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CARSON STORMWATER AND RUNOFF CAPTURE PROJECT

PRELIMINARY ENGINEERING DESIGN REPORT CARRIAGE CREST PARK

April 19, 2017

SANITATION DISTRICTS OF LOS ANGELES COUNTY

CITY OF CARSON, PUBLIC WORKS DEPARTMENT
701 East Carson Street
Carson, CA 90745

TETRA TECH

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ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
BMP	Best Management Practice
cfs	cubic feet per second
EWMP	Enhanced Watershed Management Program
LACDPW	Los Angeles County Department of Public Works
LACFCD	Los Angeles County Flood Control District
LACSD	Sanitation Districts of Los Angeles County
Los Angeles Regional Board	California Reginal Water Quality Control Board, Los Angeles Region
MS4	Multiple Separate Storm Sewer System
MS4 Permit	Los Angeles Regional Board Order R4-2012-0175, *Waste Discharge Requirements for Municipal Separate Storm Sewer System (MS4) Discharges within the Coastal Watersheds of Los Angeles County, except those Discharges Originating from the City of Long Beach MS4*
NEMA	National Electrical Manufacturers Association
PLC	Programmable Logic Controller
RTC	Real-Time Control
SCADA	Supervisory Control and Data Acquisition
SCAQMD	South Coast Air Quality Management District
SUSTAIN	System for Urban Stormwater Treatment and Analysis Integration
TMDL	Total Maximum Daily Load
WMMS	LACFCD’s Watershed Management Modeling System

EXECUTIVE SUMMARY

This Preliminary Engineering Design Report for Carriage Crest Park was prepared in accordance with the City of Carson's contributions to the Dominguez Channel Watershed Management Area Group (DCWMA Group) Enhanced Watershed Management Program (EWMP). Carriage Crest Park was identified in the EWMP as a high priority site for a regional stormwater capture project due to its proximity to two large storm drains with a total drainage area of 1,146 acres. This area discharges into Wilmington Drain which subsequently discharges into Machado Lake. The overarching objective of the project is to improve the quality of Machado Lake by eliminating dry-weather runoff and reducing wet-weather pollutant loading.

The City of Carson entered into a Cooperative Implementation Agreement (CIA) with Caltrans to fund the Carson Water Capture Project at Carriage Crest Park. The City of Carson entered into a subsequent agreement with the Sanitation Districts of Los Angeles County (LACSD) to manage the project, conduct engineering and geotechnical investigations, and assist with environmental clearance, permitting, design and construction management. This Preliminary Engineering Design Report prepared under the direction of the LACSD provides the City of Carson with 10% design-level documents that address hydrologic, hydraulic, and water quality analytics.

A key constraint for the analysis and design was known contamination in the soil underlying Carriage Crest Park, therefore infiltration cannot be employed for pollutant load reduction or groundwater recharge. Alternative water use and treatment scenarios were therefore explored, including (1) diversion to the sanitary sewer for treatment at the adjacent Joint Water Pollutant Control Plant (JWPCP), (2) onsite non-potable use to offset potable water demand, and (3) onsite filtration using a subsurface filter media bed. To develop an optimized project that maximized pollutant load reduction within the budget of the CIA, the following BMP components were analyzed:

- Channel Diversion System
- Pretreatment
- Stormwater Pump System
- Storage Facility Size
- Active Controls
- Sanitary Sewer Discharge

Several alternative configurations were evaluated in accordance to the CIA with Caltrans. Conceptual layouts and cost estimates were prepared for two of these alternatives. Alternative 1 included a diversion by gravity flow from the storm into a subsurface storage reservoir, and a pump station that subsequently dewaters the facility to the sanitary sewer for treatment at the JWPCP. Alternative 2 also pumps to the sewer for treatment, but the subsurface storage reservoir is built at a shallower depth and a pump is utilized to lift water into the reservoir from the tributary storm drain. Both alternatives recommended:

- diversion from the storm drain at a rate of 30 cubic feet per second (cfs),
- construction of at least 11 acre-feet of subsurface storage under the existing ballfields, and
- nightly discharge to the sanitary sewer at a maximum rate of 20 cfs when capacity is available.

Alternative 1 met the budgetary constraints of the Caltrans agreement while maximizing pollutant removal, and was therefore recommended to reduce pumping operations and maintenance costs. The recommended system was modeled and predicted to overachieve the long-term pollutant load reduction goals for the entire tributary drainage area, while also satisfying the intent of the EWMP by capturing runoff in excess of the City of Carson's 85th percentile runoff volume. In conjunction with the maximum nightly sewer discharge rate, the project is capable of diverting up to 26 acre-feet of stormwater from the 85th percentile, 24-hour design storm. The project is expected to achieve robust and comprehensive pollutant load reduction for all upstream jurisdictions, while also enabling operational flexibility by leveraging sensors and active controls. Continuous monitoring will provide the City of Carson and the LACSD with valuable data to assess and report performance in real-time and to prescribe maintenance as needed. Stormwater captured and diverted to the sewer would also be available for a potential advanced water purification facility to be operated by the Metropolitan Water District; water produced by the facility would augment local drinking water supplies through recharge of groundwater basins in Los Angeles and Orange Counties.

1.0 INTRODUCTION AND EXISTING CONDITIONS

The Dominguez Channel Watershed Management Area Group (DCWMA Group) is comprised of the County of Los Angeles (County), Los Angeles County Flood Control District (LACFCD), and the cities of Carson, El Segundo, Hawthorne, Inglewood, Lawndale, Lomita, and Los Angeles (including the Port of Los Angeles). The DCWMA Group was formed in response to provisions of National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Permit Order No. R4-2012-0175 (Permit). The DCWMA Group, through a cooperative and collaborative process, voluntarily developed an Enhanced Watershed Management Program (EWMP). The Final DCWMA Group EWMP was subsequently approved by the Los Angeles Regional Water Quality Control Board on April 21, 2016 (Figure 1).

Figure 1. The DCWMA Group EWMP and Addendums, approved in April, 2016, identified Carriage Crest Park as a high priority opportunity for stormwater capture

The EWMP identified a suite of watershed control measures and structural Best Management Practices (BMPs). One of the regional structural BMPs identified in the City of Carson's Addendum to the DCWMA Group EWMP was the Carriage Crest Park Project. It was identified as a high priority site for a regional stormwater capture project due to its proximity to two large storm drains with a total drainage area of 1,146 acres. This area discharges into Wilmington Drain which subsequently discharges into Machado Lake.

In order to advance the development of the Carriage Crest Park Project, the City of Carson entered into a Cooperative Implementation Agreement with Caltrans to fund the Carson Water Capture Project. The City of Carson entered into a subsequent agreement with the Sanitation Districts of Los Angeles County (LACSD) to manage the project, conduct engineering and geotechnical investigations, and assist with environmental clearance, permitting, design and construction management.

1.1 PROJECT OBJECTIVES

The objective of this project is to—under the direction and guidance of the LACSD--provide the City of Carson 10% design-level documents. The preliminary design concepts presented herein will be optimized to meet the needs of the DCWMA Group, Caltrans, and the LACSD, as demonstrated by supporting hydrologic, hydraulic, and water quality analytics. At a minimum, the design objectives included elimination of dry weather flow from the adjacent channel, and maximizing wet weather pollutant removal by constructing an 11 to 17 acre-foot regional stormwater capture project. In conjunction with the maximum nightly sewer discharge rate, the project is capable of diverting up to 26 acre-feet of stormwater during the 85th percentile, 24-hour design storm.

1.2 EXISTING SITE CONDITIONS

Carriage Crest Park is a 4.8-acre parcel owned by the City of Carson at the intersection of Figueroa Street and West Sepulveda Boulevard (Figure 2). The park includes basketball courts, ballfields, playground equipment, a parking lot, and several structures. Carriage Crest Park is immediately north of the Joint Water Pollution Control Plant (JWPCP), and the Sanitation Districts have expressed support and interest in diverting captured stormwater to the treatment plant for treatment.

Figure 2. Site location and vicinity map

1.2.1 Concept Data Review

The project concept information for Carriage Crest Park in the EWMP Addendum was reviewed, along with a drainage investigation memorandum for the Carriage Crest Park watershed, dated September 20, 2016. The EWMP concept proposed installation of two diversion structures and two pump stations—one to intercept 85th-percentile wet weather runoff from the 69-inch storm drain that transects the north portion of the park and a second to intercept dry weather flows from the double box culvert running north to south under South Figueroa Street (downstream from the junction of the 69-inch wet-weather diversion. Although this concept would manage substantial wet weather flows from Carson's tributary area to the 69-inch storm drain, it provides little wet weather benefit to other jurisdictions in the Wilmington Drain watershed and recommends installation of two separate pump stations that could be consolidated into one. The project concepts will be reevaluated in this preliminary engineering design report to identify the most cost-effective layout that (1) maximizes pollutant capture within the available budget, (2) minimizes disturbance to existing park facilities, and (3) leverages synergies with concurrent programs.

1.2.2 Utility Data Review, Survey, and Utility Mapping

The existing topographical survey information was compiled by the team using a combination of sources. An aerial survey was performed on September 30, 2016. Field surveys were performed on September 30, 2016. The benchmark used for the survey was the Los Angeles County Department of Public Works Benchmark No. 12236, a standard survey monument disc in the northeast curb of the island located in the northwest corner of the Figueroa Street and Sepulveda Boulevard intersection. The benchmark elevation is 23.1 feet (NAVD 88). Additional information was gathered by using aerial photographs and three site walks. Figure 3 shows the existing site conditions of the project area.

