twin Creek and its improved channel (SBCFCD, 2023b).
- **Berms around Basin Nos. 2, 3, and 4** are qualified as embankments and not as flood-control levees.

File review noted that USACE found their accredited levees to be in good working condition during their last assessments in 2016 (western Twin Creek levee) and 2019 (eastern Twin Creek levee) with related information updated by USACE in October 2024 to the National Levee Database.

3.3 Geotechnical Assessment and Analysis

The surficial geology of the Lynwood Recharge Basins is depicted in Figure 3, showing Lynwood Recharge Basins as undifferentiated young "wash" deposits. This means that they are either in the general pathway of the watercourse or are on a surface of an alluvial fan that has recently been reworked by water. The sedimentary deposits beneath the Lynwood Recharge Basins are routinely subjected to flushing flows that reset the water channel or regrade the area, as compared to alluvial fan deposition, which would mean growing in depth locally at a more gradual rate. Overall, the sedimentary deposits would be expected to be relatively coarse-grained.

The on-site assessment found that repurposing existing site facilities toward groundwater recharge could constitute a PERC Project Alternative by the following:

- Operating existing facilities and diverting native flows out of East Twin Creek to Lynwood Recharge Basins for recharge
- Maintaining Lynwood Recharge Basins for infiltration rate

The SBVWCD engineering consulting team performed geotechnical testing and assessment of the Lynwood Recharge Basins (Appendix B, Attachment II). Note that there are no accredited flood-control levees (i.e., berms or non-flood levees) within the Lynwood Recharge Basin system and thus there are no flood-conditions concerns for the inter-basin system. During flood conditions, the slidegate outlet from Lynwood Basin No. 1 is closed per SBCFCD's Operations and Maintenance Manual (Tetra Tech, 2014) and peak stormflow exits via the overflow spillway into the RC Channel for East Twin Creek.

Tetra Tech performed subsurface testing for infiltration properties of the near-surface sediments in Lynwood Recharge Basins in November 2022, prior to the first of many rainfall events in that water year. One of the noteworthy findings was saturated ground in Basin No. 2. Infiltration testing using a static water level at ground surface recorded no water movement because there was no hydraulic gradient. The infiltration properties tested in the field and in the lab were consistent with the other areas tested in the young wash deposits recorded on the geologic mapping and observed in the excavated test pits in Lynwood Recharge Basins.

4 Design and Analysis

The Lynwood Operational Alternative was developed with the understanding that SBCFCD's Operations and Maintenance Manual (Tetra Tech, 2014) requires peak stormflows to be bypassed for flood safety reasons. Therefore, the Lynwood Operational Alternative requires an alternative source of water for recharge, such as non-stormflow or post-peak stormflows. The identification of FIRO water as a possible source provides additional project yield but necessitates measurement of the bypassed flow to understand the energy cost to bring FIRO water from the Santa Ana River Wash facilities and lift it to the existing outlet from the Foothill Pipeline into Waterman Recharge Basin 2W.

SBVWCD reviewed the Lynwood Recharge Basins system design and determined that an operational program of opening and closing select slide gates can generate recharge without affecting flood control and stormwater management functions.

4.1 Proposed Design

The objective for the Lynwood Operational Alternative is to leverage existing infrastructure to increase the amount of recharge from the East Twin Creek watershed. A secondary objective is to enable evaluation of whether engineered groundwater recharge closer to the Pressure Zone can slow or stop the decline in the groundwater level within the Pressure Zone.

Two grading modifications are required for the Lynwood Operational Alternative:

1. **Grade above the East Twin Creek flood levee drain-gate:** Drain gate operation requires excavation and grading of the surrounding area to the base of the gate's structural wing walls. The existing trash rack will be removed and replaced with a proximate trash rack to provide access for a mechanical excavator to regrade the entry area regularly. Redeposition of sediment in front of the drain gate from peak stormflow events will likely require routine excavation to maintain gate function.

2. **Raise the invert elevation of the drop inlets at Basin Nos. 2 and 3:** The existing wing walls adjoining the backwall housing dual-pipe culverts in each basin would be raised 2.4 feet to match the invert elevation of the backwall and front-wall. New concrete would be integrated into the wingwalls and to both the front-wall and backwall to create a taller trapezoidal drop inlet than exists currently. During design development, these proposed invert elevations for the wingwalls to match the existing front-wall and backwall were found to maintain freeboard of 3-feet or more from current top of berm in each basin. This meets typical water hold berm design and operation general requirements. Thus, no regrading of the berm heights was found to be necessary during conceptual design development for the alternative.

The preliminary design details for the Lynwood Operational Alternative are provided in Appendix B, Attachment IE.

The **footprint** of the four existing Lynwood Recharge Basins is approximately 30.5 acres. No revisions of the overall basin footprints are envisioned in the preliminary conceptual design. The wetted area footprint during operation of the alternative is approximately 11.3 acres

The **water volume** in detention during operation would be 34 AF.

- The maximum water depths in each of the three water holds (Basin Nos. 2, 3, and 4) will be at the slide gates for each, ranging from 10 to 12 feet deep.
- The average depth of water is approximately 3 feet over the detention hold pond.

The primary **water inflow** features are the existing 48-inch stormwater culvert with slide gate at the downstream end of the Twin Creek Recharge Basins and the existing 48-inch stormwater culvert at Basin No. 1 with slide gate. The following inflow modifications are planned:

- Addition of **automated motorized operation** of the existing slide gates controlling flow into each of these two outflow culverts that exhaust into the Lynwood Recharge Basins.

- Addition of **acoustic flow meters**, suspended from secure housing designed to prevent public access and vandalism, to meter inflows; first to Lynwood Basin No. 1 and then into the active recharge basins, Nos. 2, 3, and 4.

No metering of Lynwood Recharge Basins Drainage Area flows out the overflow spillway for Lynwood Basin No. 1 is planned because these flows are not quantified for engineered recharge since the slide gate at the downstream end of Lynwood Basin No. 1 would be opened after the storm surge the period of water available for recharge and volume is inconsequential.

The **water outflow** feature is the existing 36-inch CMP culvert from the drop inlet in Basin No. 4 that exhausts water into the RC Channel as shown in Figure 11. The conceptual design plan sheets by SBVWCD are provided in Appendix B, Attachment 1E. In the conceptual design there are no revisions to the water outflow from Basin No. 4. Bypassed flows from the TCRB during and after a rainfall event will be quantified. The following outlflow modification is proposed for the top of the eastern levee (SBCFCD ID 2-408-5B):

- Addition of a **light-pole style stanchion** on the east bank flood-control levee over the entry point to the RC channel to measure bypassed flows that continue from East Twin Creek into the RC Channel (Appendix B, Attachment 1E).

4.1.1 Geotechnical Considerations on Project Design and Operations

The geotechnical engineering assessment of soils and sediments for their lithology and engineering properties (Appendix B, Attachment II) recommends the following (TetraTech, 2025):

- Slope of 3(H):1(V) for stability of earthen berms.
- Hydraulic slope across the berms not exceeding 75% for long periods of time (e.g., greater than 1 month) to avoid soil instability.
- During long-term infiltration periods, the maximum differential water elevation between adjacent basins should be maintained at no greater than 45% of the downstream slope height of the inter-basin berm.
    - This latter criterion can be met from the existing berm grades coupled with the respective water surface hold elevations proposed for the drop inlet structures in the preliminary conceptual design.

4.1.2 Project Operations

Operations do not alter flood protection from the Lynwood Recharge Basins. Throughout the year the manually operated slidegates in Basin Nos. 2, 3, and 4 are closed, which has no effect on flood protection. These gates would only be opened as drain gates to completely evacuate the basin of water for cleaning.

Project operations could occur at virtually any time of year depending on flood considerations and SBCFCD requirements. During the winter rainy season PTH flows would be an expected part of the operations.

During winter rains, as a large storm event approaches, the slide gates over the two inflow culverts would be closed per facility SBCFCD O&M Manuals (TetraTech, 2014 and HDR, 2013) until the rain has stopped or the peak hydrograph has passed. Each slide gate would then be opened via automation and monitored based on data from the flow meter on the bypass RC Channel out of TCRB and on the respective flow meters for each inflow culvert.

Project operations for FIRO water rely upon releases to the Waterman Recharge Basins. FIRO releases may be limited to non-storm periods or the dry season, depending on SBCFCD requirements or the operational flexibility available at Waterman Recharge Basins to enable pre-storm evacuation of water from those basins.

4.1.3 Timeline

As described in Volume 1, the timeline for project alternatives is calculated by estimating the time to design, permit, fund, and construct a project. Volume 1 includes a summary of these estimates alongside those for the other PERC Project Alternatives. Each time factor is described below for the Lynwood Operational Alternative.

- **Design Time**: Design of the Lynwood Operational Alternative to the 65+% level required for permitting consideration is estimated to take **3 months**.
- **Permit Time**: The permit time forecast for Lynwood Operational Alternative is **36 months**. This is controlled by the expectation that a USACE 408 Permit will take only one year given the limited nature of the work being conducted. All other permit requirements are expected to be accomplished within that same overlapping one-year period. This is based on the preceding discussion, SBVWCD and SBVMWD experience, and programmatic expertise.
- **Funding Time**: The time forecast from project decision-making to having a capital funding plan in place is estimated to be zero months. The funding timeline then is the sum of Design and Permit Time, **18 months**. The timing of project funding then is **July 1, 2027**. This is the timeline used to generate a net present value factor for capital funding needs.
- **Construction Time**: The construction period includes the time needed to take project designs into biddable specifications and contract documents, conduct a public bidding process for contractor selection, the project construction period, and project works commissioning. For the Lynwood Operational Alternative, this construction period is estimated to require **6 months**.

The project operational period is estimated to be **October 1, 2026, to December 31, 2075**. The project O&M Costs are estimated over this period. Estimated groundwater recharge yield is predicated on a 48-year operating period.

4.2 Watershed Hydrology

Baseline hydrology modeling for the Lynwood Recharge Basins Drainage Area was performed to quantify the volumes of water available in certain return frequency storm events and to define those. SBCFCD provided SBVWCD with a low-frequency flood hydrograph (i.e., 100-year return frequency hydrograph or Q100) to use in the development of flood modeling for flows into the Lynwood Recharge Basins. PERC consultants used these hydrographs to generate USACE Standard Project Flood (SPF) and FEMA flood flow hydrographs (Tetra Tech, 2023; attached as Appendix F).

SBCFCD's AES-simulation software used for rating stormwater runoff indicated a 340-acre area that was rated for stormwater flow at higher frequencies. SBCFCD generated AES hydrographs for 2-year, 5-year, 10- year, and 25-year return frequency events in this area.

The full drainage area into the Lynwood Recharge Basins is approximately 700 acres. Scaling the Lynwood Recharge Basins Drainage Area to the 5,800-acre drainage area of East Twin Creek's watershed above the USGS gage finds that Lynwood Recharge Basins is 12.2% of that area. A similar scaled comparison of peak flows in a Q100 flood flow in the Lynwood Recharge Basins Drainage Area to East Twin Creek finds that it is 6.5% (**Table 34**).

Table 34. Watershed Evaluations for SBCFCD Facilities along the East Twin Creek Waterway

Watershed	SBCFCD Q100 (cfs)	Peak Flow Ratio to East Twin Creek	Watershed Area (Acres)	Watershed Area Ratio to East Twin Creek
Brush Canyon	779	8.9%	219	3.8%
Waterman Canyon	5,185	59.2%	3,366	57.9%
East Twin Creek Canyon above Waterman Creek	8,758	100.0%	5,811	100.0%
Harrison Canyon	697	8.0%	377	6.5%
Lynwood Recharge Basins Drainage Area	584	6.7%	707	12.2%

Comparison of area ratios to peak flow ratios suggests that the estimated stormflows and the hydrology for the Lynwood Recharge Basins are reasonably representative. Since the Lynwood Recharge Basins Drainage Area is at a lower elevation (i.e., less rainfall in the same storm) and has a lower drainage slope, it is expected to produce a lower flow rate than a simple scaled comparison of area size.

4.3 Water Source Hydrology

The project hydrology for groundwater recharge in the Lynwood Recharge Basins is post peak storm flow water that can be diverted out of East Twin Creek. This diversion would be done using the existing drain gate from the levee-controlled area of the TCRB.

The Lynwood Operational Alternative hydrology and groundwater recharge yield is premised upon the volume and frequency of East Twin Creek stormwater hydrographs, and not upon the volume and frequency of stormwater runoff from the Lynwood Recharge Basins Drainage Area. Thus, the PERC project hydrology for the Lynwood Operational Alternative does not follow the preliminary project hydrology identified in Appendix B, Attachment IV (Tetra Tech, 2023b). That study premised a PTH for the Lynwood Recharge Basins using a hydrograph modeled and scaled to the runoff from East Twin Creek. However, in that type of storm event, the slidegate at Basin No. 1 is closed per the current Lynwood Basins Operation and Maintenance Manual (HDR, 2013) and no meaningful quantity of groundwater recharge occurs.

There are two hydrographs that have been employed to evaluate and estimate the probable groundwater recharge yield of the Lynwood Operational Alternative:

- **Condition 1:** Analyzes the PTH for East Twin Creek when the drain gate, by rule, is closed during intense rainfall and then after 24-hours is opened to allow entry flow. Because the peak storm has passed, this time period is in the tailing leg of the hydrograph entering into the Lynwood Recharge Basins for recharge (i.e., slide gates at Basin Nos. 2, 3, and 4 are closed and flow through is via the drop inlets). This condition provides a flow of water for approximately <u>six days</u>. As mentioned previously, East Twin Creek flow events such as this occur approximately <u>two times per year</u>.

- **Condition 2:** Condition 2 analyzes a FIRO flow operated at Lynwood Recharge Basins in conjunction with Waterman Recharge Basins. As described in the Waterman PERC Alternative, FIRO water can be delivered into the west side of Waterman Recharge Basin 2W, using existing infrastructure, where it is combined with native runoff from Waterman Canyon's typical March flow. For the Lynwood Operational Alternative:
    - Excess FIRO water plus Waterman native flow would outflow from Waterman Recharge Basins (in their Existing Conditions) into the Twin Creek Recharge Basins (in their Existing Conditions) in a typical March.
    - Water <u>*not infiltrated*</u> in Twin Creek Recharge Basins will enter Lynwood Recharge Basins via its drain gate.

  This is a relatively flat hydrograph of approximately 77 cfs. During a FIRO-flow event, the Lynwood Basin No. 1 slide gate is open for inflow and the interior gates are closed to regulate outflow to the drop invert elevations. The FIRO hydrology continues for 52 days with an added 8-day period for the baseflow in East Twin Creek to recede.

4.4 Groundwater Recharge Benefits

Hydraulic modeling for the PERC project flows are provided in a Technical Memorandum included in Appendix B as Attachment V (Alden 2025b). In summary, the hydraulic modeling results showed:

- The PTH hydrograph provides a sudden short flow of water for approximately two days after a 1-day storm. The peak flow rate is on the order of 65 cfs but drops to 15 cfs nine hours later. PTH flows out of East Twin Creek produce an estimated 34 AF of recharge per event.
- The relatively flat FIRO-hydrograph of 77 cfs continues for 52 days. The per-event recharge volume for FIRO is much higher than PTH inflows at ~2,300 AF of recharge per event.

The model results were used to determine the Waterman Grading Alternative's annual average recharge, infiltration rate capacity, and firm yield over the 50-year PERC planning horizon.

4.4.1 Annual Average Recharge

A PTH flow event in East Twin Creek occurs slightly more than two times per year. With a recharge yield of ~34 AF of recharge, this results in an estimated annual average yield of 70 AFY from native PTH storms.

FIRO-sourced Santa Ana River water flows are projected to be available approximately one in four years. While the per-event volume for FIRO is much higher at ~2,300 AF, the lower frequency return for FIRO-sourced water from the Santa Ana River reduces the estimated annual-average groundwater recharge yield to 615 AFY.

The net groundwater recharge benefit available on an annual basis is estimated to be the sum of the two hydrologic sources of water, **totaling ~687 AFY**. The existing Lynwood Recharge Basins configuration is estimated to produce no groundwater recharge on an annual basis.

4.4.2 Infiltration-Rate Capacity

The Lynwood Recharge Basins infiltration rate capacity is all net from a current capacity of zero. Hydraulic modeling identifies that at basin full conditions the net infiltration-rate capacity is **23.42 cfs**.

4.4.3 Firm Yield Over Planning Horizon

The Lynwood Operational Alternative has the longest period of operation in the 50-year planning horizon (July 1, 2033 to December 31, 2075) of any of the alternatives at 49.2 years. Based on the average annual yield, the rated firm yield of engineered recharge over the PERC Feasibility Study's planning horizon equals **33,847 AF**.

4.4.4 Groundwater Recharge Benefits Summary

Below are the Groundwater Recharge Benefits values associated with the Lynwood Operational Alternative that were input to the MAA Model for final scoring.

Table 35. Lynwood Operational Alternative Groundwater Recharge Benefits Summary

Groundwater Recharge Benefits Summary		
Annual Average New Recharge (AFY)	Infiltration Rate Capacity Increase (cfs)	Firm Yield over 50-Year Planning Horizon (AF)
687 AFY	23.42 cfs	33,847 AF

4.5 Cost Aspects

4.5.1 Capital Costs

The estimated capital costs are detailed in Appendix B, Attachment VIII and total $2,380,000 on a 2025 basis. The timing of the project as noted above for yield is forecast as **October 1, 2026, to December 31, 2075.** The discount factor used for capital is 4% with an expectation that the cost of money is 7% and inflation is 3%. A general contingency of 30-percent was added to each alternative. The Present Value of the capital equates to **$2,303,000**.

4.5.2 Operations & Maintenance Costs

Lynwood Basin maintenance would principally be siltation management to limit basin clogging. Using data from the Preliminary Design Report on sediment transport, it is estimated that a modest 50 cubic yards/year of sediment loading would occur. This limited amount of sediment is projected to trigger a basin scraping and cleaning effort **once every ten years** during a non-use interval.

Other maintenance measures and upkeep matters are integrated into O&M costs via replacement cycles for meters and telecommunications equipment and would be addressed in a subsequent phase.

O&M Costs are forecast on an annual equivalent basis. The day-to-day operations for Lynwood Operational Alternative would be very low as both operations and data collection would be designed for near-full automation. The basin cleaning and maintenance operations are projected to be sporadic at around a 10-year interval for scraping out sediment and a singular annual inspection of basin operating conditions.

Comparison of operating costs are done in present day dollars. The average annual costs of basin maintenance are estimated at **~$47,453 per year** as an average and on a basis of 2025 cost estimating. The O&M costs are not discounted for the sake of comparison since they will be incurred in the year that they occur. Therefore, projecting a borrowing cost for capital is not pertinent for operations. Similarly, inflationary factors are not material to comparing costs that would be similarly inflated over a similar period of time.

4.5.3 Cost Aspects Summary

Table 36 presents the Cost Aspects values associated with the Lynwood Operational Alternative that were input to the MAA Model for final scoring.

Table 36. Lynwood Operational Alternative Cost Aspects Summary

Cost Aspects Summary	
Capital Costs (2025$)	Annual O&M Costs (2025$)
$2,303,000	$47,453

4.6 Other Technical Aspects

Other aspects of the Lynwood Operational Alternative are summarized here. For comparison among other PERC Alternatives in the MAA, see Volume 1.

4.6.1 Groundwater Quality Improvements

The addition of recharge into the Bunker Hill Basin Zone B is rated on its prospective annual average recharge for the equivalent in MGD. That quantification is in keeping with the discussions and evaluations of Salt & Nutrient Management Planning. Lynwood Recharge Basins estimated average daily recharge rate based on a historic probability-based calculation of how often and how much water is materially available in the annual average groundwater recharge potential equates to **0.6 MGD**.

4.6.2 Conservation and Habitat Benefits

There are no species impacts forecast from Lynwood Recharge Basins as they are existing features with no regrading planned. Nor is there any habitat restoration anticipated since there is currently no known habitat in these basins as they are routinely scraped out for maintenance as was done in 2024 by SBCFCD. The Lynwood Recharge Basins are a part of the Upper Santa Ana River Habitat Conservation Plan (ICF, 2020) as a component of "*Twin*

Creek Spreading Grounds (VD.2.13) – Phase 2." The expected benefit to flows in the Santa Ana River is **0.9 cfs** as a chronic year-round rate.

4.6.3 Hydraulic Stress and Pressure Zone Influence

The value of relief to the hydraulic stress is described in Volume 1. It equates to the distance from the PERC Project Alternative to the center of the Pressure Zone near West 5th Street and Waterman Avenue in the City of San Bernardino. Lynwood Recharge Basins are measured as **4,100 yards** or approximately 2.3 miles.

4.6.4 Access to State Water Project Supply

The Lynwood Recharge Basins can receive State Water Project supply, **indirectly**. Water introduced to the Waterman Recharge Basins existing conditions would produce excess flows that can reach the Lynwood Recharge Basins and recharge up to 23.4 cfs.

4.6.5 Groundwater Mounding

Groundwater modeling analyses for the combination of recharge conditions from a FIRO release were evaluated in Appendix B, Attachment VII as the highest recharge rate condition to assess any reductions that may be necessary for groundwater mounding. Groundwater mounding results in the water levels forecast to potentially rise to within 50 feet of land surface. However, the geotechnical engineering evaluation found that the groundwater mounding at the property and basin perimeter did not generate any added design recommendations for seismic stability of the existing berms (Appendix B, Attachment II). The groundwater modeling does not indicate any reduction in the anticipated groundwater recharge rate due to groundwater mounding. It is recommended that groundwater modeling be conducted in a future design phase utilizing the new San Bernardino Basin model currently being developed by SBVMWD.

4.6.6 Other Technical Aspects Summary

Table 37 presents a summary of the Other Technical Aspects values associated with the Lynwood Operational Alternative that were input to the MAA Model for final scoring.

Table 37. Lynwood Operational Alternative Other Technical Aspects Summary

Other Technical Aspects Summary				
Average Annual Recharge Rate (MGD)	Santa Ana River Contribution (cfs)	Proximity to Groundwater Pressure Zone (yds)	Access to SWP Supply	Groundwater Mounding
0.6 MGD	0.9 cfs	4,100 yds	Indirect	Yes

4.7 Social Aspects

4.7.1 Job Creation

The projected construction jobs in FTE equate to **10 full-time jobs** for one year. The total employment forecast for O&M of the Lynwood Recharge Basins is **0.17 FTE** on a perpetual basis.

4.7.2 Ponded Water Depth

The Lynwood Operational Alternative ponded water depth is **10 feet**. One social aspect that will be taken into consideration is prevention of drowning. Experience at SBVWCD basins demonstrates that water basins will attract unhoused individuals or passersby in hot weather to enter the basin. Access control will be a key consideration in design. Additionally, graded slopes for easy ingress and egress may reduce drowning and other safety hazards from sloped ground.

4.7.3 Social Aspects Summary

Table 38 presents the Social Aspects values associated with the Lynwood Operational Alternative that were input to the MAA Model for final scoring.

Table 38. Lynwood Operational Alternative Social Aspects Summary

Social Aspects Summary		
Construction Jobs (FTE/time period)	O&M Jobs (FTE)	Ponded Water Depth (ft)
10/12 months	0.17	10

4.8 Legal Aspects

4.8.1 CEQA and Permitting Analysis

A brief review of the potential permit needs and issues for the Lynwood Operational Alternative is provided in **Table 39** below.

Table 39. Potential Permit Requirements for the Lynwood Operational Alternative

Potential Permit	Preliminary Review Determination
CEQA	Given the existing features perform the function of flood detention and the use of these features for groundwater recharge extends the flood control function, this project should be **categorically exempt from CEQA** inclusive of the maintenance actions.

Potential Permit	Preliminary Review Determination
USFWS	Covered under the Upper Santa Ana River HCP.
CDFW CESA 2081	Covered under the Upper Santa Ana River HCP.
CDFW LSA /1600	Covered under the Upper Santa Ana River HCP.
USACE 401/ RWQCB	Covered under the Upper Santa Ana River HCP.
USACE 404	Not likely to be required, as there is no work in a watercourse.
USACE 408	USACE 408 permit will be required, as the grading work is near a flood control facility. Obtaining this permit may take more than a year based on typical timeframe of response on a 408-permit filing.
CA DOSD Jurisdictional Dam	Lynwood Recharge Basins ***are not*** jurisdictional dams due to the discrete nature of their water holds and their respective sizes.
SBCFCD	The Lynwood Operational Alternative would require a permit from SBCFCD. It is assumed that it will qualify as a "major construction permit" because segments of the flood watercourse will be inoperable for a brief period. However, given that the alterations proposed do not modify the flood hydrograph, the acquisition of this permit is judged to be quick and simple based on discussions with SBCFCD on the nature of their permits process.

At this preliminary stage, no design considerations appear to be needed to provide for habitat impacts. Final design should consider measures to mitigate for intrusion of non-native species.

The Lynwood Recharge Basins are outside the Federal Aviation Administration (FAA) secondary buffer zone of 10,000 feet, Perimeter B, from San Bernardino International Airport (FAA, 2020). The FAA has specific design and permitting review for water holes that could provide nesting habitat for waterfowl (a flight safety hazard). However, it is within Perimeter C, 5-miles, for San Bernardino International Airport which triggers notification recommendations for the project proponents to the airport operators and triggers the need for management actions by the airport operators such as providing assessment criteria for wildlife strike risks.

4.8.2 Land Availability

This land is NOT currently owned by a partner agency.

4.8.3 Support for Claimed Water Rights

The support for new Water Rights not yet perfected is equated to the maximum diversion rate to groundwater recharge. That is estimated at **23.4 cfs** for the Lynwood Operational Alternative. The annual yield could be as high as 17,000 AF in a very wet year.

4.8.4 Legal Aspects Summary

Below are the Legal Aspects values associated with the Lynwood Operational Alternative that were input to the MAA Model for final scoring.

Table 40. Lynwood Operational Alternative Legal Aspects Summary

Legal Aspects Summary		
CEQA/Permits Required	Land Availability	Support for Claimed Water Rights (cfs)
See Table 39	No	23.42

5 Summary Results

The PERC Comprehensive Feasibility Study looked at each Project Alternative's characteristics and viability over the following key considerations:

- **Groundwater Recharge Benefits**: How much water will be captured and stored as groundwater by the project each year? Over the next 50 years?
- **Cost Aspects:** Do the economics indicate the project's financial viability, including costs, benefits, and projected return on investment?
- **Technical Aspects:** Are the necessary technology, resources, and expertise available and sufficient to implement the project?
- **Social Aspects:** How well does the project align with the available human resources and how well can it align with existing operations?
- **Legal Aspects:** Are there legal or regulatory requirements that could impact the project?

In some respects, this amounts to a discovery process to identify whether any proposed project has fatal flaws that prevent its execution. The Lynwood Operational Alternative **does not have any apparent fatal flaws**. Operationally, the Lynwood Operational Alternative is believed to be a **very best fit** to the dual objectives in a SBCFCD flood control facility; flood control functionality is fully maintained while groundwater recharge is greatly enhanced.

5.1.1 MAA Indicator Values

PERC and its regional partners executed an integrated multiple accounts analysis (MAA) by assessing their key considerations and weighting them. The MAA developed for PERC as a comprehensive analytical tool and the weighted scoring method are described in Volume 1.

Table 42 shows the MAA Indicators and their respective Lynwood Operational Alternative Values.

Table 41. Lynwood Operational Alternative MAA Indicator Values

Account	Subaccounts	Indicators	Lynwood Alternative Values
Groundwater Recharge Benefits	Groundwater Recharge Benefit (Net AFY)	AFY	687
	Infiltration-rate-capacity increase (cfs)	Net Increase in Infiltration Rate Capacity (cfs)	23.42
		Ease of Maintenance (FTE)	0.15
		Timeline to Implement (years)	1.25
	Recharge benefit on a “firm yield” 50-year horizon (AF)	AF	33,847
Cost Aspects	Capital Costs	Capital Costs NPV	$2,303,000
		Grant Sources	0%
	O&M	O&M in 2025 $	$47,453
Other Technical Aspects	Groundwater Quality Improvements *(Salt & Nutrient Management Planning)*	Volume of Annual Recharge	687.27
	Conservation and Habitat Benefits	Santa Ana River Contribution	0.85
		Habitat Restoration	0.00
		Species/Habitat Impacts	0.00
	Proximity to Groundwater Pressure Zone	Distance to Pressure Zone (yds)	4,100
	Access to State Water Project Supply	Direct, Indirect, or No Access	Indirect
	Groundwater Mounding	Rate Limiting Mounding *(Liquefaction Issue)*	Yes
Social Aspects	Project Job Creation	Number of Jobs Forecast for Construction	10.0

Account	Subaccounts	Indicators	Lynwood Alternative Values
		Number of Jobs Forecast from Operational Needs	0.17
	Public Safety Hazards of Project	Ponded Water Depth (ft)	10.0
Legal Aspects	CEQA	CEQA Filing Type (e.g. NOE)	Categorical
	Permits Required/ Requirements	USFWS Permit Requirements	River-HCP
		CDFW CESA 2081 Permit Requirements	River-HCP
		CDFW LSA /1600 Permit Requirement	River-HCP
		USACE/RWQCB 401 Permit Required	River-HCP
		USACE 404 Permit Required	Typical
		USACE 408 Permit Required	Typical
		CA DOSD Jurisdictional Dam	None-Required
		City of San Bernardino Consent Decree Area Permit	None-Required
		SBCFCD	Major
	Land Availability	Property Ownership by Partner Agencies (Y/N)	N
	Water Rights	Support for utilization of water rights not yet Licensed	23.42

5.1.2 Score and Rank

The Lynwood Operational Alternative MAA summary scores are shown in **Table 43**.

Table 42. Lynwood Operational Alternative MAA Scoring Summary

Account	Lynwood Operational Alternative MAA Summary Score
Groundwater Recharge Benefits	1.49
Cost Aspects	1.48
Other Technical Aspects	0.48
Social Aspects	0.12
Legal Aspects	0.55
Total	**4.12**
Priority Rank	**4th**

The MAA Summary Scoring prioritizes the Lynwood Operational Alternative as the **4th highest priority** project when taking under consideration the partner-developed characteristics, criteria, and their weighted importance in meeting regional goals. It is a feasible and viable project that **likely warrants near-term prioritization** for applying human resources, financial resources, and political capital.

Citations

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Appendices

- **Appendix A**: Field Photos of Existing Conditions at Waterman Recharge Basins
- **Appendix B**: Preliminary Design Report for Waterman Recharge Basins, Twin Creek Spreading Grounds and Lynwood Basins
- **Appendix C**: Field Photos of Twin Creek Recharge Basins Existing Features for PERC Project Alternatives
- **Appendix D**: Field Photos of Lynwood Basin Existing Features for PERC Alternative

Appendix A

Field Photos of Existing Conditions at Waterman Recharge Basins

San Bernardino Valley Water Conservation District
Program for Expansion of Recharge Capacity (PERC) Comprehensive Feasibility Study

Volume 2
Detailed Feasibility Analysis of PERC Project Alternatives at East Twin Creek

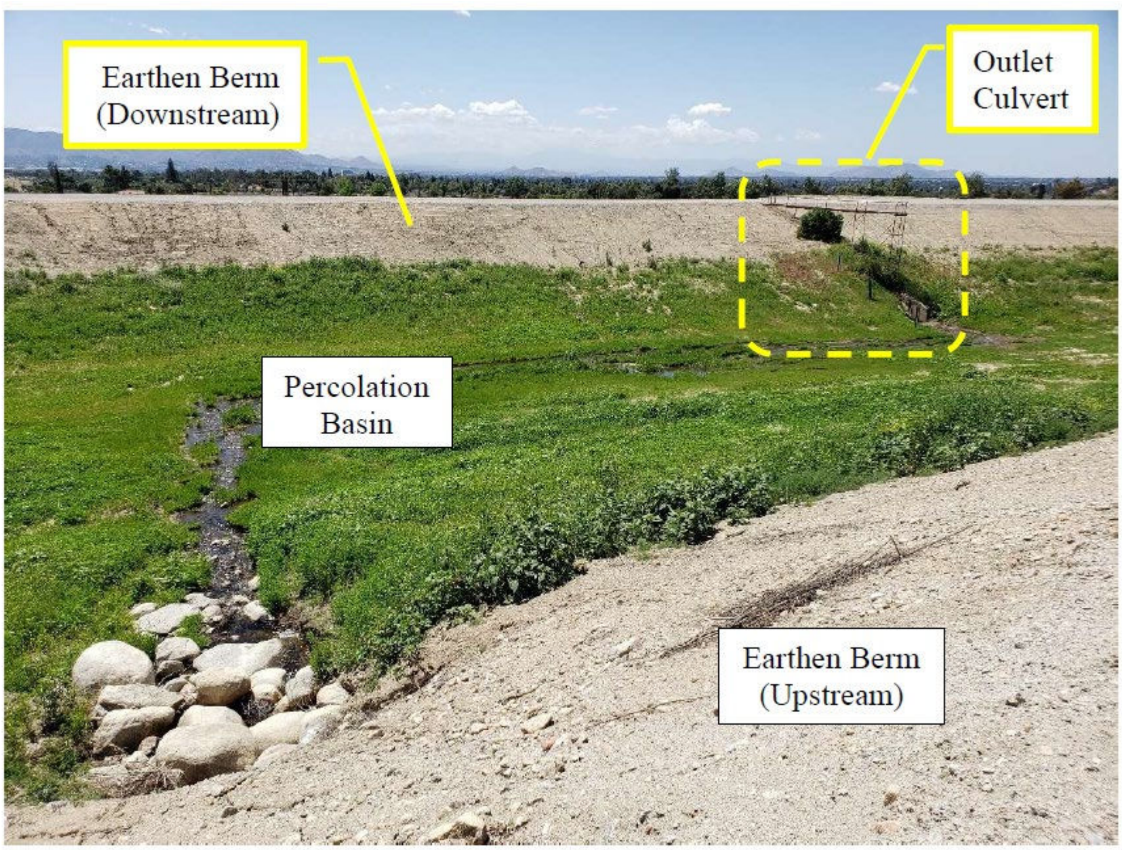

Date & Time: Wed, Jan 17, 2024 at 11:13:07 PST
Position: +034.172491° / -117.272451° (±15.3ft)
Altitude: 1474ft (±11.4ft)
Datum: WGS-84
Azimuth/Bearing: 092° S88E 1636mils True (±12°)
Elevation Grade: -049%
Horizon Grade: -052%
Zoom: 0.5X
native Waterman Creek above 1C