Figure 3. Proposed Carriage Crest Park BMP Project Location

In order to locate all of the existing utilities in the Carriage Crest Park Project area, several sources were utilized. Online resources such as the LA County Department of Public Works have storm drain as-built information and utility base maps available for download directly from the County's website. The County also provides an online Geographical Information System (GIS) Data Portal that contains storm drain and sewer line shape files which were utilized for the project. The City provided information on existing water use and as-builts within the park. Table 1 lists the as-builts found from online County resources and as-builts received from the City. To obtain additional information regarding other utilities such as sewer, water, cable, telephone, gas, oil, and electricity, utility information request letters were sent to the utility purveyors in the area. The utility purveyors are tabulated in Table 2 below. As part of the geotechnical evaluation, Spectrum Geophysics was contracted to perform an on-site utility investigation. Spectrum Geophysics uses a full range of utility locating tools including electromagnetic receivers, conductivity meters, and ground penetrating radar units. All of the collected information was then compiled into one utility base map, shown in Figure 4.

Table 1. As-Builts found Online and Received from the City

As-Built Drawing No.	Project Name
364-1201-D4.1	Carriagedale Drive Lateral (LACFCD)
364-1201-D6.1 to D6.4	County Project No. 1201 Lines A, B, C & D (LACFCD)
99-165	Landscape and Architectural Construction Documents for Carriage Crest Park Renovation

Table 2. Utility Purveyors

Utility	Company	Notified	Responded	Facility Presence
Communications	AT&T	8/23/16	-	-
Communications	Clear Channel Outdoor	8/23/16	-	-
Communications	MCI/Verizon	8/23/16	8/30/16	No
Communications	MediaOne	8/23/16	-	-
Communications	XO Communications	8/23/16	9/13/16	Yes
Electric	Torrance Logistics Company / PBF Energy	8/23/16	10/4/16	Yes
Electric	Southern California Edison	8/23/16	9/2/16	Yes
Oil/Gas	Phillips 66 Pipeline LLC	8/23/16	9/16/16	Yes
Oil/Gas	Brea Canyon Oil Company	8/23/16	-	-
Oil/Gas	Chevron	8/23/16	8/30/16	Yes
Oil/Gas	Plains All American Pipeline	8/23/16	-	-
Oil/Gas	Paramount Petroleum Corporation	8/23/16	8/26/16	Yes
Oil/Gas	Shore Terminals LLC	8/23/16	-	-
Gas	Southern California Gas Company	8/23/16	-	-
Oil/Gas	Shell Oil Pipeline	8/23/16	9/2/16	TBD
Oil/Gas	Tesoro Refining and Marketing Company	8/23/16	9/15/16	N/A
Traffic	Los Angeles County Public Works (Transportation Department)	8/23/16	9/8/16	No
Sewer	Los Angeles County Sanitation District	8/23/16	8/30/16	Yes
Water	Metropolitan Water – Palos Verdes	8/23/16	8/31/16	No
Water	Dominguez Water Company	8/23/16	-	-

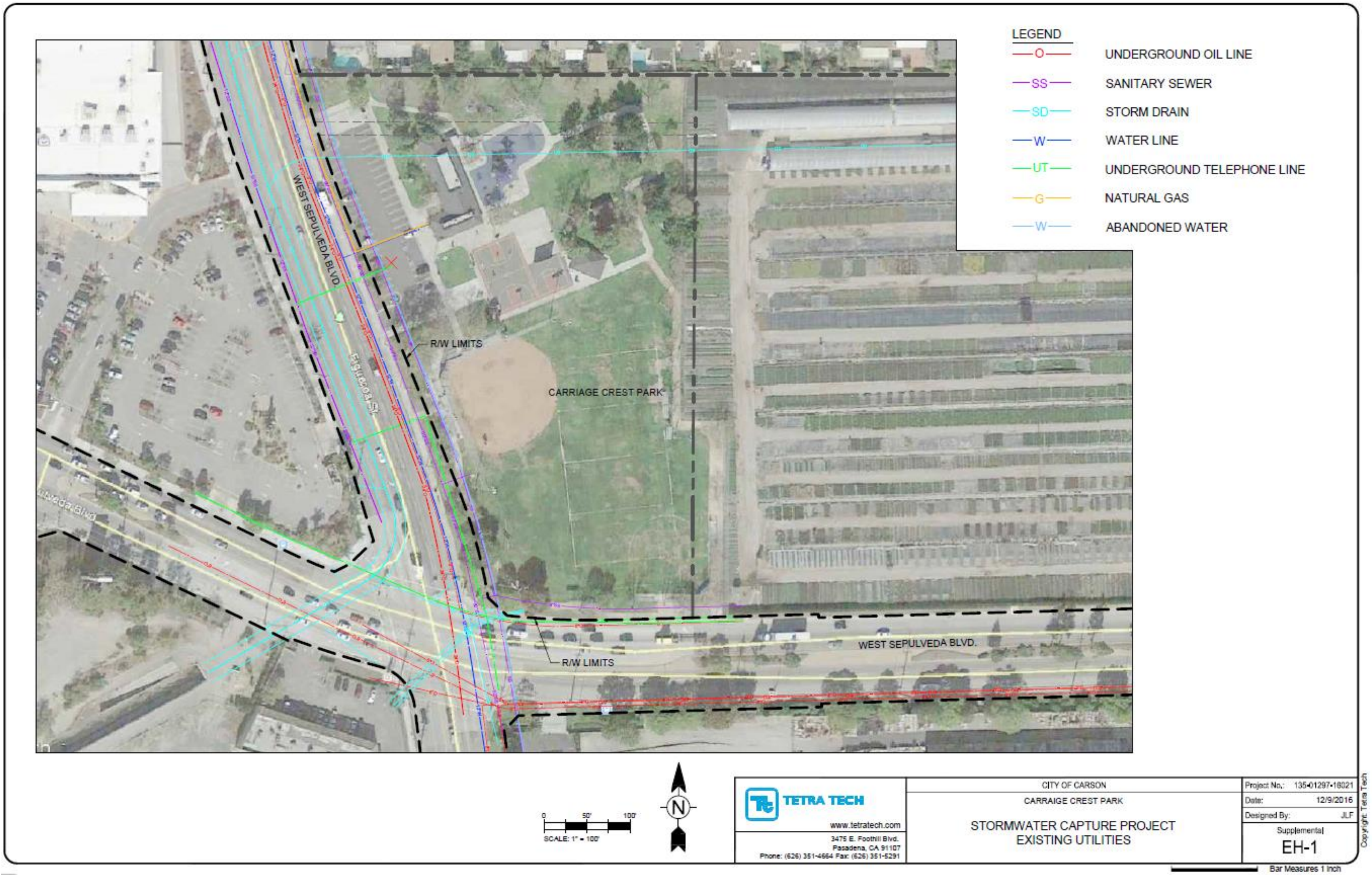


Figure 4. Map of Existing Utilities

1.2.3 Geotechnical Investigation and Soil Contamination Investigation

A geotechnical engineering evaluation for the project was conducted to evaluate the subsurface conditions at the site and to provide recommendations for the design and construction of the proposed improvements. The evaluation included subsurface investigations to an approximate depth of 51.5 feet. Details regarding the field exploration process, sampling and drilling procedures, laboratory testing, standards and equipment used, and the findings from the evaluation are provided in the Draft Geotechnical Investigation Report (Tetra Tech 2016; Appendix A). This section summarizes the findings from the geotechnical evaluation specifically related to the onsite soil types, historic groundwater levels, and existing soil contaminants. General structural design recommendations are covered in detail within the Draft Geotechnical Investigation Report.

1.2.3.1 Existing Soil Types

Based upon the findings from our subsurface investigation, the project site is mantled by artificial fill soils which were encountered across the entire site. The thickness of the fill materials ranged from approximately 4 to 9 feet below the existing surface and the fill materials were typically composed of medium dense, brown to dark olive gray silty sand and clayey sands, stiff dark gray to black lean clay and, light yellowish brown very stiff silt, containing traces of roots, wood fragments, gravel and brick fragments.. Beneath the fill, mostly alluvium and some isolated shallow organic marsh sediments were encountered in the exploratory borings. Locally, these alluvial deposits are classified as near shore alluvial and marsh type deposits. The native alluvium consisted of fine-grained (clay) and coarse-grained (sand) soils. The coarse-grained soils were generally found at a depth ranging from 22 to 25 feet below the ground surface throughout the subject site. In addition, a 2.5 feet thick layer of dark brown to black organic lean clay was observed in B-5 at a depth between 9.5 and 12 feet. Ring and SPT blowcounts within the organic clay layer indicate firm to very stiff consistency. The organic clay layer was observed to have visible organic matter with a strong organic odor, suggesting deposits associated with shallow-water marsh or quagmire sediments.