Date & Time: Wed, Jan 17, 2024 at 11:15:23 PST
Position: +034.172344° / -117.272449° (±15.5ft)
Altitude: 1468ft (±11.1ft)
Datum: WGS-84
Azimuth/Bearing: 036° N36E 0640mils True (±12°)
Elevation Grade: -024%
Horizon Grade: -002%
Zoom: 0.5X
Waterman 1C diversion radial gates. West side is not operable

Figure L West Bay and Radial Gate at Heading 1C - INOPERABLE

Figure M East Bay Radial Gate Frozen Open at 1.8 feet - INOPERABLE


Date & Time: Wed, Jan 17, 2024 at 11:20:20 PST
Position: +034.172648° / -117.272656° (±15.3ft)
Altitude: 1481ft (±11.4ft)
Datum: WGS-84
Azimuth/Bearing: 114° S66E 2027mils True (±12°)
Elevation Grade: -030%
Horizon Grade: -001%
Zoom: 0.5X
Waterman 1B diversion radial gates looking NE. Not operable now but in decent shape


Earthen Berm (Downstream)
Outlet Culvert
Percolation Basin
Earthen Berm (Upstream)

Appendix B

Preliminary Design Report for Waterman Percolation Basins, Twin Creek Spreading Grounds and Lynwood Basins

San Bernardino Valley Water Conservation District
Program for Expansion of Recharge Capacity (PERC) Comprehensive Feasibility Study

Volume 2

Detailed Feasibility Analysis of PERC Project Alternatives at East Twin Creek

San Bernardino Valley Water Conservation District
Helping Nature Store Our Water

ARTP – Waterman Percolation Basins, Twin Creek Spreading Grounds, and Lynwood Basins

Feasibility Study Support Professional Services

San Bernardino County, California

Final Preliminary Design Report

May 2025

Tetra Tech
17885 Von Karman Avenue, Suite 500
Irvine, California 92614

ARTP – Waterman Percolation Basins, Twin Creek Spreading Grounds, and Lynwood Basins

Feasibility Study Support Professional Services

San Bernardino County, California

Final Preliminary Design Report

May 2025

Prepared for:

San Bernardino Valley
Water Conservation District

Prepared by:

Tetra Tech
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Attachment III – Summary Hydrology Report (issued on May 2025)

Attachment IV – Final Hydrology Report – Addendum (issued on November 2023)

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1.0 INTRODUCTION

1.1 Purpose and Scope of Work

The San Bernardino Valley Water Conservation District (Conservation District) provides groundwater recharge for the Bunker Hill Basin in the San Bernardino County, California. In 2019, the Conservation District and the San Bernardino Valley Municipal Water District entered into a partnership agreement to build a portion of the Active Recharge Transfer Projects (ARTP), which are a series of stormwater capture projects within the Conservation District boundaries, including East Twin Creek and Waterman Creek. As part of the ARTP, headed by the Conservation District and in cooperation with the San Bernardino County Flood Control District (Flood District or SBCFCD), the Conservation District prepared conceptual designs to improve the existing Waterman and Lynwood basins, and Twin Creek Spreading Grounds facilities. The ARTP will ultimately implement the design improvements to the existing facilities to improve groundwater recharging conditions within the facilities (Tetra Tech, 2024).

Under the contract with the Conservation District, Tetra Tech completed feasibility-level analyses of the Conservation District's conceptual designs. This preliminary design report provides the basis for a conceptual-level basin facility improvement design, including discussions on a design approach, assumptions, and considerations, and the estimates of total project construction costs for all individual design alternatives by facilities. Additionally, this report attaches other pertinent project technical memorandums such as hydrology report, hydraulics report, geotechnical report, sediment transport analysis report, and groundwater recharging modeling report as attachments.

1.2 Description of Facilities

Waterman and Lynwood Basins, and Twin Creek Spreading Grounds are located in the San Bernardino County, California, extending from 0.5 miles north of East 40th Street (upstream limit of Waterman Basin) to 0.3 miles south of 210 Freeway (downstream limit of Lynwood Basins). The Waterman Basin and Twin Creek Spreading Grounds were surrounded by levees, built by the U.S. Army Corps of Engineers (USACE) in mid- to late-1950s. Later, the Flood District added internal berms and spillways to better control the flow of surface water and improve groundwater recharge. In 1961, the Flood District constructed the Lynwood Basins which are a series of four basins, connected by gated culverts.

All project facilities with the Flood District's facility system ID Numbers are shown in Figure 1.1.

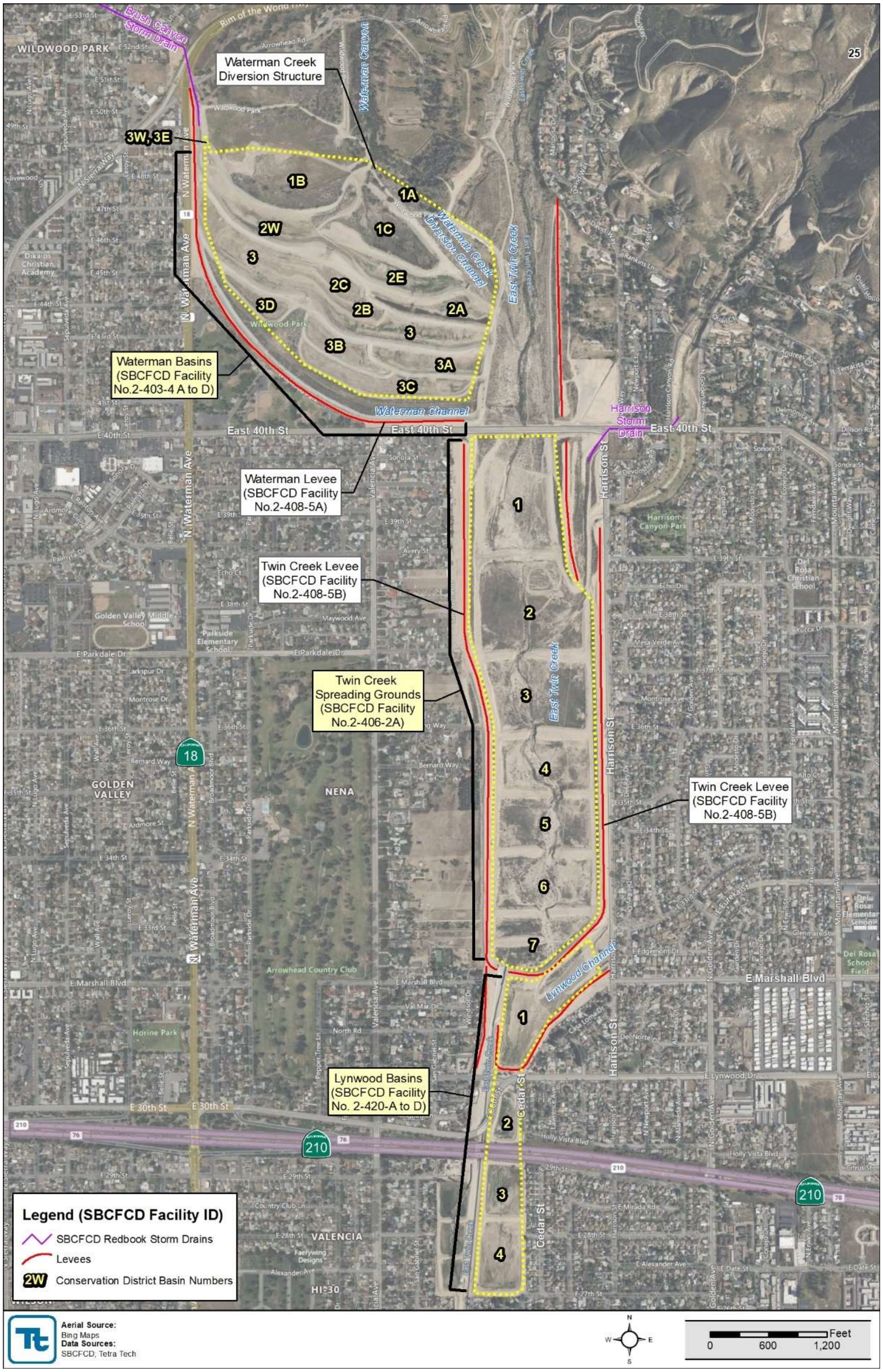

Figure 1.1 – Location Map of Existing Project Facilities

1.3 Surveying and Mapping

The aerial survey to obtain a Light Detection and Ranging (LiDAR) survey and aerial orthoimagery (aerial image) acquisition was performed on March 16, 2022. Supplemental ground surveys of hard structures, including pipes, diversion structures, and spillways, were performed on March 24 and September 29, 2022. All surveys were processed and combined in AutoCAD Civil 3D software to generate a 3-dimensional (3-D) surface. Exhibits showing the existing condition surveys are included as follows:

- Exhibit A – Overall topographic maps of each of 3 project facilities
- Exhibit B – Detailed topographic mapping of each project facilities with drain pipe elevations

The 3-D surface from the survey was used to extract topographic information to create a terrain data for HEC-RAS models. The horizontal datum for the survey is the California Coordinate System of 1988 (CCS83), Zone 5, North American Datum of 1983 (NAD83), in U.S. Survey Feet, while the vertical datum is North American Vertical Datum of 1988 (NAVD88) in U.S. Survey Feet.

2.0 BASIS OF DESIGN

2.1 Development of Design Concept

The conceptual-level design concepts of the proposed improvement were formulated by the Conservation District for three individual project facilities: Waterman Percolation Basins (WPB), Twin Creek Spreading Grounds (TCSG), and Lynwood Basins. The original conceptual design drawings were provided to Tetra Tech as part of the Request for Proposal (RFP) package, issued by the Conservation District in July 2021. However, after reviewing the draft Hydraulic Parent Document (Tetra Tech, 2024) in March 2024, the Conservation District decided not to pursue the original design concept from the 2021 RFP but develop and provide new design alternatives for all project facilities. The sketches of the new design concepts were first provided to Tetra Tech via emails in June 2024, and then followed by a face-to-face meeting to discuss details at the Tetra Tech office on June 27, 2024.

The improvement designs for the facilities can be categorized into two types: a grading alternative and operational alternative. Grading alternatives were initially drafted by Tetra Tech using Civil3D software, based on the Conservation District's design concepts. Operational alternatives were developed, based on the directions, provided by the Conservation District during the monthly calls, and were also initially drafted by Tetra Tech. The final drawings of the conceptual-level designs were developed by another engineering consultant, Russell Consulting & Engineering (Russell Consulting), under a separate contract with the Conservation District and included as Attachment I of this report. The development of the design alternatives for the project at any stage was not part of the signed scope of work for Tetra Tech. Therefore, Tetra Tech only provided initial drafting support during the process of developing the design concepts.

2.2 Grading Alternative

A grading alternative includes a large-scale earthwork that would reshape all or part of internal basins within the facility perimeter boundaries, defined by the USACE-built flood control levee structures, by reshaping internal berms. Inside the reshaped basins, the basin floors will be either raised with fill material or lowered by excavation and removal of existing material. Existing culverts will also be removed with removal of existing berms and replaced with new culverts at new berm locations. Based on the new basin operational scenarios and goals, additional structures such as interties (lateral pipe connections between basins), spillways, weirs, and/or erosion protections will be added to a grading alternative.

Based on the directions from the Conservation District, Tetra Tech developed the 3-D surface of proposed grading and prepared exhibits to show the preliminary grading line works and design details to be included as part of the drawings. The 3-D surface was used to generate accurate earthwork quantities (i.e. excavation and fill) by comparing to another 3-D surface of existing condition topographic mapping. The 3-D surfaces of both existing and proposed conditions topographic mappings were exported from Civil3D software to be incorporated into a 2-dimensional hydraulic routing model as base maps.

For the project, following grading alternatives were developed.

- Waterman Percolation Basin Grading Alternative (WPBGA)
- Twin Creek Spreading Grounds Grading Alternative No.1 (TCSGGA1)
- Twin Creek Spreading Grounds Grading Alternative No.2 (TCSGGA2)

Descriptions of the grading alternatives are included in Subsections 2.9 (WPBGA), 2.11 (TCSGGA1), and 2.12 (TCSGGA2).

2.3 Operational Alternative

For an operational alternative, the benefit of alternative is maximized not by implementing a large-scale structural upgrade to the facility, such as reshaping of earthen basins as in a grading alternative, but by improving the operation efficiency and effectiveness of existing facilities. The alternative is not necessarily improving the structural efficiency of basins to recharge groundwater as there is no improvement to a recharging basin or berm. However, the operational improvement will result in a better distribution of available basin inflow to multiple basins so water could have a higher chance of being infiltrated at the basins floors.

The primary purposes of the operational alternatives are as follows:

- Restoration of full functionality of existing facilities
- Improvement and/or adjustment of existing operational procedures to optimize groundwater recharging capability of each basins
- Installation of monitoring devices (such as flow meters) and remote operational capability of basin closure devices to ensure the improved operation procedures are properly being implemented in real time.

For the project, following operational alternatives were developed.

- Waterman Percolation Basin Operational Alternative (WPBOA)
- Lynwood Basins Operational Alternative (LBGOA)

Descriptions of the Operational alternatives are included in Subsections 2.10 (WPBOA) and 2.13 (LBGOA).

2.4 Geotechnical Analysis

Geotechnical subsurface investigation was performed to explore subsurface conditions within the basins and spreading grounds. The field investigation was performed by Tetra Tech from October 17 through October 24, 2022, and included the drilling, logging, and sampling of 23 hollow stem auger borings, 15 exploratory test pits, and 15 test pit infiltration tests. The subsequent geotechnical analysis evaluated pertinent engineering properties of the soil stratigraphy and provided preliminary foundation recommendations for the proposed water conveyance structures which would be used in the final design phase. The analysis also included an engineering analysis regarding the stability of the existing and proposed basin berm slopes. The infiltration testing and estimates of water infiltration rates from the analysis were incorporated into hydraulic analysis to generate the infiltration hydrographs to be used in the groundwater analysis.

Although supplemental field investigation and subsequent updated geotechnical analysis are likely to be performed as part of the future final design phase, the subsurface investigation results from this project are also expected to be used as a basis for the final design geotechnical analysis.

Detailed discussions of the geotechnical subsurface investigation and analysis results are included as part of the geotechnical technical memorandum. (Attachment II; Tetra Tech, 2025a).

2.5 Hydrologic Analysis

In 2022, Tetra Tech performed the hydrologic analysis that included the frequent storm events, such as 2-, 5-, 10-, and 25-year storm events, for the primary purpose of evaluating the performance of the recharge basins and infrequent storm events such as the 100-year storm and SPFs for the primary purpose of evaluating the impacts of potential design alternatives on flood conditions. FEMA levee certification flow was also evaluated to ensure the design alternatives meet the regulatory requirements and guidelines. Because the Flood District was concerned about the performance of the proposed basin design under the 100-year storm events, the Flood District as well as the Conservation District were closely coordinated in a series of coordination efforts to determine the most appropriate analysis approach and methodology. The final hydrology report was submitted and approved by the Conservation District in February 2023 (Tetra Tech, 2023a), and the summary hydrology report was prepared and submitted to the Conservation District in May 2025 (Attachment III; Tetra Tech, 2025b).

In November, 2023, an additional hydrologic analysis was performed to determine the hydrograph for the average annual flow, which was later more appropriately renamed as Project Typical Hydrograph (PTH) flow, for the project. The PTH flow was selected as the project inflow condition for which the typical operation of groundwater recharging was likely to take place within the project basins. This additional report was added to the previously approved hydrology report as an addendum. (Attachment IV; Tetra Tech, 2023b).

The resulting peak flow and runoff hydrographs from the hydrologic analyses were used in the hydraulic analysis as a boundary condition and input parameters for a hydraulic routing model to simulate the flow through the project basins and spreading grounds.