1.2.3.2 Ground Water

According to the State of California (CDMG, 1998), the historic high groundwater level near the site has been mapped at a depth of about 10 feet. Groundwater was encountered in the Tetra Tech exploratory borings at a depth of approximately 42 to 44.1 feet. A review of the database from the Los Angeles County Department of Public Works (LACDPW) for nearby wells (http://dpw.lacounty.gov/general/wells/) and Geotracker database was also conducted and showed that the shallowest groundwater depth was recorded at 37.2 feet in 2014. Based on the assessment of the local stratigraphy and local topography, it is our opinion that the LACDPW and the Geotracker wells can be utilized for interpretation of the project groundwater conditions. Therefore, it is our conclusion that the groundwater at the site has been deeper than about 35 feet within the last 50 years. Fluctuations of the groundwater level, localized zones of perched water, and increased soil moisture content should be anticipated during and following the rainy season. Based on the research and observed conditions, groundwater is not expected to impact the design and construction of the proposed development.

1.2.3.3 Existing Soil Contamination

Analytical testing was performed on soil samples collected during drilling operations at the Carriage Crest Park Site. The purpose of the testing was to determine whether material proposed to be excavated during site development would require special handling and/or disposal. The sampling program was developed based on a review of previous site (and adjacent site) uses. Sample locations are shown on the Project Layout and Boring Location Map (Figure 5). Although there is no known on-site contaminant source, adjacent properties to the east have been utilized as nurseries, and one adjacent site to the west (across Figueroa Avenue) was the location of an underground storage tank that could potentially be the source of a petroleum hydrocarbon release.

Impacts from the underground storage tank would only be detected at depths greater than the depth at which the tank and/or piping are buried, and would be evidenced by the presence of more mobile contaminants such as Total Petroleum Hydrocarbons (TPH) and Volatile Organic Compounds (VOCs). As a result, samples were collected and analyzed for the entire twenty-foot depth of the borings for these compounds. All samples were collected in accordance with industry standard sample collection protocols and were delivered to Eurofins, Calscience Labs in Garden Grove, California, a State certified analytical testing laboratory.

These results identified no detectable levels of herbicides in any of the samples collected. Furthermore, TPH and VOCs were detected in only isolated, relatively random samples at low concentrations. As a result, it does not appear that these compounds are of significant concern. However, it should be noted that, during drilling operations at the site, petroleum vapors were observed. It is possible that the source of the observed odors were subsurface vapors from the adjacent site that migrated beneath the subject site.

Analyses for pesticides identified several samples with concentrations of 4,4'-DDD, 4,4'-DDE and/or 4,4'-DDT exceeding the California Total Threshold Limit Concentration (TTLC), which is used to define a hazardous waste. No discernable trend in the compound specific impacts was evident across all of the locations and depth intervals. Initially, only samples collected from 1 foot and 5 feet below ground surface were analyzed for these constituents. However, at four of the five locations, concentrations of at least one of these compounds exceeded the TTLC at the deepest depth tested (i.e. 5 feet below ground surface (bgs)); and, at each of these four locations, the concentration of at least one of the compounds increased between the 1-foot and the 5-foot deep samples. Subsequent testing of deeper samples taken at depths of 10 and 15 feet showed a significant drop in concentrations indicating that the impacts are limited to the upper 5 to 8 feet.

Pesticides levels may be elevated due to surface water run-on, airborne particulate deposition, or over-spraying of these chemicals from the adjacent nurseries. Because pesticides and herbicide are typically absorbed in the surface soils and not highly mobile, only samples from the upper five feet were analyzed for these contaminants.

Given that these pesticide impacts were identified at all five of the locations sampled, the soil cuttings from these borings within the upper 8 feet should be considered a California Hazardous Waste and managed accordingly. In addition, any soil excavated as part of any construction activities at the subject site should be tested for pesticides (at a minimum) in accordance with the waste profiling and in conformance with the acceptance criteria of the licensed disposal facility identified for the project.

A detailed summary and results of the analytical soil testing is provided in Appendix B.

1.2.3.4 Infiltration

Infiltration of the captured runoff was not explored in detail due to known soil contamination and groundwater contamination. As infiltration would most likely increase the mobility of the contaminates in the soil into local groundwater aquifers as well as posing a risk to mobilizing existing contamination plumes in the groundwater aquifers, infiltration was not considered as a viable disposal option for the detained runoff.

1.2.3.5 Summary

Based on the results of the field exploration and engineering analyses, it is Tetra Tech's opinion that the proposed construction is feasible from a geotechnical standpoint, provided that the recommendations contained in the Draft Geotechnical Investigation Report are incorporated into the design plans and implemented during construction.

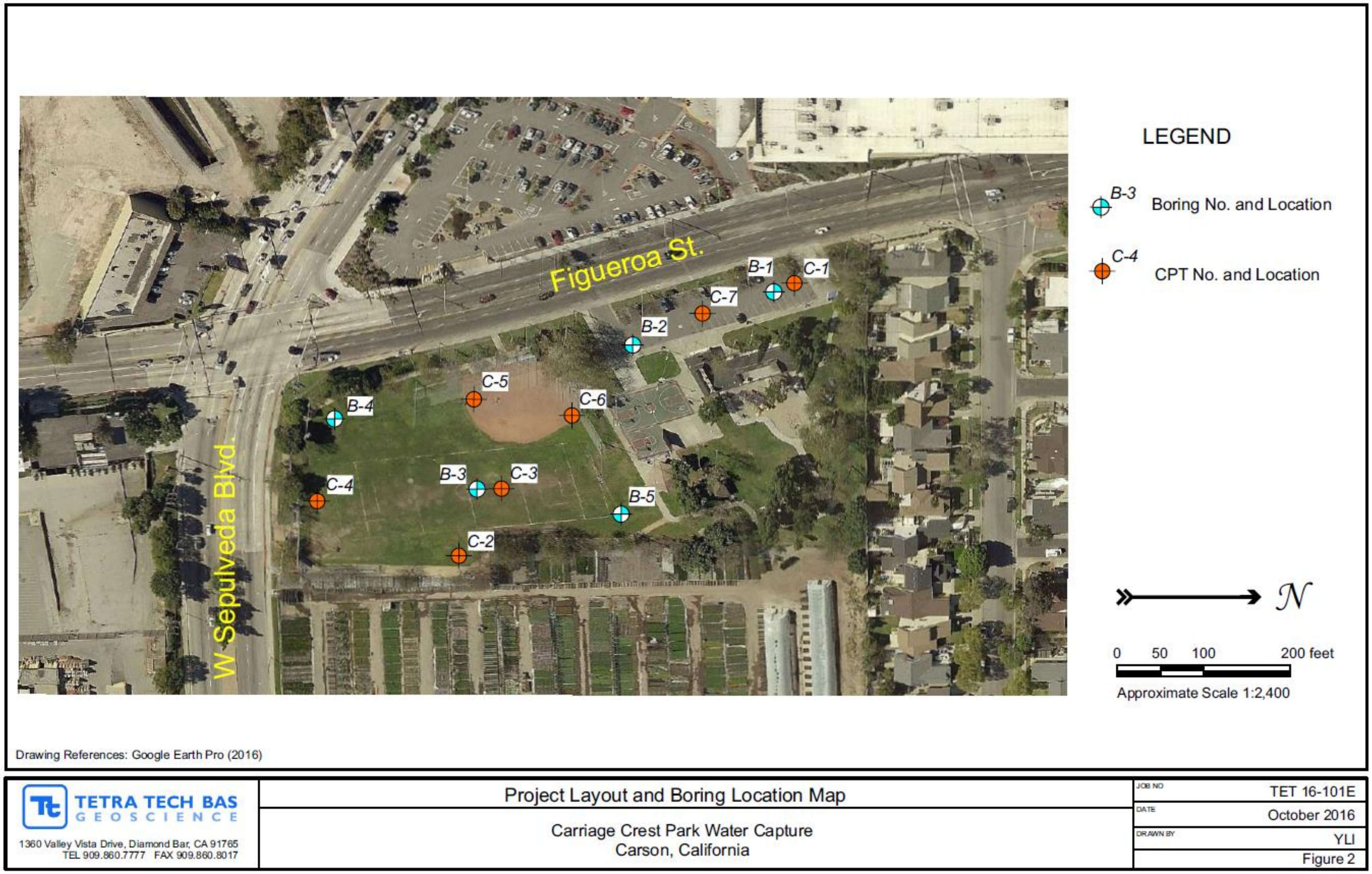


Figure 5. Boring Location Map

2.0 REGULATORY CONTEXT

This section briefly introduces the regulatory background driving the regional stormwater facility at Carriage Crest Park, and discusses strategies for pursuing compliance with the regulations.

2.1 DOMINGUEZ CHANNEL EWMP AND WATER QUALITY DRIVERS

As discussed, the DCWMA Group was voluntarily formed to address the requirements of the Permit. The Group's EWMP focuses on addressing water quality priorities for land tributary to the receiving water bodies of Dominguez Channel, Machado Lake, and Los Angeles Harbor (Figure 6).

Carriage Crest Park is located immediately upstream of Wilmington Drain, which is a flood control channel tributary to Machado Lake; the water quality priorities for Wilmington Drain and Machado Lake (summarized in Table 3) are therefore relevant to the design of the project. Wilmington Drain is a tributary to an inland receiving water in the *Basin Plan for the Coastal Watersheds of the Los Angeles and Ventura Counties* (Basin Plan); as such, the DCWMA EWMP interprets language in the Basin Plan to assume that beneficial uses assigned to downstream receiving water body (i.e., Machado Lake) also apply to upstream tributaries. This interpretation of the "tributary rule" would imply that Wilmington Drain is assigned the following beneficial uses to protect the water quality of Machado Lake:

- WARM: warm freshwater habitat
- WET: wetland habitat
- WILD: wildlife habitat
- REC-1: water contact recreation
- REC-2: non-contact water recreation

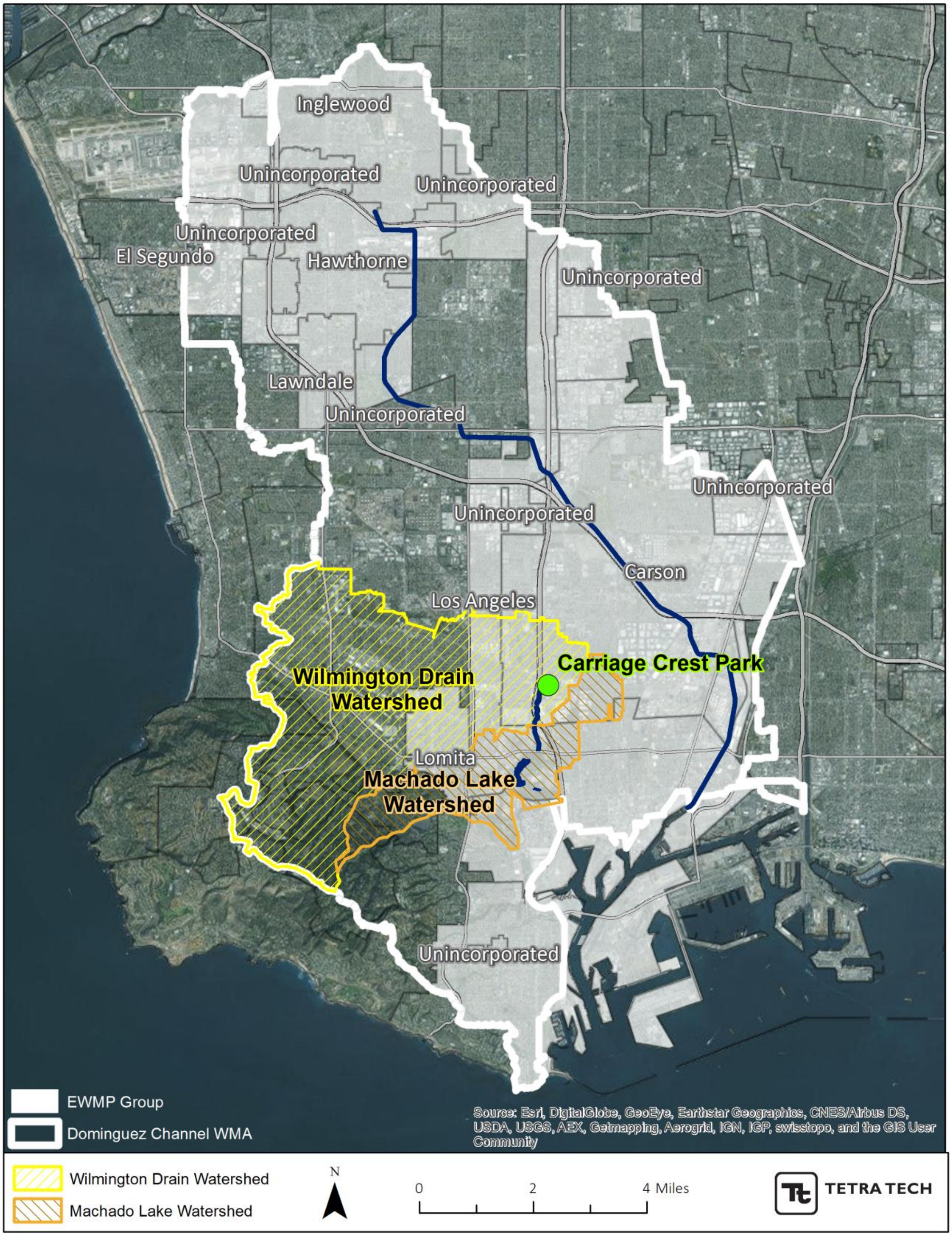


Figure 6. Dominguez Channel WMA boundary, Wilmington Drain watershed, Machado Lake watershed, and Carriage Crest Park location

The DCWMA EWMP proposes several projects to address the beneficial uses and Category 1 water quality priorities for Machado Lake. Purified water from the Terminal Island Water Reclamation Plant (operated by the City of Los Angeles), will be piped into Machado Lake when needed to dilute nutrient concentrations below the applicable receiving water limitations. To minimize the frequency of these lake management events, it is assumed by the DCWMA Group that additional control measures will be needed in the Wilmington Drain watershed to reduce nutrient loading to the lake (D. Petschauer, personal communication, December 7, 2016).

To address trash and sediment, full capture devices will be installed upstream from the water bodies and the frequency of non-structural control measures will be increased (e.g., enhanced street sweeping). Restoration of Machado Lake and Wilmington Drain will also remove residual sediments and associated legacy toxics to address organic compounds.

Given these projects were assumed by the DCWMA EWMP to manage each pollutant to—or below—each respective water quality objective, the EWMP identified the next-highest priority pollutants during a reasonable assurance analysis (RAA). The RAA predicted which pollutant would require the highest effort to address (i.e., the “limiting pollutant”), and used that constituent as the basis for a compliance analysis. As shown in bold in Table 3, bacteria was designated limiting pollutant for both the Wilmington Drain and Machado Lake.

Table 3. Water Quality Priorities Relevant to Carriage Crest Park According to DCWMA EWMP (constituents in **bold font** represent the “limiting pollutant” used for the EWMP RAA)

Water Body-Pollutant Combinations	Wilmington Drain	Machado Lake
Category 1: TMDLs	None	Trash, Total Phosphorus, Total Nitrogen, Ammonia, Chlorophyll-a, PCBs (sediment), DDT (sediment), Chlordane (sediment), Dieldrin (sediment), Dissolved Oxygen
Category 2: 303(d) Listings	**Coliform Bacteria**[3], Copper (dissolved),[1] Lead (dissolved)[1]	None (included in Category 1)
Category 3: Observed Exceedances	Total Nitrogen,[2] DDT (sediment), PCBs (sediment), Chlordane, Dieldrin (sediment)	***E. coli*****,**[3] pH

[1] Monitoring data suggest that metals are meeting water quality objectives and may be considered for delisting

[2] Based on 1 mg/L Machado Lake TMDL (note that regional objective = 10 mg/L). [3] Fecal coliform was modeled as a proxy for *E. coli*

2.2 SENATE BILL 485 AND LOCAL WATER SUPPLY DRIVERS

Dry weather runoff has been effectively managed via low-flow diversions by sanitation districts throughout Southern California, although wet weather runoff has traditionally been considered off limits. Pursuant to Senate Bill 485, the LACSD are now authorized to manage dry weather *and* stormwater runoff to assist local jurisdictions within the District's service area to comply with stormwater-related regulatory requirements. This has significant implications on the stormwater capture strategy at Carriage Crest because the project site is located directly upstream of the JWPCP and has limited onsite treatment opportunities. Senate Bill 485 enables the proposal of innovative solutions for stormwater management at Carriage Crest Park.

Although water quality improvement is the primary motivation for this project, local water supply augmentation presents an ancillary benefit. The JWPCP currently provides primary and secondary treatment before disinfecting and discharging to the ocean outfall. The Metropolitan Water District of Southern California, in partnership with the LACSD, will construct a 500,000 gallon-per-day demonstration project at the JWPCP and will consider a potential full scale project to treat up to 150 MGD for indirect potable reuse. Stormwater contributed to the plant could provide an additional local water resource to supplement the process.

3.0 DECISION SUPPORT MODELING

The purpose of the Carriage Crest Park project is to maximize pollutant and stormwater capture; therefore, alternative system configurations were modeled to quantify potential performance. This is particularly important to inform the design process, because Carriage Crest Park has limited available BMP footprint space (meaning that practical hydraulic considerations like diversion structure design and pumping rates may substantially impact performance). The following sections briefly summarize the strategy to most accurately simulate these realistic engineering constraints while optimizing the system configuration.

3.1 BASELINE CONDITIONS AND CONSTRAINTS

The following subsections summarize the compliance metrics, baseline runoff and pollutant loading, onsite water demand, and sanitary sewer constraints used to inform modeling.

3.1.1 Stormwater Compliance Metrics

The MS4 Permit requires that EWMP projects be sized, where feasible, to retain the 85th percentile design storm volume to achieve multiple benefits (including flood management and water supply augmentation) above and beyond water quality improvement. Capture of the 85th percentile design storm volume was therefore used as the primary compliance metric for the following modeling analysis.

Assessing performance using multiple metrics provides higher certainty that the recommended configuration will achieve water quality improvement and satisfy the requirements of the MS4 Permit. Therefore--in addition to 85th percentile design storm capture—long-term pollutant load reduction was also used as a metric to optimize the system configuration within the budgetary constraints of the available Caltrans funding. As discussed in section 2.1, bacteria was deemed the limiting pollutant for Wilmington Drain in the EWMP RAA under the assumption that the Machado Lake management project will fully manage nutrients and will preclude the need to reduce nutrient loading to Wilmington Drain; however, the optimization analysis herein will target long-term total nitrogen reduction to enable the City of Carson flexibility to advance towards EWMP compliance independent of the Machado Lake management project. This strategy will protect the City in the event that unforeseen issues occur with the lake management project or if the cost to opt in is prohibitive. As discussed earlier in section 2.1, the proposed recycled water line to Machado Lake will allow response to elevated contaminants, but still relies on upstream reduction of total nitrogen loading by control measures like the proposed Carriage Crest Park project.