2.6 Hydraulic Analyses of Design Alternatives

For each project alternative, multiple flood conditions and routing scenarios were evaluated. With the design at a conceptual-level phase, the purpose of hydraulic analysis was not just to evaluate the performance of the facility at a single flooding condition, but to evaluate its responses to multiple flooding conditions and scenarios so the information can be used to adjust and update the improvement design at the future final design phase. Additionally, the results will be used to ensure the design would comply with the design guidelines and regulatory requirements of various agencies and stakeholders as described below.

The hydraulic analysis will confirm and verify the following design requirements (Tetra Tech, 2024):

- The WPB, TCSG, and Lynwood Basins are the Flood District's facilities, so the proposed ARTP need to demonstrate both no adverse impacts to the flood control capabilities of these facilities and likelihood of increasing groundwater recharge.
- These facilities are located in FEMA designated Zone A special flood hazard areas so proposed encroachments, such as construction of the ARTP, require floodplain permits. Application for these permits must demonstrate through hydrologic and hydraulic analyses completed in accordance with standard engineering practice the impact of the proposed encroachments on flood levels during the base flood (the flood having a one percent chance of being equaled or exceeded in any year).

The hydraulic analyses of project alternatives are presented in the hydraulic technical memorandum (Attachment V; Tetra Tech, 2025c).

2.7 Sediment Transport Analyses

Sediment transport analyses were performed for WPB and TCSG to estimate (1) bulking factors used in the levee freeboard analyses and (2) future dredging volumes required to maintain levee freeboard and infiltration rates. Levee freeboard is lost when too much coarse sediment (i.e., sand, gravel, and cobble) accumulates in the spreading grounds or the creeks upstream of the spreading grounds, while infiltration rates change as fine sediment (i.e., silt and clay) deposits clog the pore spaces in the surface sediment. Computations were performed independently for the fine and coarse sediment loading because the controlling processes, and therefore the transport and deposition relationships are different.

The approach to analyzing sediment transport was based on a conceptual understanding of the system informed by field reconnaissance, historical aerial photography analysis, hydrologic analysis, hydraulic analysis, geotechnical investigation, and sediment sampling. Fine sediment yields were estimated using the Modified Universal Soil Loss Equation (MUSLE). To estimate coarse sediment transport capacity, the Waterman Creek, East Twin Creek, and the connected spreading grounds were divided into reaches based on modeled hydraulic conditions. Parameters that describe average hydraulic condition by reach were used to develop bed material transport capacity rating curves using the Ackers-White equation. Coarse sediment yields were estimated by integrating the rating curves over the simulated flood hydrographs. Mass balance calculations were then used to estimate coarse sediment deposition within each reach.

The sediment transport analyses of project alternatives are presented in the sediment transport technical memorandum (Attachment VI; Tetra Tech, 2025d).

2.8 Groundwater Modeling Analyses

Once the hydraulic analyses were completed, groundwater modeling analyses were performed to evaluate potential recharge and effects on groundwater elevations, based on calculations of potential stormwater inflow and basin infiltration rates. Stormwater recharge at the project facilities will create groundwater mounding in the vicinity of the basins. As such, potential impacts from the proposed project on stability of the site features and adjacent structures were evaluated. Groundwater modeling provides useful information for this type of evaluation and was applied to this study to understand the amount of groundwater recharge achievable at each facility, accounting for rejected recharge, and to identify areas of shallow groundwater (i.e. less than 50 feet from ground surface), caused by mounding.

The groundwater modeling analyses of project alternatives are presented in the groundwater technical memorandum (Attachment VII; Tetra Tech, 2025e).

2.9 Waterman Percolation Basin Grading Alternative (WPBGA)

The Waterman Percolation Basins, located upstream (North) of East 40th Street, will be improved under the Waterman Percolation Basin Grading Alternative (WPBGA). WPBGA will include two distinct improvement targets: a structural improvement of the existing Waterman Creek Diversion Channel (WCDC) at the entrance of the basins and grading improvement of internal basins to promote groundwater recharging.

Preliminary design drawings for both WCDC and WPB, provided by the Conservation District, are included in Attachment 1.A.

2.9.1 Waterman Creek Diversion Channel (WCDC)

The existing WCDC comprises following diversion structures: 5-timber stoplog gates (structure No.1A), double 5-ft wide by 10-ft high reinforced concrete box (RCB) culvert with flashboards (structure No.1B), double 12-ft wide by 11-ft high RCB culvert with double radial gates (structure No.1C), and bypass opening to Waterman Creek. In the structure No.1C, each of the two bays of the RCB has a radial gate. Currently, a radial gate in the East bay is completely shut and non-operational, while the other one in the West bay appears to be non-operational but stuck partially open by 1.8 feet from the floor as shown in Figure 2.1.

(East Bay) **(West Bay)**

Figure 2.1 – Existing Conditions of Radial Gates at WCDC Diversion Structure No.1C

The existing RCB culvert (1C) will be replaced with a new double 7.5-ft wide by 10-ft high RCB culvert with radial gates, although the maximum bay opening is likely to be limited to 7.5 feet high due to a radial gate itself. Per the request from the Flood District, the new culvert will need to be structurally designed to withstand a weight of a large excavator and other off-road trucks (traffic load bearing of up to approximately 35 ton) which will travel over the culvert to perform basin maintenance and sediment removal. The existing diversion structures Nos. 1 and 2 will be removed and replaced with permanent floodwalls, preventing any future diversion of flow through these flow paths. In the proposed operational condition, for the 100-year flood event, the radial gates will be closed, pushing all flow, entering the WCDC, towards Waterman Creek, bypassing the entire WPB. For the rest of flooding scenarios, both radial gates will be open allowing the flow entering the WCDC to either continue down to Waterman Creek or be diverted to the WPB via the new RCB culvert for groundwater infiltration as shown in Figure 2.2.

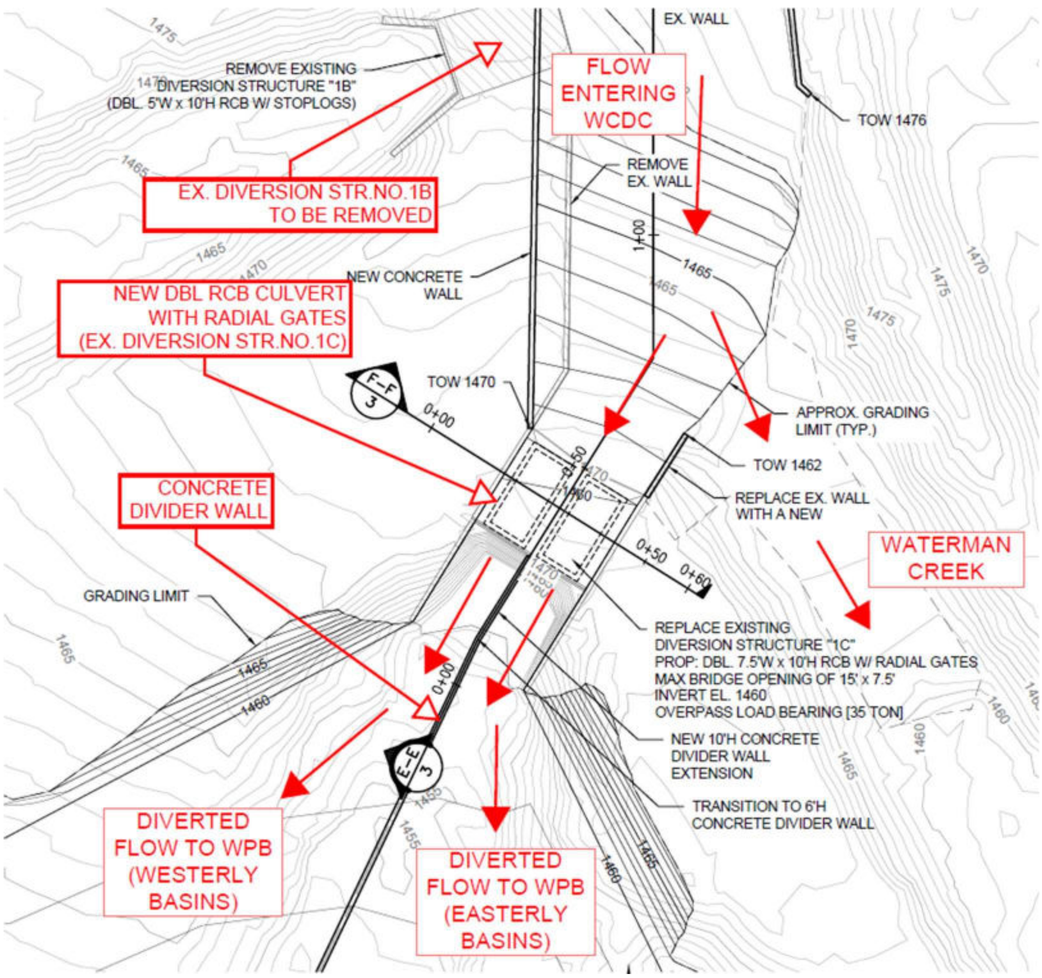

Figure 2.2 – Flow Diversion at Proposed WCDC RCB Culvert (Ex. Structure No.1C)

At the immediately downstream of the new RCB culvert, a 10-ft high concrete divider wall will be constructed for a distance of approximately 30 to 35 feet to prevent equally divided flow from each bay of the culvert from combining back together but to let it continue to either easterly or westerly percolation basins.

2.9.2 Waterman Percolation Basins (WPB)

The WPB includes the USACE-built flood control levees along the Western and Southern boundaries (Flood District Facility No. 2-408-5A) and a series of internal earthen berms, creating percolation basins (Flood District Facility No. 2-403-A to D) between them as shown in Figure 2.3, and, in a larger scale, creating a complex network of basins, hydraulically connected by multiple basin outlet culverts. Currently, there are a lot of sediment deposits on the basin floors and vegetation growing over them.

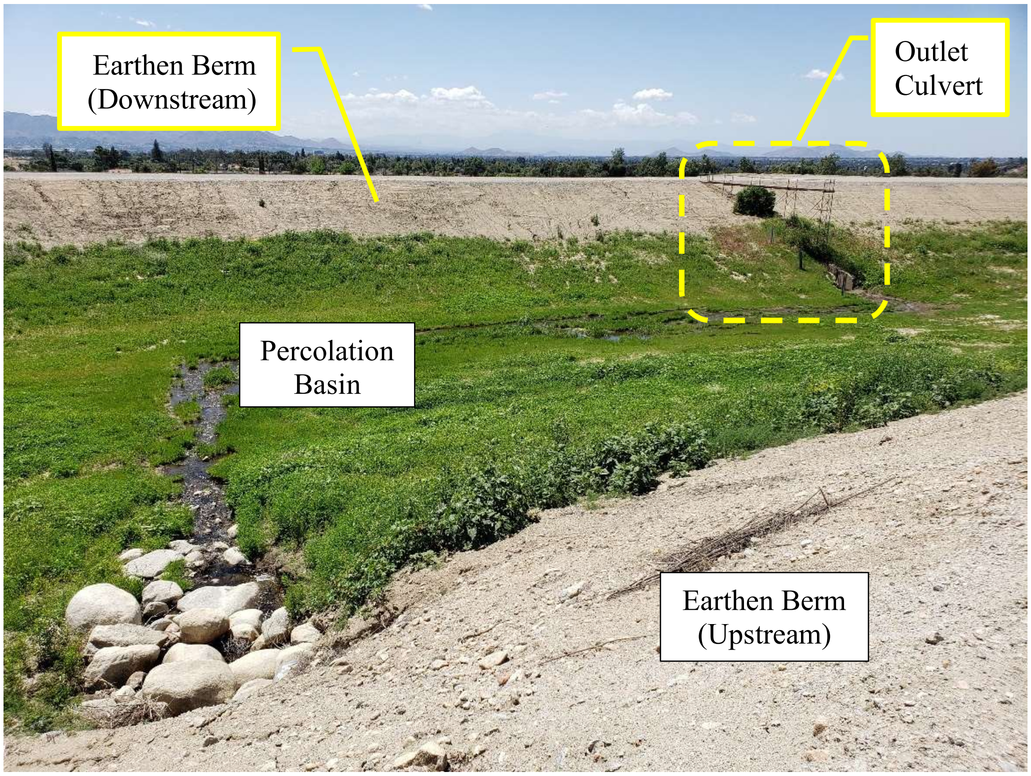

Figure 2.3 – Typical Percolation Basin with Outlet Culvert

Overall, the current layout of existing basin network will be kept in the proposed grading alternative with the following notable changes:

- Basins are grouped into Easterly and Westerly basins, divided by a raised fill between them, with each receiving the equal amount of flow from the WCDC structure. Existing large basins that span the entire width of the WPB will be divided into Easterly and Westerly basins. The two groups are hydraulically connected by interties which are flat connection pipes, allowing flow to freely move around between East and West basins when the intertie gates are open.
- The existing Basin 1B will be filled with dirt material and will be removed from the WPB, which is consistent with removal of the diversion structure 1B in the WCDC (See Subsection 2.9.1).
- Some of the smaller existing basins will be combined into a single basin by excavating a berm between them.

- The numbering of basins is changed so that the number will increase from upstream to downstream without using letters, ‘A’, ‘B’, or ‘C’.

The proposed layout of the WPB is presented in Figure 2.4.

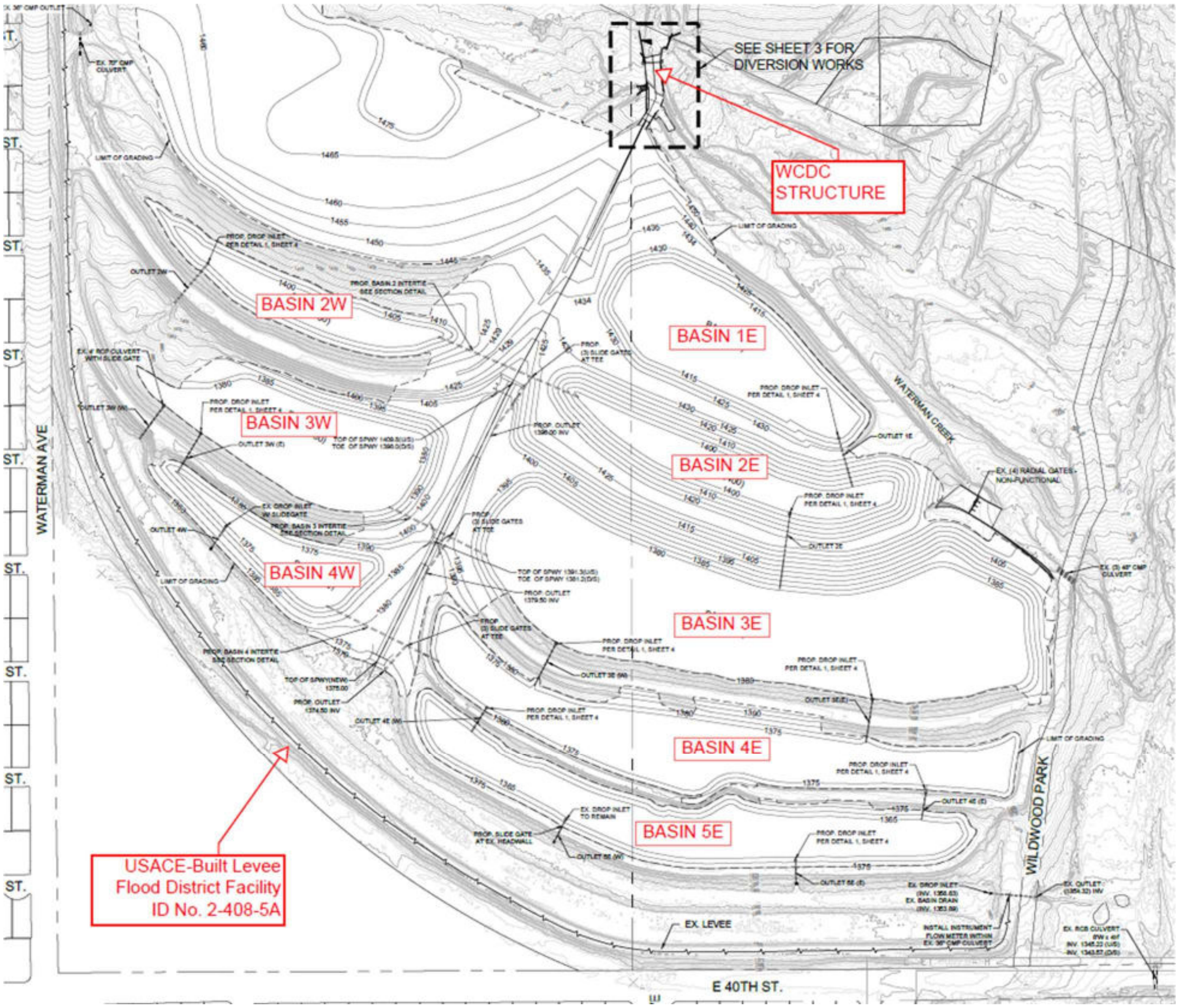

Figure 2.4 – Proposed Layout of WPBGA

Steep side slopes of existing earthen berms will be regraded to 3(H):1(V) slope, while top of the berms will be raised in some areas to meet the target freeboard elevation. Any fill on the berms will need to be compacted to the minimum 90% of ASTM D1557 dry density.

Proposed basin floor elevations are mostly lower than the current floor elevations, resulting in excavation. The exposed surface after excavation may require scarification to reduce the density to below the maximum allowable 85% of ASTM D1557 dry density in order to promote groundwater percolation. In areas where localized fill is required on the basin floor, the fill must be placed also with the maximum 85% compaction rate. The range of compaction requirement for the basin floor must be evaluated in the final design phase to determine the optimum value that both supports groundwater percolation and provides structural stability against excessive erosion.

Existing basin outlet culverts which include pipes, catwalks, inlet/outlet structures, and slide gates, are likely to be replaced as the inlet and outlet invert elevations have drastically changed with proposed basin floor elevations and in many cases, the pipes need to be extended to meet new berm side slopes. In the final design phase, the conditions of existing outlet parts need to be evaluated to determine whether any of them could be salvaged and reused. At the upstream end of each culvert, a drop inlet in a form of a concrete riser will be constructed instead of a typical pipe opening at the basin floor elevation. The drop inlet elevations will be designed so that a basin needs to be filled with water up to 3 feet below the top of berm elevation before starting to discharge water through an outlet culvert as shown in Figure 2.5

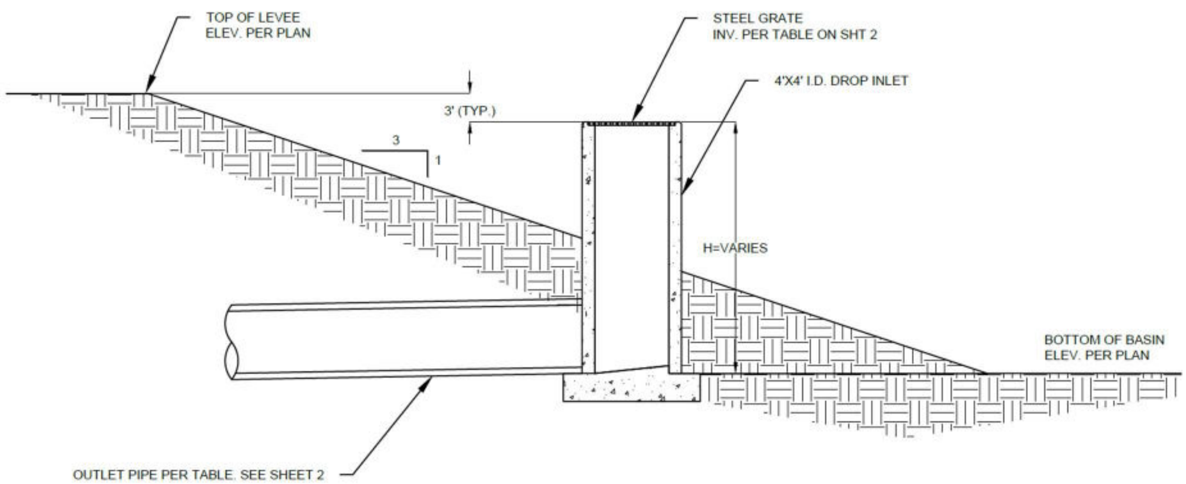

Figure 2.5 – Typical Drop Inlet for Basin Outlet Structure

Interties will be installed between East and West basins with a flat longitudinal slope, allowing water to move freely from one to the other when a sluice gate for intertie is in an open position. In the middle of intertie, a drain pipe is installed with a junction structure to drain the basins as part of maintenance activities. Discharged flow from a drain pipe will be conveyed through an interior channel down to a downstream basin as shown in Figure 2.6.

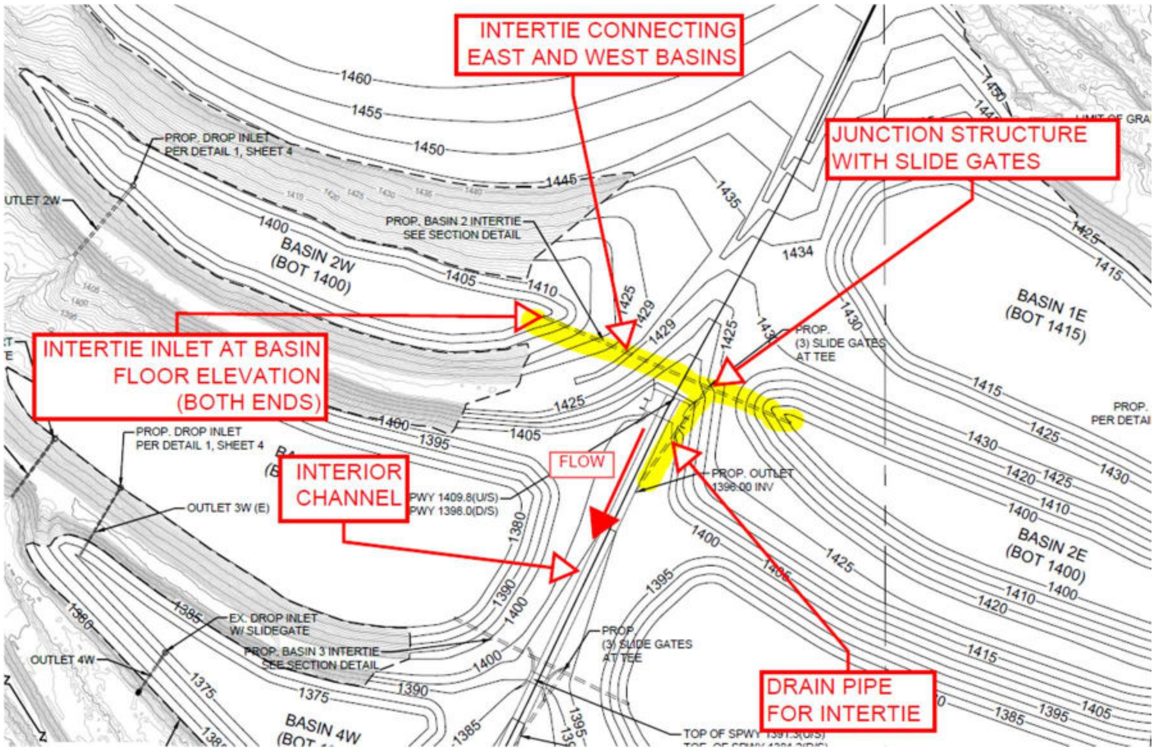

Figure 2.6 – Layout of Intertie and Drain Pipe

2.10 Waterman Percolation Basin Operational Alternative (WPBOA)

Under this alternative, the Waterman Basins, located upstream (North) of East 40th Street, will be improved under the Waterman Percolation Basin Operational Alternative (WPBOA). As an operational alternative, the benefit of the alternative will be maximized by improving the operation efficiency and effectiveness of existing facilities instead of implementing a large scale earthwork improvement. As a result, an operational alternative requires relatively less construction cost than a grading alternative although the benefit of the operational alternative may be somewhat limited. Analyzing the benefit-cost ratio of this alternative, with the benefit being the improved performance in groundwater recharging, is not part of this project's scope of work and would need to be verified in the next phase.

This alternative will either repair the existing double 12-ft by 11-ft high RCB culvert with radial gates (diversion structure No.1C) to an operable condition or replace with a new in-kind RCB as shown in Figure 2.7. Currently, the gates appear to be non-operational and either completely shut or partially shut, restricting Waterman Creek flow from entering the WPB. At the final design phase, the existing structure will need to be structurally analyzed to determine whether repair or full or partial replacement will be necessary. The future analysis also needs to evaluate the existing structure could withstand a weight of a large excavator and other off-road trucks (traffic load bearing of up to approximately 35 ton) which will travel over the culvert to perform basin maintenance and sediment removal.

All other diversion structures of the WCDC, including most of the retaining walls, will be protected in place without receiving any improvement.

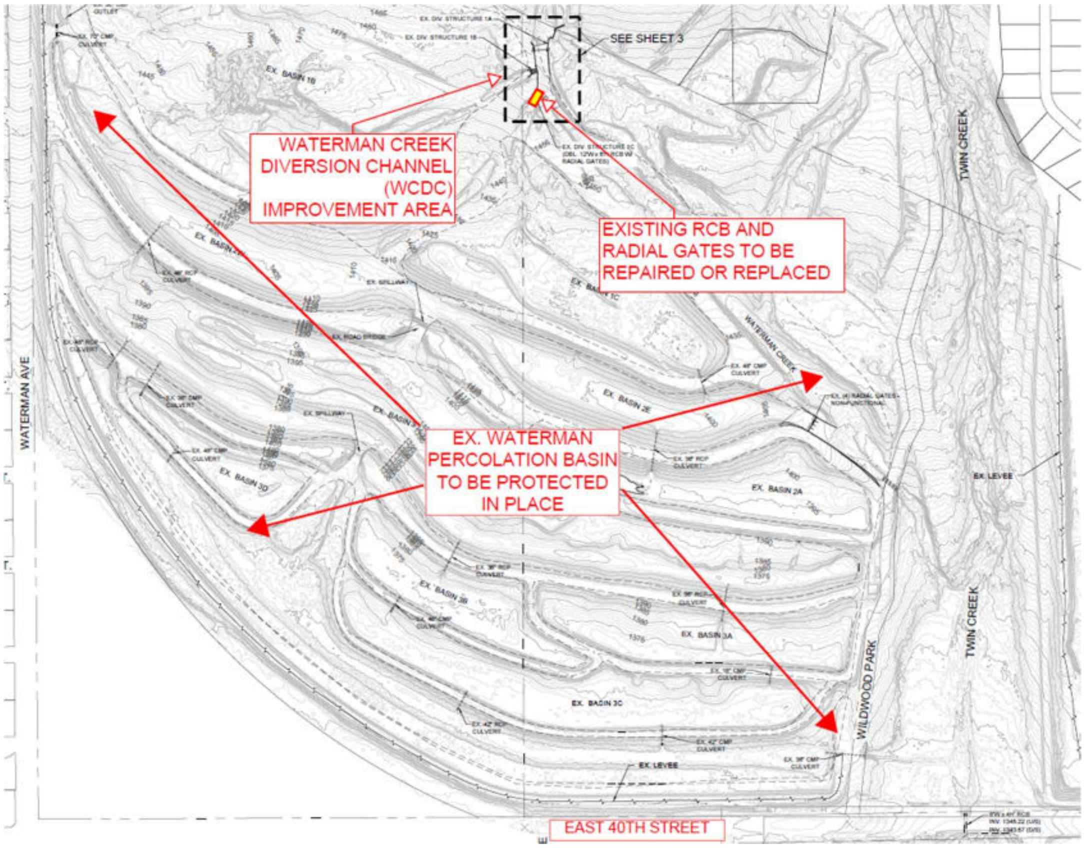

Figure 2.7 – WPB Operational Alternative Layout

In the proposed operational condition, for the 100-year flood event, the radial gates will be closed, pushing all flow, entering the WCDC, towards Waterman Creek, bypassing the entire WPB. For the rest of flooding scenarios, both radial gates will be open allowing the flow entering the WCDC to either continue down to Waterman Creek or be diverted to the WPB via the new RCB culvert for groundwater infiltration as shown in Figure 2.7. Although it was not evaluated in the hydraulic analysis, with the radial gates being fully operational, the radial gates can be manually operated in such a way that inflows of stormwater can be matched to the percolation rates of the proposed WPB system, if necessary.

In the future final design phase, it is recommended the basin maintenance, including removal of sediment deposit from the basin floors, be considered for inclusion as part of this alternative to ensure the increased volume of inflow through the repaired gate opening could be efficiently infiltrated into groundwater. The cost of maintenance could be part of the construction or regular maintenance activities by the responsible agencies.

Preliminary design drawings, provided by the Conservation District, are included in Attachment I.B.

2.11 Twin Creek Spreading Grounds Grading Alternative No.1 (TCSGGA 1)

The TCSG (Flood District Facility No. 2-406-2A) includes the USACE-built flood control levees along the Western and Eastern limits (Figure 1.1; Flood District Facility No. 2-408-5B) of the spreading ground and a series of internal earthen berms, creating individual holds between them. In the original condition, there were total of 7 holds with the upstream 6 holds divided by earthen berms with riprap spillway and the downstream most hold, bounded by the USACE-built flood control levee on its southern limit with a concrete spillway at the southwest corner of the hold. A typical view of internal berms and a hold between them is shown in Figure 2.9.

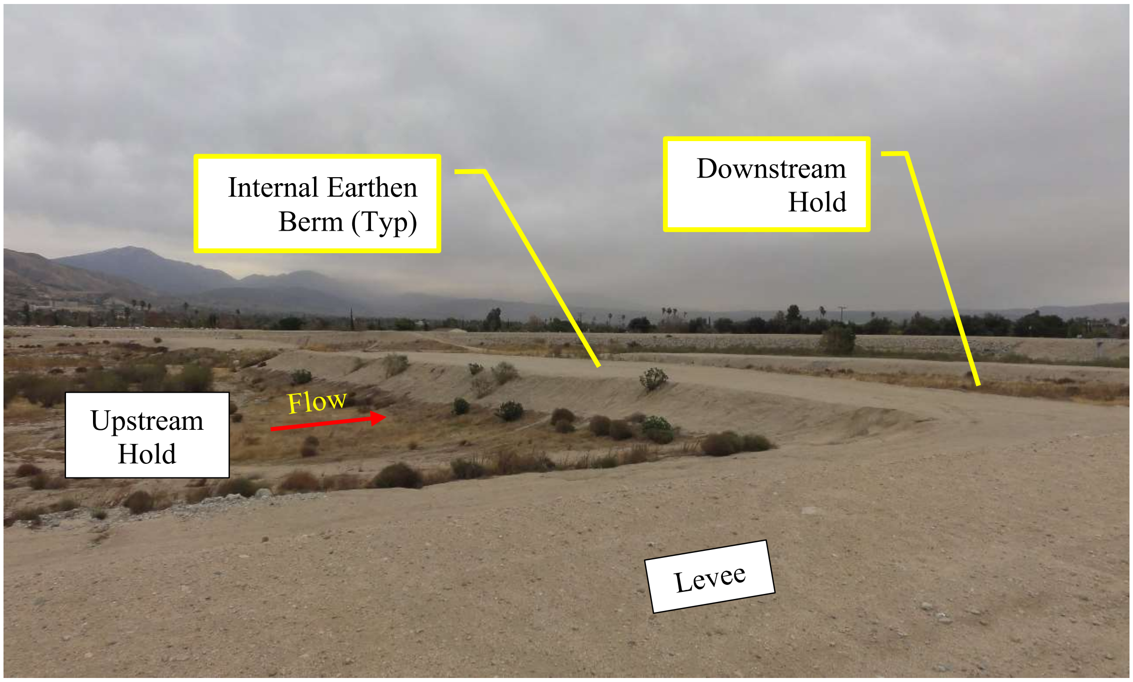

Figure 2.8 – Typical TCSG Internal Berm and Hold

Currently, most of the internal berms were partially breached to the hold floor elevations as shown in Figure 2.9. In many areas, there appear to be excess dirt material, likely excavated from the basin floor as part of maintenance, pushed against side slopes of the levees and internal berms, thickening the embankments.