Furthermore, the DCWMA EWMP suggests that management of total nitrogen would also manage all other water quality priorities, including bacteria. Sizing based on total nitrogen will therefore allow the City of Carson to present the Los Angeles Regional Water Quality Control Board with a conservative project that achieves comprehensive pollutant load reduction with higher certainty.

This two-pronged compliance analysis provides a more robust demonstration that the project configuration will attain comprehensive yet cost-effective pollutant reduction, and will perform in the long term under variable storm types and sizes.

3.1.2 Watershed Characterization

For this study, the Los Angeles County Watershed Management Modeling System (WMMS) was used within the Loading Simulation Program C++ (LSPC) to simulate the contaminant loading, runoff volume, and flow rate associated with a long-term, continuous time series (Water Year 2001 to Water Year 2011). The WMMS is accepted by the Los Angeles Water Quality Control Board for performance of compliance analyses in the context of EWMP development.

The drainage area delineation to Carriage Crest Park was updated on the basis of field investigations and high-resolution Light Detection and Ranging (LiDAR) elevation data, as shown in Figure 7. The revised delineation incorporated an additional area of approximately 30 acres of local drainage to catch basins located on the northwest and northeast corners of the Sepulveda Boulevard and Figueroa Street intersection. Total and impervious areas tributary to the project from each jurisdiction are tabulated in Table 4; note that a small portion of Caltrans right-of-way is also tributary to the project, although as-built plans for Caltrans' MS4 infrastructure could not be obtained to precisely verify this (minor) portion of the contributing area.

Long-term baseline flows and pollutant loads to the site are also summarized by jurisdiction in Table 4. The total loadings presented in this table represent the maximum possible reductions that could be achieved by control measures at Carriage Crest Park, albeit pragmatic diversion limitations, space constraints, and subsequent treatment mechanisms will ultimately limit how much runoff and pollutant mass can potentially be diverted out of the main channel (as further discussed in section 3.2).

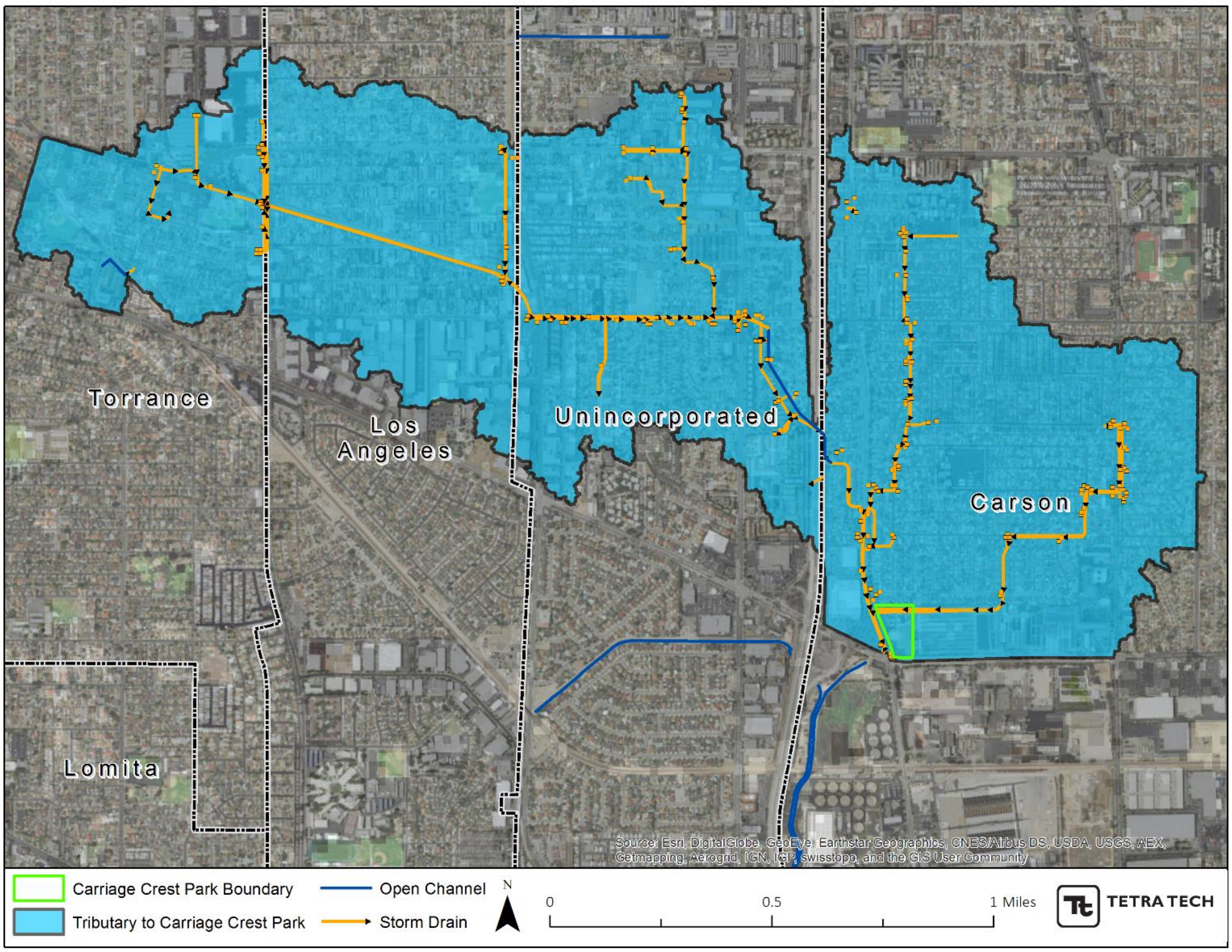


Figure 7. Drainage area delineation to Carriage Crest project site.

Table 4. Summary of contributing drainage area, baseline runoff, and pollutant loads

Jurisdiction	Total Tributary Area (ac)	Impervious Tributary Area (ac)	Average Annual Runoff (ac-ft)	Average Annual TN Surface Flux (lb) [1]	85th Percentile Surface Runoff (ac-ft)
Carson	455	201	233	1,300	15
Unincorporated	319	171	171	853	11
Los Angeles	234	155	146	804	10
Torrance	138	84	86	476	6
Total	1,146	611	636	3,433	43

[1] Note that this represents land surface loading contributed to the MS4, and that the baseline loading transported to Carriage Crest was predicted to be slightly less (3,014 lb of TN) due to storage and reduction processes occurring within the channel during the course of the simulation.

3.1.3 Onsite Baseline Water Demand Estimation

Carriage Crest Park is currently irrigated using potable water. One potential fate of captured stormwater is onsite use to offset potable irrigation, as well as other non-potable purposes such as toilet flushing. To simulate this water use alternative, water use reported in the previous year's water bill was estimated and tabulated on a monthly basis (Figure 8). For modeling purposes, the monthly demand was assumed to occur at a constant daily rate.

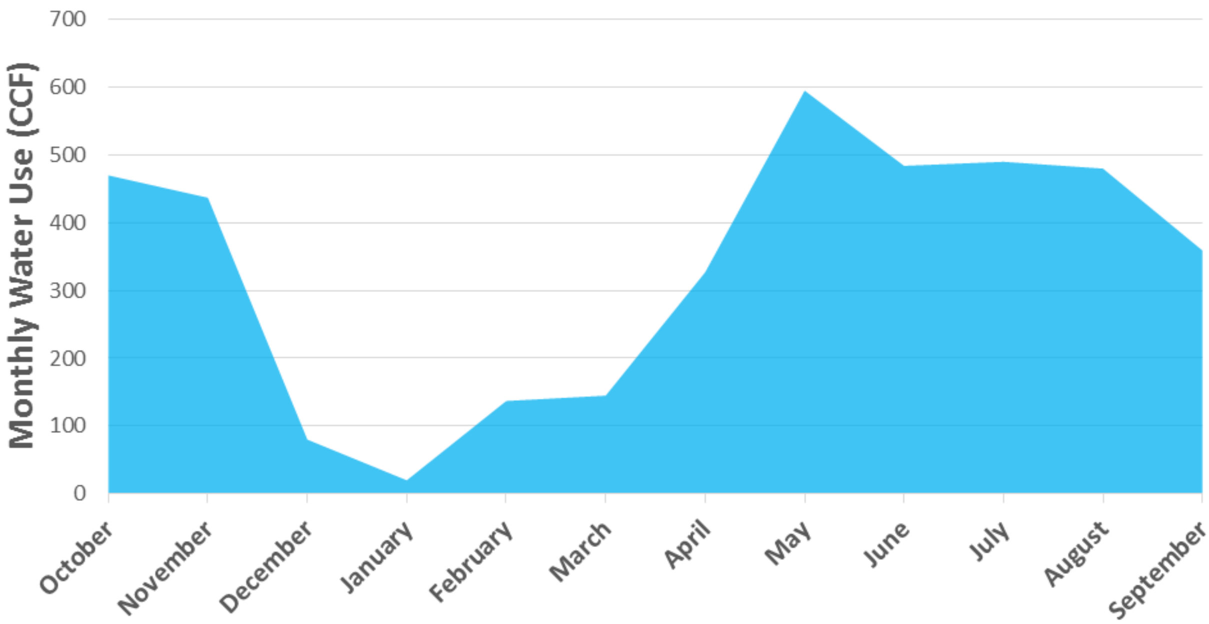


Figure 8. Water demand at Carriage Crest Park interpreted from water bill data

3.1.4 Sanitary Sewer Discharge Constraints

Controlled discharge to the sanitary sewer for treatment at the adjacent JWPCP provides another potential fate for captured stormwater. This alternative would rely on real-time control (RTC) systems to time the discharge such that the sanitary collection system and the downstream JWPCP would not be overwhelmed or adversely impacted by stormwater contributions. In practice, this will be accomplished by instrumenting sewer manhole D225 with a sensor that will limit stormwater discharges to only when capacity is available. To simulate this variable discharge rate (in order to predict pollutant load reduction and inform system design) in the absence of long-term monitoring data in this particular sewer, fluctuations in sewer capacity needed to be estimated using available data.