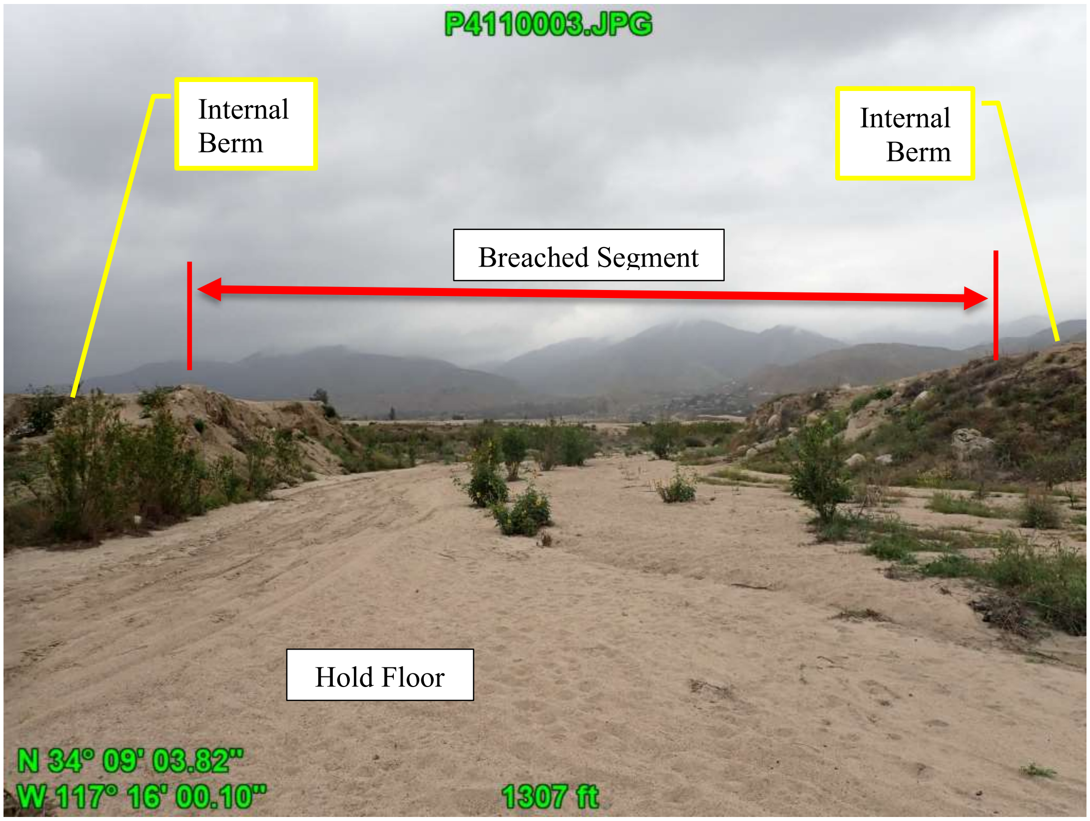

Figure 2.9 – Breached Internal Berm in TCSG

In this grading alternative No.1, only the existing Hold No.2 will be rehabilitated to capture sediment and provide a more efficient groundwater infiltration area by removing excess dirt from the floor. The breached segment of the downstream internal berm will also be restored with a concrete-lined saddled weir and erosion protection as shown in Figure 2.10. The remaining portion of existing riprap at the upstream internal berm for Hold No.2 will be salvaged, stockpiled, and reused to reconstruct a riprap placement over the breached segment.

The proposed hold floor elevation is lower than the current floor elevation, resulting in excavation. The exposed surface after excavation may require scarification to reduce the density to below the maximum allowable 85% of ASTM D1557 dry density in order to promote groundwater infiltration. In areas where localized fill is required on the hold floor, the fill must be placed with the maximum 85% compaction rate. The range of compaction requirement for the hold floor must be evaluated in the final design phase to determine the optimum value that both supports groundwater percolation and provides structural stability against excessive erosion.

Any fill on the berms will need to be compacted to the minimum 90% of ASTM D1557 dry density.

No other holds or internal berms will be improved or rehabilitated as part of this alternative.

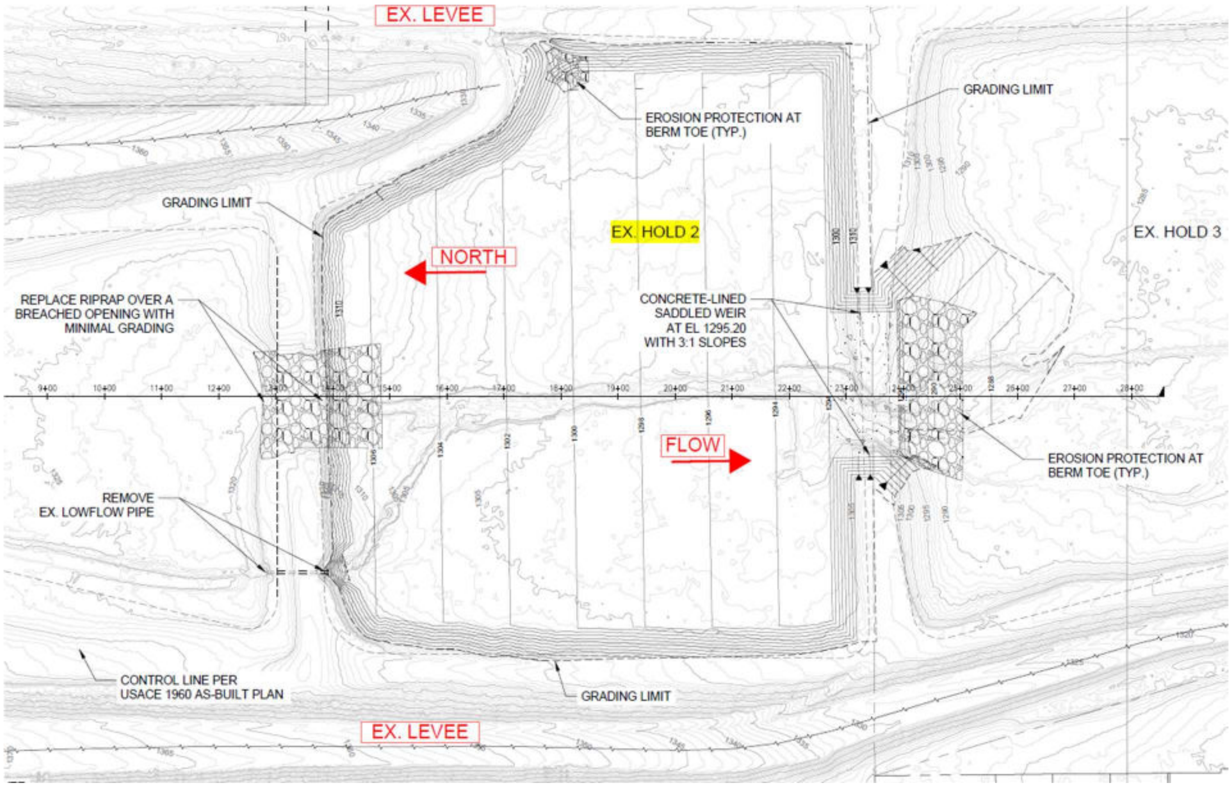

Figure 2.10 – TCSGGA1 Grading Layout

Preliminary design drawings, provided by the Conservation District, are included in Attachment I.C.

2.12 Twin Creek Spreading Grounds Grading Alternative No.2 (TCSGGA 2)

The TCSG (Flood District Facility No. 2-406-2A) includes the USACE-built flood control levees along the Western and Eastern limits (Figure 1.1; Flood District Facility No. 2-408-5B) of the spreading grounds and a series of internal earthen berms, creating individual holds between them. In the original condition, there were total of 7 holds with the upstream 6 holds divided by earthen berms with riprap spillway and the downstream most hold, bounded by the USACE-built flood control levee on its southern limit with a concrete spillway at the southwest corner of the hold. A typical view of internal berms and a hold between them is shown in Figure 2.9. In many areas, there appear to be excess dirt material, likely excavated from the hold floor as part of a maintenance, pushed against side slopes of the levees and internal berms, thickening the embankments.

In this grading alternative No.2, the entire TCSG will be improved from East 40th Street crossing (upstream limit) to the concrete spillway (downstream limit), affecting all 7 existing holds. All 6 existing earthen internal berms will be removed and replaced with 10 new concrete-lined berms, creating 11 new holds within the TCSG as shown in Figure 2.11. Hold floors of the 11 holds will be raised with imported fill so there is a constant longitudinal slope at 0.017% from the existing 8-ft wide by 4-ft high RCB culvert underneath East 40th Street crossing (upstream limit of TCSG) to the entrance of the existing spillway (downstream limit of TCSG). At some holds, more than

15 feet of imported fill would need to be placed to raise the floor elevations as shown on the profile in Figure 2.12. The existing dip crossing and RCB culvert at East 40th Street will be replaced with a new bridge and concrete channel underneath it. A new bridge and its abutments will be designed and constructed by others, but the creek underneath the bridge will be concrete-lined by this project.

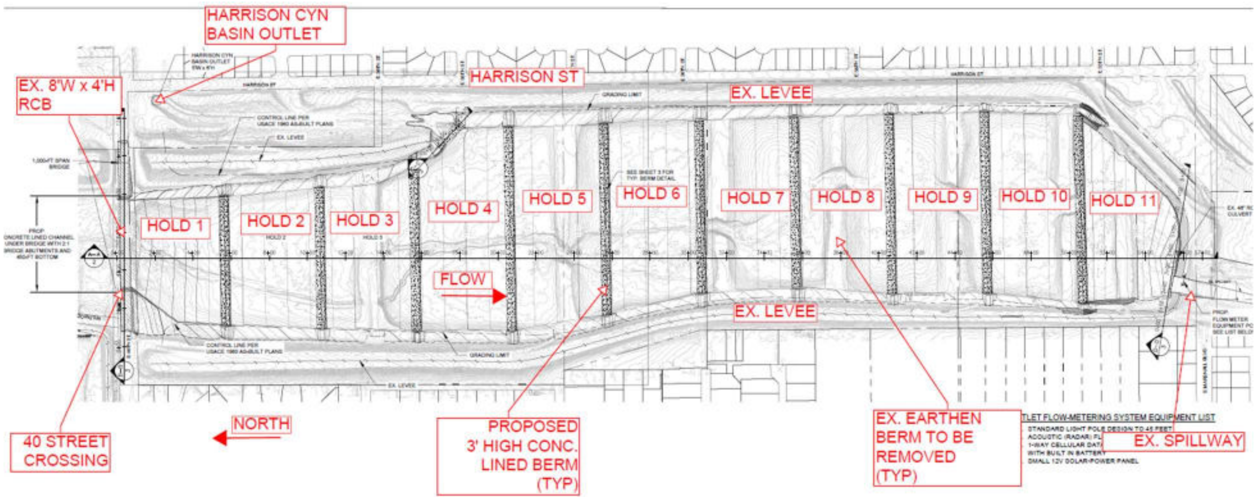

Figure 2.11 – TCSGGA2 Grading Layout

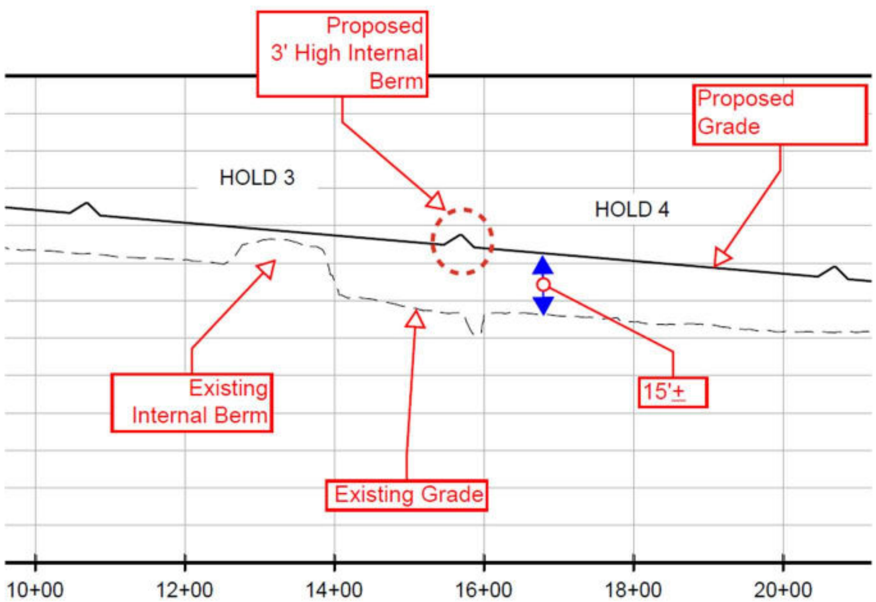

Figure 2.12 – Typical Profile View of TCSGGA2

In a typical cross-sectional view, a new internal berm will be about 3 feet high from the adjacent floor elevations and lined with concrete both upstream and downstream sides and top of the berm as shown in Figure 2.13. A riprap erosion protection will be installed at the downstream toe of the berm to protect a hold floor from the high velocity flow coming down the berm side. Along an internal berm structure (i.e. direction perpendicular to a flow direction), there is no notch, such as a spillway, but a constant elevation from one end to the other, creating a long side-to-side weir condition. Therefore, water will flow over the berm as widespread as the length of a berm structure. This would allow ponded water upstream of the berm to be spread over the width of hold when it flows over the crest, and as it flows downstream of the berm, flow will also have a better chance to be spread over the entire hold floor, increasing the effectiveness of groundwater infiltration. Just upstream of the berm, with no low flow discharge pipe, water will always be ponded behind the berm creating a backwater until the water is infiltrated into the ground. During a flood event, flow will slow down in this backwater area causing sediment deposition behind the berm which will in turn reduce the capacity of each hold to contain water. After a significant storm event, it is recommended that the area behind the berm is monitored and maintained to remove any excess sediment deposits to ensure continued effective groundwater infiltration activities in the holds.

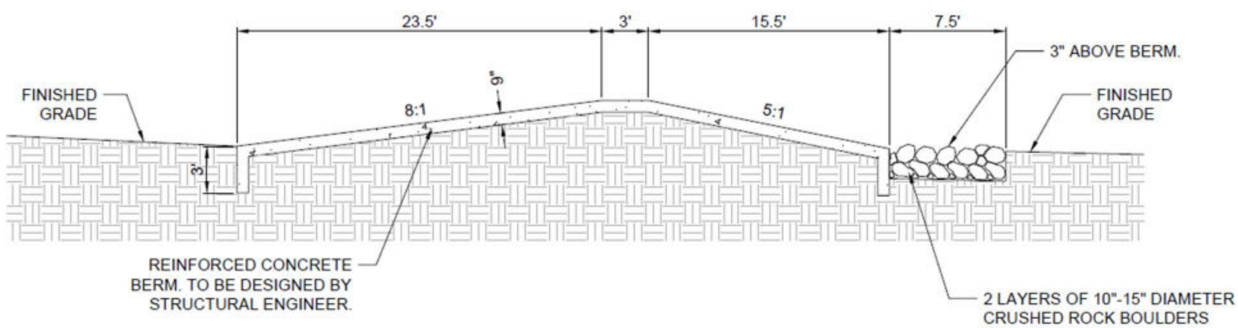

Figure 2.13 – Typical 3-Ft High Internal Berm in TCSGGA2

Proposed hold floor elevations are mostly higher than the current floor elevations, resulting in fill placement. Prior to placing fill, the existing ground may require scarification to reduce the density to below the maximum allowable 85% of ASTM D1557 dry density in order to promote groundwater infiltration. When new fill material is placed on the hold floor, the fill must be placed with the maximum 85% compaction rate. The range of compaction requirement for the hold floor must be evaluated in the final design phase to determine the optimum value that both supports groundwater percolation and provides structural stability against excessive erosion.

Within the structural prism of the 3-foot high berms, fill material will need to be compacted to the minimum 90% of ASTM D1557 dry density to provide structural strength against retained water and protection against underseepage. The limit of the prism will project below the new hold floor elevation at a 2(H):1(V) side slope.

A water level sensor, powered by a solar panel, will be installed near the entrance of existing spillway, located at the downstream limit of TCSG. This flow meter will be installed with a standard light pole to monitor the flow over the spillway.

Preliminary design drawings, provided by the Conservation District, are included in Attachment I.D.

2.13 Lynwood Basin Operational Alternative (LBOA)

The Lynwood Basins (Flood District Facility No. 2-420 A to D), located downstream (South) of TCSG, will be improved under the Lynwood Basin Operational Alternative (LBOA). As an operation alternative, the benefit of the alternative will be maximized by improving the operation efficiency and effectiveness of existing facilities. As a result, an operational alternative requires relatively less construction cost. Analyzing the benefit-cost ratio of this alternative, with the benefit being the improved performance in groundwater recharging, is not part of this project's scope of work and would need to be verified in the next phase. The design elements, developed under directions of the Conservation District, are presented in Figure 2.14, an excerpt from the preliminary design drawings, provided by the Conservation District.

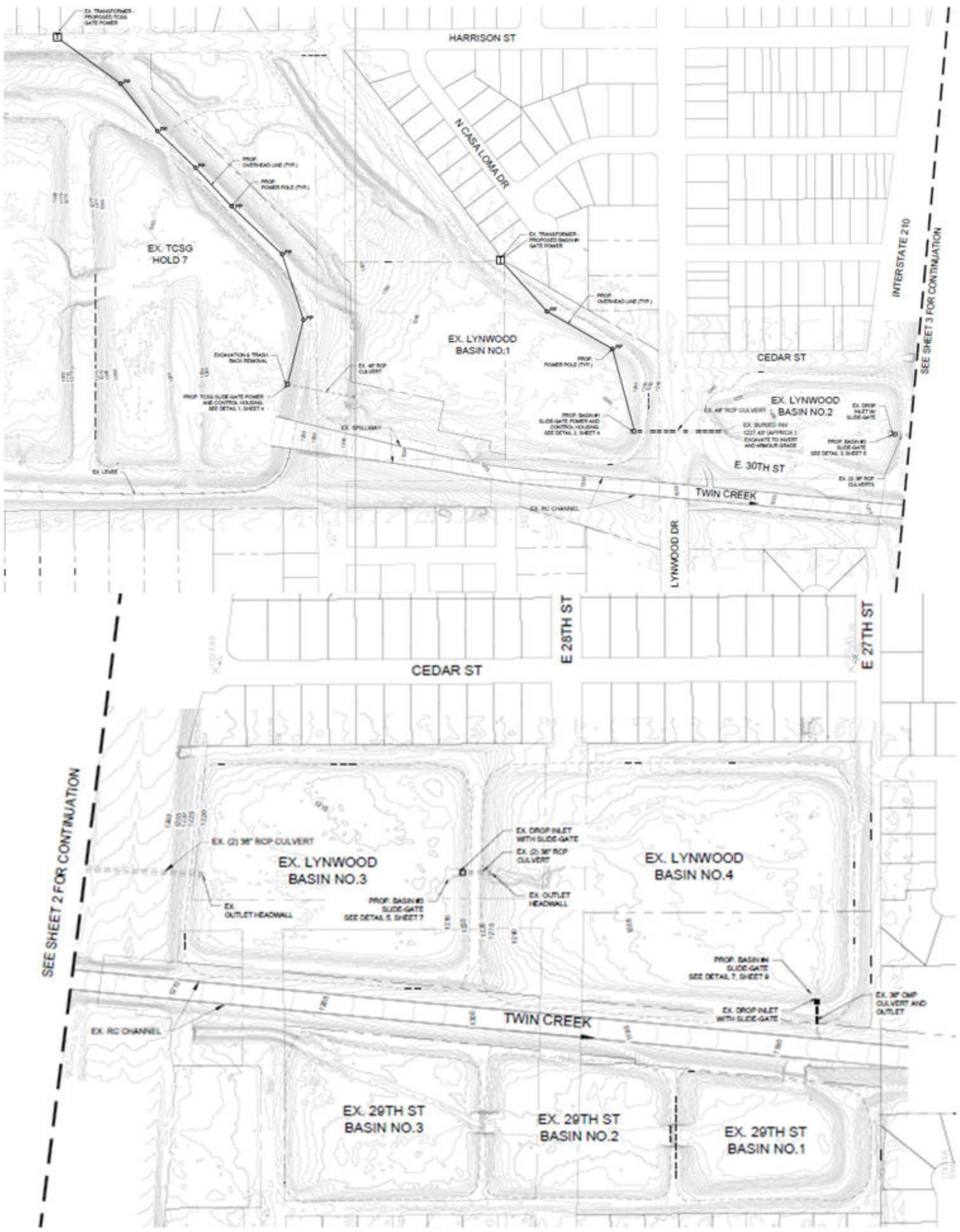

Figure 2.14 – Overall View of Proposed Design Elements of LBOA

Unlike a grading alternative, LBOA will not involve a large-scale earthwork to reshape existing basins except localized excavation near the basin outlets to uncover the existing structures, buried under sediment, to restore their full functionality. For this uncovering effort, the upstream end of the existing 48-inch diameter outlet structure between existing TCSG Hold 7 (most downstream TCSG hold) and Lynwood Basin No.1 and the downstream end of the existing 48-inch diameter RCP outlet structure between Lynwood Basins No.1 and No.2 will be locally excavated to restore the original design conditions, allowing the full use of these culverts.

As shown in Figure 2.14, within the project boundaries, there are total of 5 basin outlet systems being impacted by the project: one connecting TCSG and Lynwood Basin system (entering Lynwood Basin No.1); three connecting Lynwood Basins Nos. 1 through 4; and one connecting the Lynwood Basin No.4 and Twin Creek concrete channel. The existing inlet structure at the upstream end of Lynwood Basin No.1, located under Harrison Street, will not be impacted by the project but protected in place, and its operation is not considered as part of this operational alternative.

Each of the 5 outlet systems impacted by the project comprises the reinforced concrete inlet and outlet structures at the basin floor level and a catwalk that extends from top of berm to the upstream end of the outlet as shown in Figure 2.15. Currently, at the end of the catwalk, an operational staff can operate a slide gate lift. In the proposed condition, the catwalks will receive slide gate housings to house new equipment to remotely monitor the basin water levels and send captured electronic data to the operator via a wireless cellular communication system. The slide gate housings for the upstream 2 basins (i.e. TCSG and Basin No.1) will also be equipped with new motorized drive assemblies to remotely and automatically operate motors to lift or lower the existing slide gates to control the operation of the basins.

The upstream 2 slide gate housings that are equipped with the motor assemblies to operate the existing slide gates will need to be connected to existing transformers in the vicinity with new overhead electrical lines to power the motors.

The list of instruments and equipment to be installed in the housing, provided by the Conservation District, is included in Subsection 3.2.5.

Figure 2.15 – Typical Existing Basin Outlet System with Outlet Structure and Catwalk

In order to remotely monitor the water levels in the basins, the alternative includes installation of multiple radar (acoustic) water level sensors. Five water level sensors will be installed at the 5 basin outlet structures listed above, mounted to bottom of catwalk below the housing. In addition to a motor and control housing, an additional water level sensor, powered by a solar panel, will be installed near the entrance of existing spillway, located at the downstream limit of TCSG. This flow meter will be installed with a standard light pole to monitor the flow over the spillway.

For the Basin 2 and 3 outlet systems, the existing wingwalls between the headwall for pipes and headwall for the slide gate will be retrofitted by doweling concrete wall extensions to match the top of the headwalls as shown in Figure 2.16 (an excerpt from the preliminary design drawings, Attachment I.E).

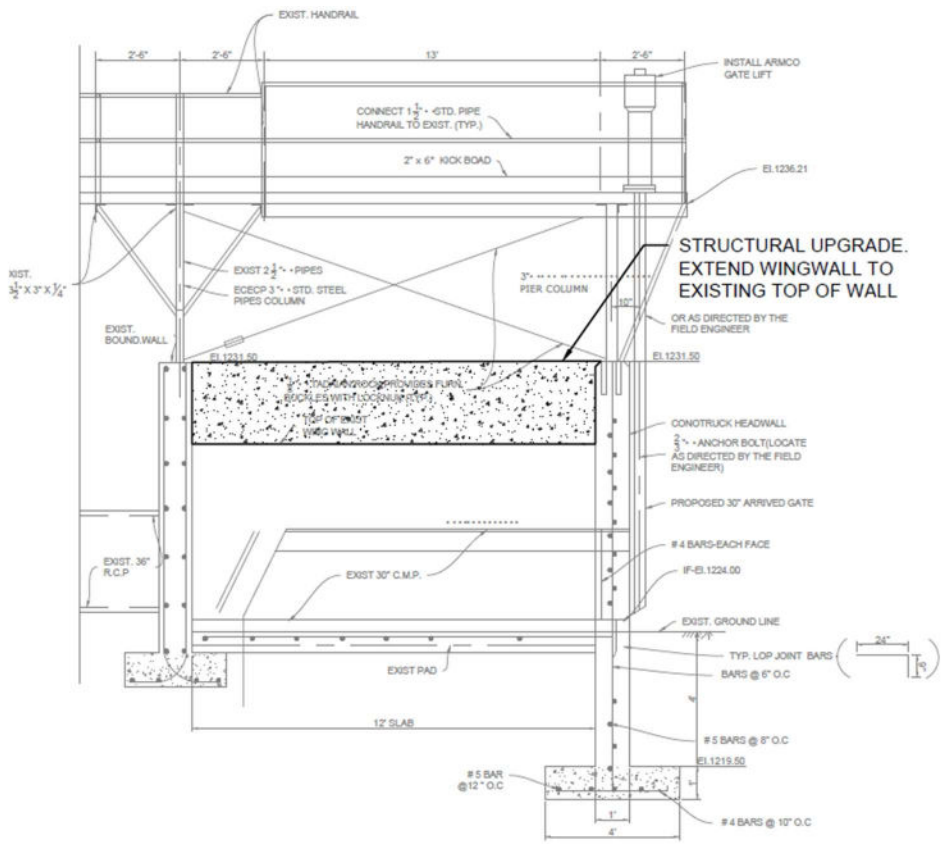

Figure 2.16 – Typical Outlet Wingwall Modification (Basins 2 and 3)

It should be noted that this operational alternative assumes no inflow through the existing basin inlet under Harrison Street into Basin No.1. All inflow of water will enter Basin No.1 through the diversion outlet from existing TCSG Hold 7, located east of the existing spillway, and propagates downstream through a network of basins.

Preliminary design drawings, provided by the Conservation District, are included in Attachment I.E.

3.0 COST ESTIMATES

3.1 General

The cost estimates have been prepared for the conceptual-level design alternatives. The design concepts and approaches were developed and provided by the Conservation District. Primary construction cost items include earthwork, such as excavation and fill, to construct basin and berms. The cost items also include basin outlets, concrete spillways, concrete weir, RCB culvert, and a slide gate housing. An estimate for habitat mitigation measures were not part of this project but should be evaluated during a future design phase.

For the purpose of quantity development for primary construction cost items, Tetra Tech developed a 3-D finished grade surface for each grading alternative using Civil3D software. This 3-D finished grade surface was compared to a 3-D existing condition mapping from the 2022 survey to calculate excavation and fill volumes.

Due to their significant impacts to the overall project construction cost estimate, the unit costs for earthwork were defined, based on a series of coordination efforts with the Conservation District. The final versions of earthwork unit costs were determined based on the data from the previous projects in the vicinity and other current Conservation District design projects, being performed by other consultants and provided to Tetra Tech in an email on February 3, 2025 (Table 3.1)

Table 3.1 – Earthwork Unit Costs (Provided by the Conservation District)

Item	Unit	Unit Cost
Excavation	CY	$ 5
Backfill (Typical)	CY	$ 12
Backfill (Compacted)	CY	$ 16
Structure Excavation	CY	$ 55
Export Excess Material	CY	$ 15
Import Fill (Typical)	CY	$ 21
Import Fill (Compacted)	CY	$ 25

The following assumptions were incorporated into the earthwork unit costs above:

- The description, ‘Typical’, represents a relative lower compaction requirement (maximum 85% of ASTM D1557 dry density) for fill material, used to construct a basin or hold floor where a groundwater infiltration must be promoted through a softer material.
- The description, ‘Compacted’, represents a standard compaction requirement (minimum 90% of ASTM D1557 dry density) for fill material, use to construct berms which would retain ponded water and prevent seepage of water to downstream.

- The import fill assumes the material source would be within the distance of 5 miles. In the final design phase, potential availability of excess material from other Conservation District or Flood District construction sites must be evaluated, as the availability would likely reduce the import fill unit cost.

Other unit costs were developed based on the recent projects in the area and RS Means Cost Reference book and, if necessary, assisted by USACE's MCACES software.

The quantities of cost items are based on the conceptual-level design drawings, provided by the Conservation District (Attachment I) and determined using Excel spreadsheet. The backup documents for cost estimates and quantity determination are included in Attachment VIII.

No supplemental geotechnical subsurface exploration was included in the cost estimates. The need for the supplemental work and its extents need to be evaluated in future and must be considered as necessary.

The cost for maintenance was not considered, although the maintenance activities to remove current sediment deposits from the basin floor could significantly increase the groundwater recharging efficiency, especially for the operational alternatives. The maintenance activities can be part of the operating agency's periodic basin maintenance cost or, if decided by the Conservation District in the future phase, become a part of the construction cost.

The summary of construction cost estimates for improvement alternatives, considered for the project is in Table 3.2. It should be noted that these conceptual-level design cost estimates are not suitable for construction or planning purposes, but for a comparison purpose between alternatives only. Discussion on the alternative-specific assumptions for each alternative is included in the subsections below.

Table 3.2 – Summary of Total Project Construction Costs for All Alternatives

Facility	Alternative	Alternative ID	Total Project Construction Cost
Waterman Percolation Basin	Grading Alternative	WPBGA	**$29,020,000**
	Operational Alternative	WPBOA	**$1,360,000**
Twin Creek Spreading Grounds	Grading Alternative No.1	TCSGGA1	**$11,790,000**
	Grading Alternative No.2	TCSGGA2	**$96,350,000**
Lynwood Basims	Operational Alternative	LBOA	**$1,922,000**

3.2 Primary Cost Estimate Assumptions for Each Alternative

Below are the primary assumptions for cost estimates for alternatives. These assumptions were made to result in a conservative estimate, when a detailed evaluation or analysis for a certain cost item was not part of the scope of this project.

3.2.1 WPBGA

- The existing double 12-ft by 11-ft high RCB culvert with radial gates (diversion structure No.1C) will be replaced with a new double 7.5-ft wide by 10-ft high RCB. Additional structural reinforcement is assumed for concrete to withstand a traffic loading up to 35 tons.
- All existing outlet culverts will be fully replaced with new culverts. Restoration, modification, or reuse of parts of the existing culverts will need to be evaluated in the final design phase.
- A total of 12 new slide gates will be installed: total of 9 slide gates at 3 basin interties (3 each) and 3 slide gates at the basin outlets 3W(W), 4W, and 5E(W).

3.2.2 WPBOA

- The existing double 12-ft by 11-ft high RCB culvert with radial gates (diversion structure No.1C) will be replaced with a new double 7.5-ft wide by 10-ft high RCB. Considering the alternative considers restoring of full functionality to the existing facility as a primary project goal, at the final design phase, the existing structure will need to be structurally analyzed to determine whether repair or partial replacement could be possible while achieving the project goals. Additional structural reinforcement is assumed for concrete to withstand a traffic loading up to 35 tons.

3.2.3 TCSGGA1

- All existing riprap within the footprint of alternative is assumed to be removed and disposed of offsite and replaced with new material. During the final phase, the condition and sizing of the exiting riprap need to be evaluated for reuse.
- The cost for diversion and control of water to bypass the flows from Twin Creek and Harrison Canyon during construction is included. It is recommended that the construction schedule is determined to avoid a heavy rainy season.

3.2.4 TCSGGA2

- The alternative is a net import earthwork project. It is assumed that the source of fill material is within 5 miles.
- All existing riprap within the footprint of alternative is assumed to be removed and disposed of offsite and replaced with new material. During the final phase, the condition and sizing of the exiting riprap need to be evaluated for reuse.
- The cost for diversion and control of water to bypass the flows from Twin Creek and Harrison Canyon during construction is included. It is recommended that the construction schedule is determined to avoid a heavy rainy season.
- The existing dip crossing over East 40th Street will be replaced with a new bridge and concrete channel underneath it. A new bridge and its abutments will be designed and

constructed by others, but the creek underneath the bridge will be concrete-lined by this project.

3.2.5 LBOA

- Each outlet structure will be improved with a new slide gate housing. According to the design drawings, provided by the Conservation District, each housing will be equipped with the following features:
    - Housing unit
    - Slide Gate Motorized Drive Assembly and Motor (upstream 2 slide gate housings only)
    - 220V Electrical Service Panel with (upstream 2 slide gate housings only)
        - 220V Circuits (Motor)
        - 110V Circuits to Plug and Lighting
    - Lighting Fixture
    - Signal Control Switch - (e.g., DIGI®Universal Asynchronous Receiver/Transmitter (UART))
    - Cellular Data Uplink (e.g., DIGI® Wireless Cellular Router)
    - Radar(acoustic) water level sensor mounted to bottom of catwalk below housing and wired into housing – *This item will be paid for under a separate cost item*.
    - Two remote cameras – (1) for security, (1) for external water and gate conditions observation
    - Air conditioner (upstream 2 slide gate housings only)
    - Door and Lock Security Mechanism
    - Building Passive Ventilation and Insulation

- In the cost estimate, new slide gate housings will be named either 'slide-gate housing' or 'slide-gate power and control housing' to differentiate the housings that are equipped with new motorized drive assemblies and motor to lift the slide gates (i.e. TCSG and Basin No.1) from those that are equipped just with the water level monitoring devices (i.e. Basins Nos.2 through 4).
- The costs for equipment under the cost items, 'Slide-gate Housing' and 'Slide-gate Power and Control Housing', were estimated, based on the cost of similar product or reasonable engineering assumptions, and then adjusted for delivery, installation, and contractor's profit markup, at the conceptual level. This cost is very preliminary at this point and was estimated to be at the rough order of magnitude (ROM) estimate.
- The existing slide gate assembly is not being replaced but will be improved with a new motorized drive assembly to be operated remotely.
- Detailed breakdown of the lump sum unit costs for 'Slide-Gate Housing' and 'Slide-Gate Power and Control Housing' is included in Attachment VIII.

- The existing catwalks and slide gates for the outlets are assumed to be in good conditions and therefore require no replacement or repair. In the final design phase, the structural integrity and size of the existing catwalks and slide gates need to be evaluated to determine whether they need to be replaced or repair.

3.3 Summary of Cost Estimate for Each Alternative

The summary of cost estimate for each proposed alternative are presented below.