According to the LACSD, the dry weather peak flow rate in the sanitary sewer at manhole D225 is approximately 29 cfs, and the maximum safe capacity is 74 cfs. This implies—in the absence of inflow and infiltration (I&I) caused by storm events—that the sewer typically has at least 45 cfs of capacity available to accept stormwater inputs during dry weather. This available capacity will decrease following wet weather as I&I throughout the extensive sewershed contributes to sewer flow.

To predict the relative increase in sewer flow due to I&I throughout the modeled period, an analysis was performed using all 72 rain gauges throughout the JWPCP sewershed (Figure 9). The rainfall during each hour of the modeling period was summarized along with the 6-hour, 12-hour, 24-hour, 48-hour, and 72-hour cumulative rainfall for each timestep. These data were combined with identifiers for the day of the week and the hour of the day to generate 463 input data points for each modeled hour of the simulation. The input data were compared with hourly JWPCP primary effluent flow rates (available from July 1, 2008, through April 30, 2011) to identify patterns between long-term rainfall throughout the sewershed and I&I-induced increases on plant flows (Figure 10). The predictive I&I model was trained using the first approximately 700 days of monitoring data (approximately 7.8 million data points), then the I&I model was validated using the last 700 days of monitored data. The predicted JWPCP flows were then compared to average (median) conditions at the plant to identify the relative variance from normal for each hour of the 10-year simulation. The flow at manhole D225 was assumed to respond proportionally to the relative variance observed or predicted at the plant; for example, if the flow rate at the JWPCP during a certain hour was predicted 25% higher than normal, it was assumed that the sewer adjacent to Carriage Crest Park was also flowing 25% fuller than the normal dry weather peak flow rate of 29 cfs.

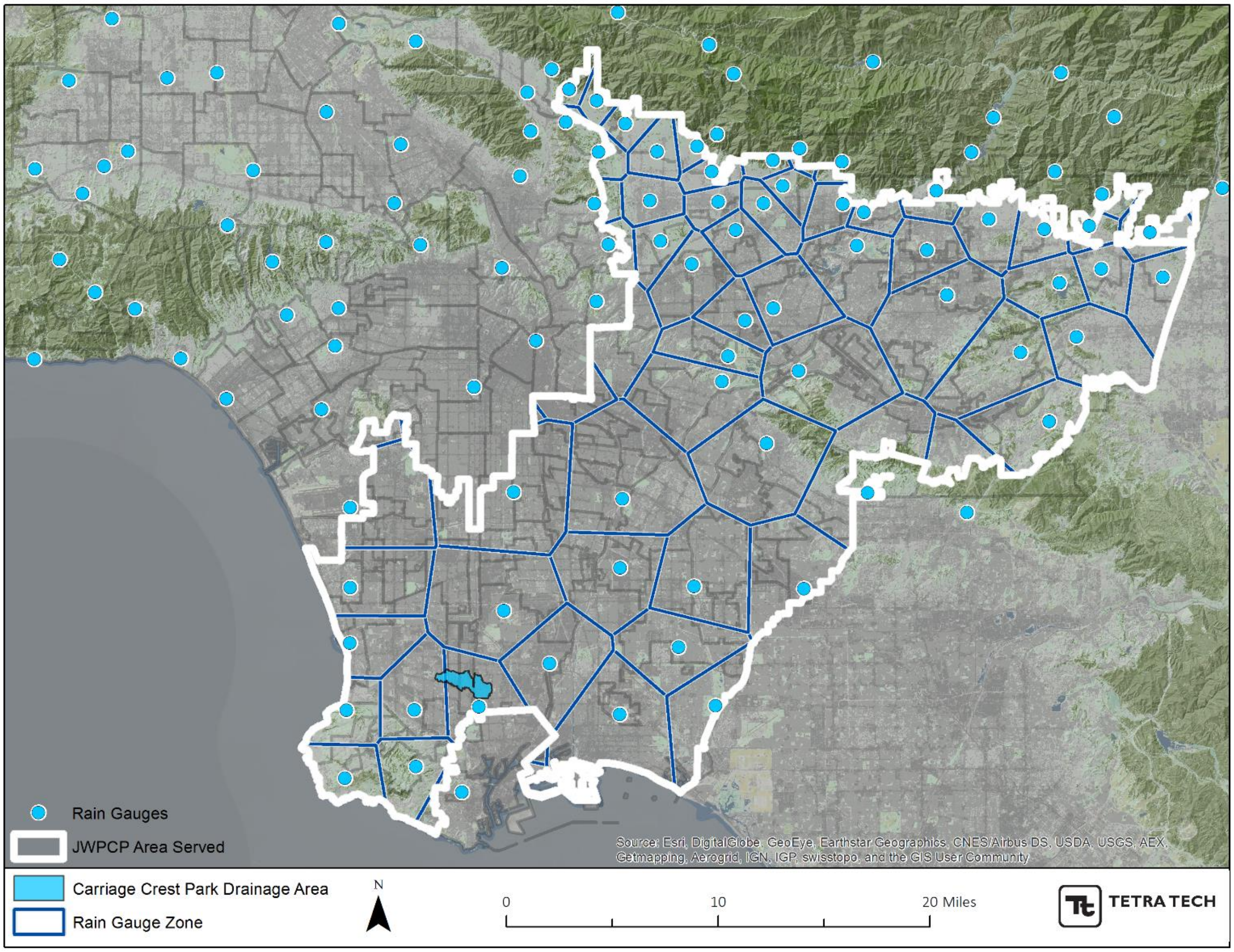


Figure 9. Rain gauges used for I&I analysis

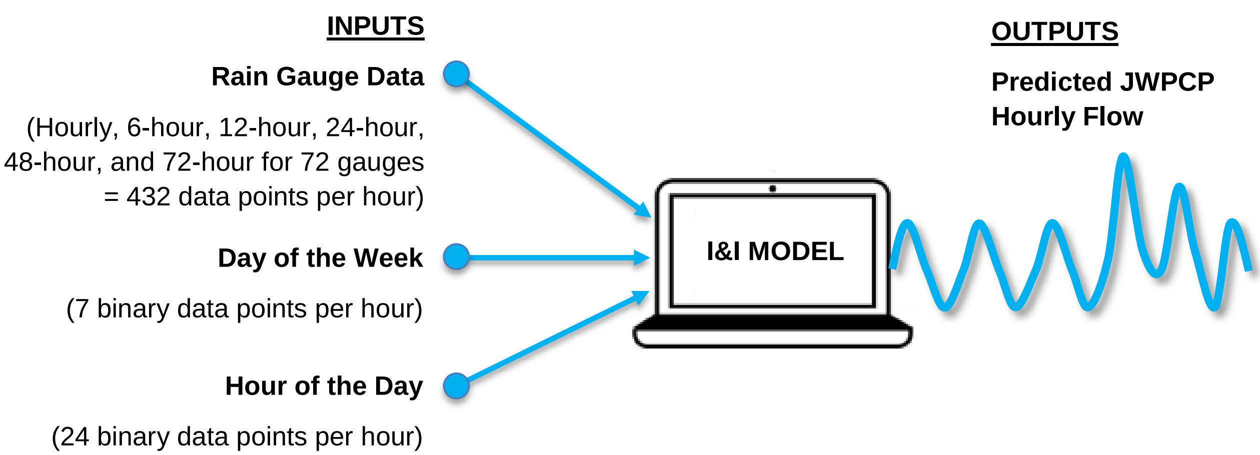


Figure 10. Conceptual schematic of predictive I&I model inputs and outputs

Results of the I&I analysis suggested efficient prediction of the JWPCP flows, as reflected by the agreement metrics reported in Table 5. When applied to the validation dataset, the I&I model-predicted outputs demonstrated excellent agreement with the actual observed data. The model was therefore fed rain-gauge data available from October 1, 2001, through June 30, 2008, to predict the historical JWPCP flow rates for which observed data were not available. The predicted and observed flow rates were compared to median observed flow conditions to compute the relative increase in flows due to I&I, and those relative increases were applied to the sewer flow rates to calculate the maximum allowable discharge to the sewer during each hourly modeled timestep. This maximum allowable discharge rate will be further constrained by the pump capacity and operational scenarios selected in subsequent analyses.