Table 3.3 – Summary of Cost Estimate for WPBGA

No.	ITEM	QTY	UNIT	UNIT COST	ITEM COST
1	MOBILIZATION (10%)	1	LS	$1,700,000	$1,700,000
2	CLEAR AND GRUB	115	AC	$5,000	$575,000
3	EXCAVATION	543,899	CY	$5	$2,719,495
4	BACKFILL (TYPICAL)	30,025	CY	$12	$360,300
5	BACKFILL (COMPACTED)	450,476	CY	$16	$7,207,616
6	STRUCTURAL EXCAVATION	133	CY	$55	$7,333
7	EXPORT EXCESS MATERIAL	63,398	CY	$15	$950,970
8	IMPORT FILL (TYPICAL)	-	CY	$21	$0
9	IMPORT FILL (COMPACTED)	-	CY	$25	$0
	PERCOLATION BASINS				
10	DEMOLITION	1	LS	$230,000	$230,000
11	1.5' DIA. RCP	117	LF	$75	$8,775
12	3' DIA. RCP	751	LF	$290	$217,790
13	3.5' DIA. RCP	182	LF	$380	$69,160
14	4' DIA. RCP (Culverts)	734	LF	$500	$367,000
15	4' DIA. RCP (Interties)	1,760	LF	$500	$880,000
16	DROP INLET STRUCTURE	10	EA	$25,000	$250,000
17	OUTLET STRUCTURE	12	EA	$17,000	$204,000
18	SLIDE GATE	12	EA	$75,000	$900,000
19	SPILLWAY (D/S of Basins 2W and 2E)	1	LS	$420,000	$420,000
20	SPILLWAY (D/S of Basins 3W and 3E)	1	LS	$390,000	$390,000
21	SPILLWAY (D/S of Basins 4W and 4E)	1	LS	$350,000	$350,000
22	DIVIDER WALL (D/S of Div Structure)	40	LF	$1,300	$52,000
	DIVERSION STRUCTURE				

No.	ITEM	QTY	UNIT	UNIT COST	ITEM COST
23	DEMOLITION	1	LS	$130,000	$130,000
24	DBL. 7.5'(W) x 10'(H) RCB	1	LS	$250,000	$250,000
25	RADIAL GATE	2	EA	$50,000	$100,000
26	RETAINING WALLS	330	LF	$900	$297,000
27	FLOW METER (INCL STRUCTURE)	1	EA	$15,000	$15,000
28	EROSION CONTROL / SWPPP	1	LS	$50,000	$50,000
	TOTAL BID ITEMS				**$18,701,439**
	CONTINGENCY (30%)				$5,610,000
	DESIGN and PERMITTING (10%)				$1,900,000
	HABITAT MITIGATION MEASURES			TBD	
	CONSTRUCTION ADMIN (15%)				$2,805,000
	TOTAL PROJECT CONSTRUCTION COST				**$29,016,000**

Table 3.4 – Summary of Cost Estimate for WPBOA

No.	ITEM	QTY	UNIT	UNIT COST	ITEM COST
1	MOBILIZATION (20%)	1.00	LS	$100,000	$100,000
2	CLEAR AND GRUB	0.39	AC	$8,000	$3,120
3	EXCAVATION	-	CY	$5	$0
4	BACKFILL (TYPICAL)	-	CY	$12	$0
5	BACKFILL (COMPACTED)	-	CY	$16	$0
6	STRUCTURAL EXCAVATION	-	CY	$55	$0
7	EXPORT EXCESS MATERIAL	-	CY	$15	$0
8	IMPORT FILL (TYPICAL)	-	CY	$21	$0
9	IMPORT FILL (COMPACTED)	-	CY	$25	$0
	PERCOLATION BASINS				
10	DEMOLITION	-	LS	N.A.	$0
11	1.5' DIA. RCP	-	LF	$75	$0
12	3' DIA. RCP	-	LF	$290	$0
13	3.5' DIA. RCP	-	LF	$380	$0
14	4' DIA. RCP (Culverts)	-	LF	$500	$0

No.	ITEM	QTY	UNIT	UNIT COST	ITEM COST
15	4' DIA. RCP (Interties)	-	LF	$500	$0
16	DROP INLET STRUCTURE	-	EA	$25,000	$0
17	OUTLET STRUCTURE	-	EA	$17,000	$0
18	SLIDE GATE	-	EA	$75,000	$0
19	SPILLWAY (D/S of Basins 2W and 2E)	-	LS	$420,000	$0
20	SPILLWAY (D/S of Basins 3W and 3E)	-	LS	$390,000	$0
21	SPILLWAY (D/S of Basins 4W and 4E)	-	LS	$350,000	$0
22	DIVIDER WALL (D/S of Div Structure)	-	LF	$1,300	$0
	DIVERSION STRUCTURE				
23	DEMOLITION	1	LS	$70,000	$70,000
24	DBL. 7.5'(W) x 10'(H) RCB	1	LS	$250,000	$250,000
25	RADIAL GATE	2	EA	$50,000	$100,000
26	RETAINING WALLS	-	LF	$900	$0
27	REGRADING	1000	SY	$20	$20,000
28	FLOW METER (INCL STRUCTURE)	1	EA	$15,000	$15,000
29	EROSION CONTROL / SWPPP	1	LS	$30,000	$30,000
	TOTAL BID ITEMS				**$588,120**
	CONTINGENCY (30%)				$180,000
	DESIGN and PERMITTING				$500,000
	HABITAT MITIGATION MEASURES			TBD	
	CONSTRUCTION ADMIN (15%)				$88,000
	TOTAL PROJECT CONSTRUCTION COST				**$1,356,000**

Table 3.5 – Summary of Cost Estimate for TCSGGA1

No.	ITEM	QTY	UNIT	UNIT COST	ITEM COST
1	MOBILIZATION (10%)	1	LS	$690,000	$690,000
2	CLEAR AND GRUB	24	AC	$5,000	$120,000
3	DEMOLITION	1	LS	$110,000	$110,000
4	DIVERSION AND CONTROL OF WATER	1	LS	$80,000	$80,000
5	EXCAVATION	172,800	CY	$5	$864,000

No.	ITEM	QTY	UNIT	UNIT COST	ITEM COST
6	BACKFILL (TYPICAL)	-	CY	$12	
7	BACKFILL (COMPACTED)	5,300	CY	$16	$84,800
8	STRUCTURAL EXCAVATION	-	CY	$55	
9	EXPORT EXCESS MATERIAL	167,500	CY	$15	$2,512,500
10	IMPORT FILL (TYPICAL)	-	CY	$21	
11	IMPORT FILL (COMPACTED)	-	CY	$25	
12	1/2-TON RIPRAP (NON-CONCRETED)	7,955	CY	$200	$1,591,000
13	1/4-TON RIPRAP (NON-CONCRETED), D/S OF TOTAL 10 INTERNAL BERMS	-	CY	$200	
14	CONCRETE-LINED SADDLED WEIR, D/S OF HOLD 2	1,235	CY	$1,200	$1,482,000
15	CONCRETE-LINING FOR INTERNAL BERM, TOTAL OF 10 INTERNAL BERMS	-	CY	N/A	
16	CONCRETE-LINED CHANNEL AT 40TH STREET	-	CY	N/A	
17	CONCRETE-LINED MAINT. CROSSING	-	CY	N/A	
18	FLOW METER (INCL STRUCTURE)	1	EA	$15,000	$17,000
19	EROSION CONTROL / SWPPP	1	LS	$30,000	$30,000
	TOTAL BID ITEMS				**$7,581,300**
	CONTINGENCY (30%)				$2,270,000
	DESIGN and PERMITTING (10%)				$800,000
	HABITAT MITIGATION MEASURES			TBD	
	CONSTRUCTION ADMIN (15%)				$1,137,000
	TOTAL PROJECT CONSTRUCTION COST				**$11,788,000**

Table 3.6 – Summary of Cost Estimate for TCSGGA2

No.	ITEM	QTY	UNIT	UNIT COST	ITEM COST
1	MOBILIZATION (10%)	1	LS	$5,930,000	$5,930,000
2	CLEAR AND GRUB	127	AC	$5,000	$635,000
3	DEMOLITION	1	LS	$150,000	$150,000
4	DIVERSION AND CONTROL OF WATER	1	LS	$200,000	$200,000
5	EXCAVATION	69,900	CY	$5	$349,500
6	BACKFILL (TYPICAL)	-	CY	$12	$0

No.	ITEM	QTY	UNIT	UNIT COST	ITEM COST
7	BACKFILL (COMPACTED)	-	CY	$16	$0
8	STRUCTURAL EXCAVATION	-	CY	$55	$0
9	EXPORT EXCESS MATERIAL	-	CY	$15	$0
10	IMPORT FILL (TYPICAL)	1,543,800	CY	$21	$32,419,800
11	IMPORT FILL (COMPACTED)	377,481	CY	$25	$9,437,025
12	1/2-TON RIPRAP (NON-CONCRETED)	-	CY	$200	
13	1/4-TON RIPRAP (NON-CONCRETED), D/S OF TOTAL 10 INTERNAL BERMS	5,056	CY	$200	$1,011,200
14	CONCRETE-LINED SADDLED WEIR, D/S OF HOLD 2	-	CY	$1,200	
15	CONCRETE-LINING FOR INTERNAL BERM, TOTAL OF 10 INTERNAL BERMS	11,759	CY	$1,200	$14,110,800
16	CONCRETE-LINED CHANNEL AT 40TH STREET	700	CY	$1,200	$840,000
17	CONCRETE-LINED MAINT. CROSSING	154	CY	$800	$123,200
18	FLOW METER (INCL STRUCTURE)	1	EA	$15,000	$17,000
19	EROSION CONTROL / SWPPP	1	LS	$50,000	$50,000
	TOTAL BID ITEMS				**$65,273,525**
	CONTINGENCY (30%)				$19,580,000
	DESIGN and PERMITTING				$1,700,000
	HABITAT MITIGATION MEASURES			TBD	
	CONSTRUCTION ADMIN (15%)				$9,791,000
	TOTAL PROJECT CONSTRUCTION COST				**$96,345,000**

Table 3.7 – Summary of Cost Estimate for LBOA

No.	ITEM	QTY	UNIT	UNIT COST	ITEM COST
1	MOBILIZATION (10%)	1	LS	$160,000	$160,000
2	CLEAR AND GRUB	0.75	AC	$5,000	$3,750
3	DEMOLITION (TRASH RACK)	1	LS	$5,000	$5,000
4	EXCAVATION	-	CY	$5	$0
5	BACKFILL (TYPICAL)	-	CY	$12	$0
6	BACKFILL (COMPACTED)	-	CY	$16	$0
7	STRUCTURAL EXCAVATION	-	CY	$55	$0

No.	ITEM	QTY	UNIT	UNIT COST	ITEM COST
8	EXPORT EXCESS MATERIAL	-	CY	$15	$0
9	IMPORT FILL (TYPICAL)	-	CY	$21	$0
10	IMPORT FILL (COMPACTED)	-	CY	$25	$0
11	EXCAVATION TO UNCOVER EX. STRUCTURES	2	EA	$5,000	$10,000
12	EX. OUTLET STRUCTURE MODIFICATION (BASINS 2 AND 3)	2	EA	$4,400	$8,800
13	SLIDE-GATE POWER AND CONTROL HOUSING (TCSG AND BASIN 1)	2	EA	$80,000	$160,000
14	SLIDE-GATE HOUSING (BASINS 2 THROUGH 4)	3	EA	$40,000	$120,000
15	EX. CATWALK MODIFICATION	-	EA	N.A.	$0
16	FLOW METER (BYPASSED FLOW IN EX SPILLWAY)	1	EA	$17,000	$17,000
17	FLOW METER (BASIN OUTLETS)	5	EA	$5,000	$25,000
18	EROSION CONTROL / SWPPP	1	LS	$5,000	$5,000
19	UTILITIES	1	LS	$110,000	$110,000
20	SCADA	1	LS	$300,000	$300,000
	TOTAL BID ITEMS				**$914,550**
	CONTINGENCY (30%)				$270,000
	DESIGN and PERMITTING				$600,000
	HABITAT MITIGATION MEASURES			TBD	
	CONSTRUCTION ADMIN (15%)				$137,000
	TOTAL PROJECT CONSTRUCTION COST				**$1,922,000**

4.0 REFERENCES

Tetra Tech. 2023a. ARTP – Waterman, Lynwood Basins, and Twin Creek Spreading Grounds, Feasibility Study Support Professional Services, San Bernardino County, California, Final Hydrology Report, February 2023.

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Appendix C

Field Photos of Twin Creek Recharge Basins Existing Conditions

San Bernardino Valley Water Conservation District
Program for Expansion of Recharge Capacity (PERC) Comprehensive Feasibility Study

Volume 2

Detailed Feasibility Analysis of PERC Project Alternatives at East Twin Creek

Figure N Breached Internal Berm in TCRB Existing Conditions

Figure O Southern Flood Levee at TCRB Looking East - RC Channel Entry and Drain Gate Visible in Background

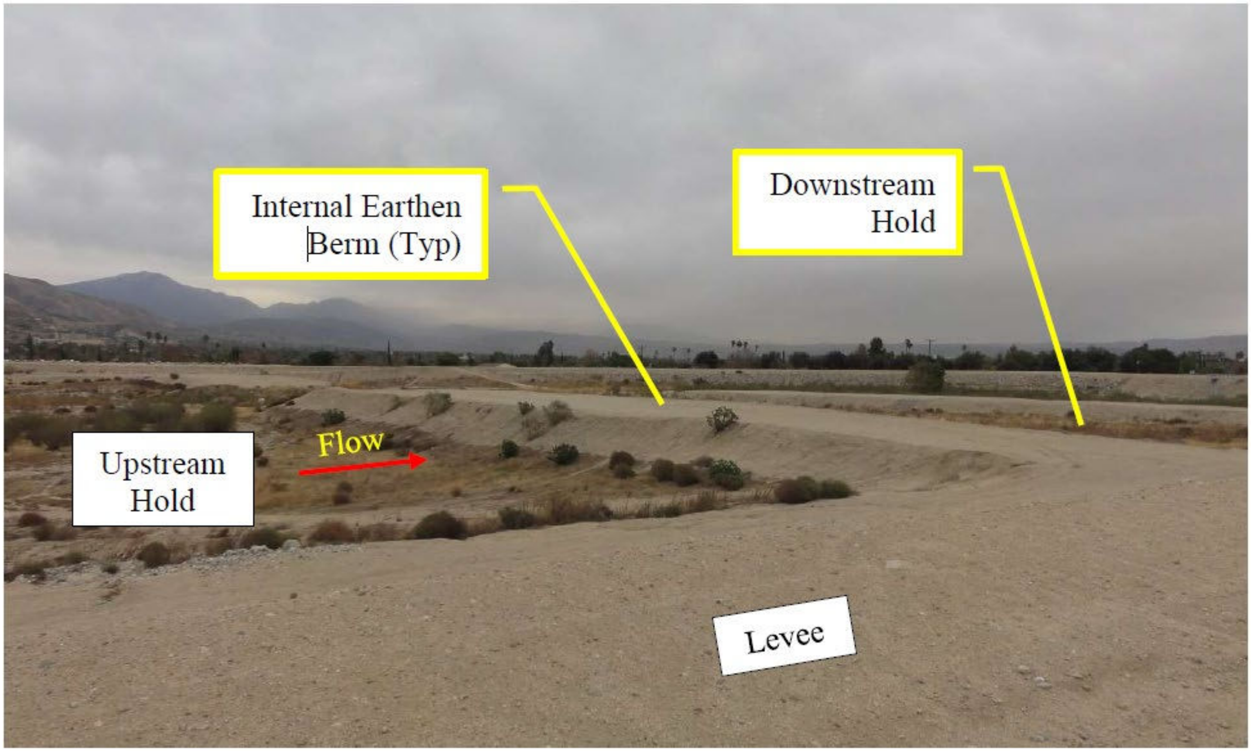

Figure P Typical TCRB Internal Berm and Hold

Appendix D

Field Photos of Lynwood Basin Existing Features for PERC Alternative

San Bernardino Valley Water Conservation District
Program for Expansion of Recharge Capacity (PERC) Comprehensive Feasibility Study

Volume 2
Detailed Feasibility Analysis of PERC Project Alternatives at East Twin Creek

Figure Q - View of Manwalk to Twin Creek Recharge Basins Drain Gate

Figure R - View of TCRB Drain Gate buried by deposits of sand

Figure S - Twin Creek Recharge Basins Drain-Gate Mechanism

Figure T- Lynwood Basin No. 1: 48-inch diameter slidegate over outlet – observed in full open position Nov. 20, 2024

Figure U- Slidegate over outflow in forefront of drop-inlet structure typical for Lynwood Basin Nos. 2 and 3

Figure V - Sidewall of drop inlet to dual-pipe outflow culvert at Basin Nos. 2 & 3 (picture where man was standing)

Figure W - Lynwood Basin No. 4 Drop Inlet and Man walk to Slidegate Mechanism

Figure X - Lynwood Basin No. 4 36-inch diameter Slidegate over outlet pipe - Observed open on Nov. 20,2024