During subsequent modeling, four sewer discharge operational scenarios were analyzed:

- **Nightly Dewatering:** Discharge to sewer allowed only between the hours of 10pm and 8am
- **24/7 Dewatering:** Discharge to sewer allowed any time
- **Dry Weather Operation:** Discharge to sewer occurs only during dry weather conditions in sewer
- **Wet Weather Operation:** Discharge to sewer occurs as long as sewer capacity is available even during a rain event

Table 5. Agreement metrics for sewer I&I model over calibration and validation periods

Metric Comparing Predicted JWPCP Flow to Observed Flow	Calibration Period (700 days)	Validation Period (700 days)
Coefficient of Determination (R^2)	0.81	0.89
Nash-Sutcliffe Model Efficiency (NSE)	0.81	0.89
Root Mean Square Error (RMSE)	0.03	0.02

3.2 WATER QUALITY OPTIMIZATION STRATEGY

As discussed in preceding sections, the primary design goal of the Carriage Crest project is to reduce long-term annual loading of total nitrogen, bacteria, and other pollutants to Wilmington Drain and Machado Lake. To ensure that the system will be sized to maximize load reductions within the budgetary constraints of the Caltrans funding, optimization modeling was performed.

The purpose of optimization modeling is to balance design components (including BMP volume, inflow diversion rate, and outflow discharge rate) such that no one component limits the performance of the system (Figure 11). Optimization supports decision making throughout the design process by guiding selection of the most cost-effective system design.

The model setup for water quality simulation and optimization is complex, involving several modeling systems and iterative feedback from design engineers. The general methodology is discussed below, and the results are presented in section 3.3.

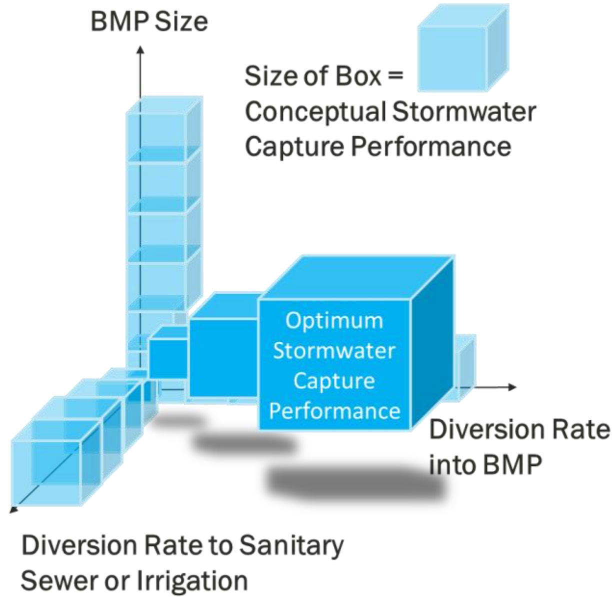


Figure 11. Conceptual illustration of optimization modeling balancing various design components to maximize performance

3.2.1 Preliminary Size and Diversion Optimization (SUSTAIN)

The first step of the modeling was to predict BMP performance for a range of potential BMP sizes, diversion inflow rates, and water-use alternatives (onsite irrigation or discharge to sanitary sewer). EPA's System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) model was used for this analysis because its built-in optimization algorithms automate the process of evaluating millions of different BMP configurations to select a cost-effective solution. The model was run using 10 years of runoff and pollutant loading timeseries data generated by the WMMS at an hourly timestep. During this preliminary decision-support modeling, the water-use alternatives were simulated using the following simplified assumptions:

- Irrigation was performed daily at the average monthly rate calculated from the preceding year of water bill data, and
- Discharge to the sanitary sewer was performed nightly from 10:00pm through 8:00am at a constant rate.

These preliminary optimization model runs produced cost-effectiveness curves that relate each combination of design components to the respective pollutant or stormwater capture performance. Comparing the relative differences between various water-use scenarios allowed decisions to be made regarding which scenarios to pursue more detailed modeling, and which are not cost-effective.

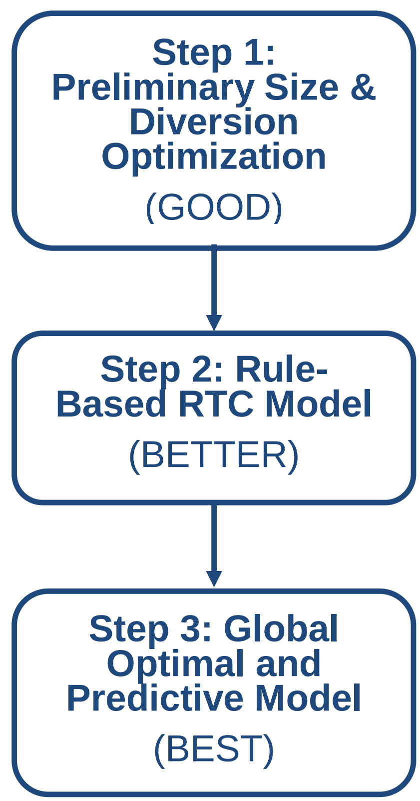


Figure 12. Optimization model workflow

3.2.2 Rule-Based RTC Model (r-bRTC)

After preliminary sizing and diversion rates were assessed with SUSTAIN, the selected optimal solutions were evaluated using a rule-based RTC (r-bRTC) model to generate more accurate predictions of stormwater and pollutant capture. The model operates using similar hydraulic algorithms as SUSTAIN, and previous validations comparing SUSTAIN-modeled and r-bRTC-modeled hydraulics have reported Nash-Sutcliffe Efficiencies of 0.98. The r-bRTC model simulates the functionality of RTC technology by applying predefined rules to actively control the flow of water into and out of the BMP. The sanitary sewer flows discussed in section 0 were fed into the r-bRTC model to enforce hourly constraints on maximum sewer discharge (i.e., to simulate the conditions when stormwater cannot be discharged to the sewer because it is flowing full with I&I). The results were used to report potential pollutant reductions and predict volumetric sewer discharge over the 10-year simulation period accounting for wet weather sewer limitations.

3.2.3 Global Optimal and Predictive Model (Csoft)

The Csoft software package was next used to validate the performance of real-time controls at Carriage Crest Park under advanced control logic that will maximize the performance of the facility. Csoft is currently actively used for hydraulic control and optimization of combined sewer systems throughout the United States (e.g., in Louisville, Kentucky, and Wilmington, Delaware) and internationally (e.g., Montreal, Quebec City, and Ottawa, Canada; and Paris and Bordeaux, France). Csoft links directly to existing Supervisory Control and Data Acquisition (SCADA) systems to support operators by optimizing the control setpoints throughout the sewer network (i.e., the software identifies when valves, gates, and pumps should be operated to manage overall system performance). It is the ideal model for this application in which flows and storage must be actively controlled to enforce certain constraints and multiple objectives must be optimized over a long-term simulation.

During this analysis, the software was used in simulation mode to evaluate storm-drain flows, capacity within the BMP at Carriage Crest Park, and predicted sewer capacity during each hour of the long term simulation, and optimized for each timestep with setpoints for routing of water throughout the system.

The optimization of setpoints was performed using algorithms to prevent the sewer capacity from being overwhelmed, while also maximizing stormwater capture and pollutant removal. Optimization was bounded by operational constraints described in section 0. Cost functions were built into the model to maximize water capture during nighttime hours. Because the Csoft simulation is computationally intensive, as it computes global optimal and predictive control at hourly timesteps, the benefits were summarized for one representative wet year (water year 2011) within the 2001-2011 timeframe.

3.3 OPTIMIZATION MODELING RESULTS

The following subsections describe the results of optimization modeling used to support project design.

3.3.1 Optimum BMP Configuration

The optimization analysis aimed to maximize the long-term pollutant load reduction and 85th- percentile design storm volume capture by simultaneously varying the BMP size, diversion rate into the BMP, and dewatering rate from the BMP to the sanitary sewer within the available project budget. Because infiltration is not available at the BMP site, the total volume diverted into the BMP will be restricted by the size of the BMP and the rate at which stored water can be pumped to the sanitary sewer. By optimizing based on three variables, multiple pathways to EWMP target compliance were identified and the most cost-effective alternatives were investigated.

Figure 13 and Figure 14 display the results in a cost-benefit chart, where each point on the chart represents a unique combination of BMP size, diversion rate into the BMP, and maximum discharge rate to the sanitary sewer for each operational scenario. Recall that dry weather operation allows discharge only during dry weather conditions in the sewer, while wet weather operation allows discharge to the sewer if any capacity is available. The chart is also color-coded on the basis of equivalent design storm capture. For the purpose of this analysis, each respective design storm was considered fully captured if the design storm runoff volume and peak flow could be accommodated by the modeled alternative configuration.

The onsite non-potable use alternative was also modeled but results are not displayed in Figure 13 and Figure 14 because insignificant nitrogen reduction was achieved for the range of analyzed diversion flow rates and BMP sizes. Poor performance was attributed to relatively low daily usage that never fully dewaters the storage chamber throughout the 10-year simulation. This water use alternative was therefore deemed inefficient for water quality improvement vis-à-vis diversion to the sanitary sewer, though it does provide an option to offset onsite potable and non-potable water demand (as further discussed in section 4.5).

The optimum BMP configuration that maximizes long-term pollutant load reduction for the available budget is identified on each chart, which is **11 acre-feet of storage, 30 cfs diversion from the storm drain, and 20 cfs maximum discharge rate to the sewer**. This option represents the most cost-effective configuration for pollutant removal based on the relative costs of the various design components. The recommended optimum configuration is also capable of capturing runoff in excess of the 85^{th} percentile equivalent storm volume attributed to the City of Carson's contributing area for a total capture volume of 26 acre-feet during the 85^{th} percentile, 24-hour design storm.

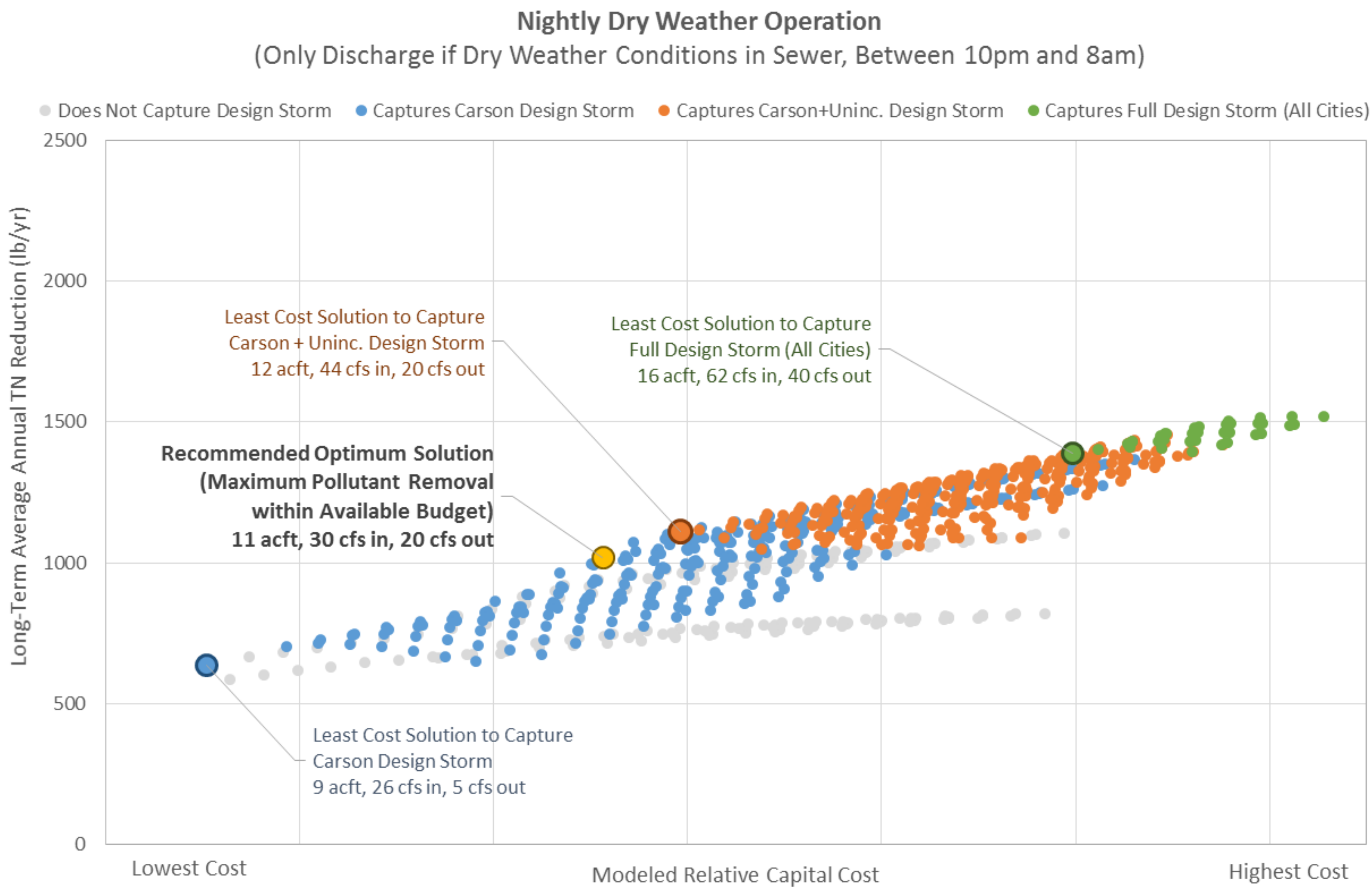


Figure 13. Cost-benefit analysis for nightly dry weather operation (each point on the chart represents a unique combination of BMP size, diversion rate, and dewatering rate.

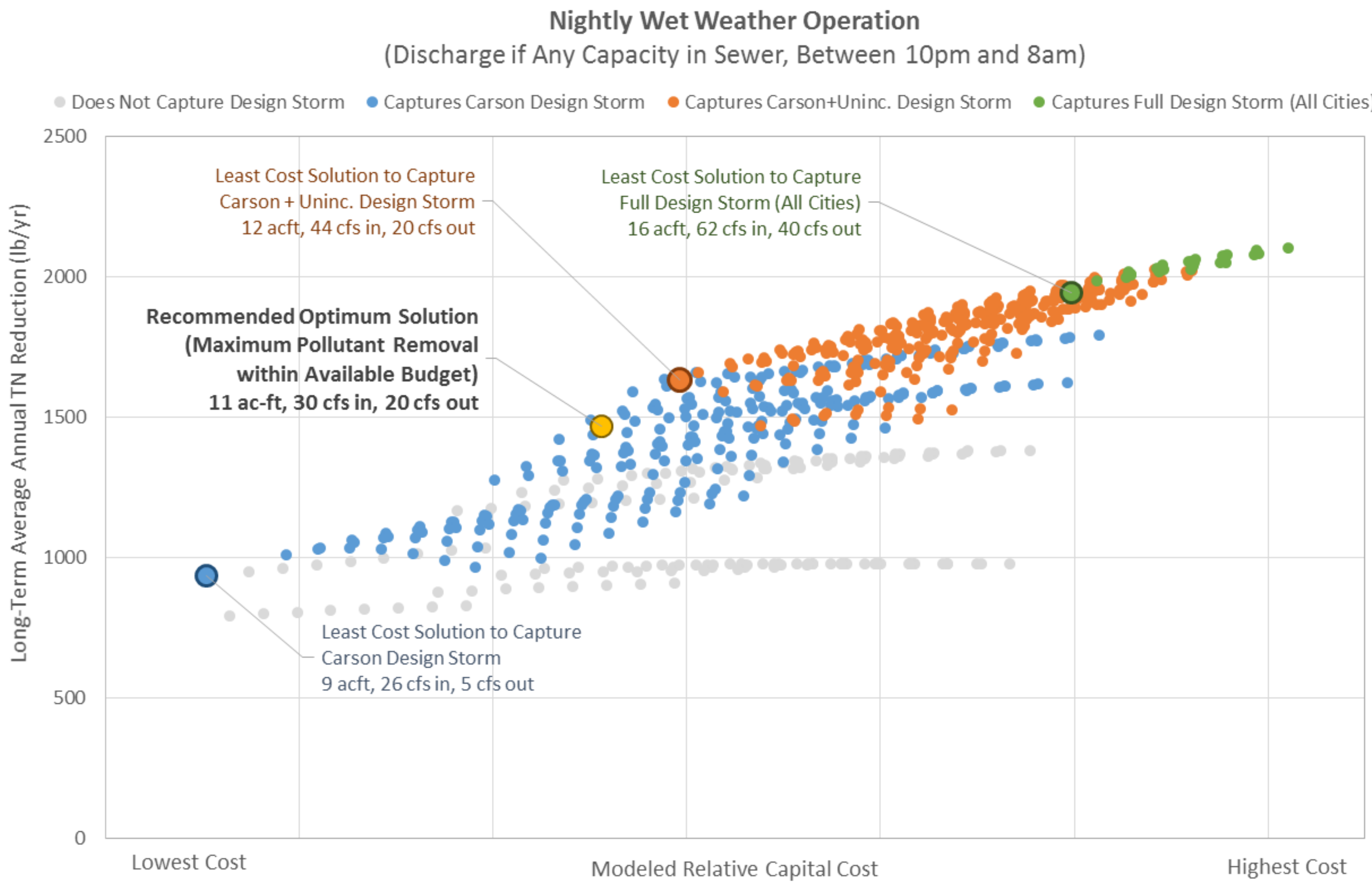


Figure 14. Cost-benefit analysis for nightly wet weather operation (each point on the chart represents a unique combination of BMP size, diversion rate, and dewatering rate.

One additional alternative configuration that was considered—but ultimately not recommended—was a filtration option, where diverted runoff would be filtered through a media bed then pumped back to the channel. Although this option could provide substantial removal of sediment-bound pollutants, stormwater sand filters can be unreliable for nutrient reduction when inadequate residence time is allowed (Barrett 2008; Geosyntec Consultants and Wright Water Engineering 2012; Hunt et al. 2012). Hydraulic limitations of a flow-through system would also substantially limit the amount of water that could be diverted into the system (for example, a typical media filtration rate of 5 inches per hour translates to a flux of 5.5 cfs if media were installed across the entire bottom of the 1.1-acre facility). Throttling the flow rate to 5.5 cfs would severely limit total nitrogen removal compared to what was predicted for the sanitary sewer diversion. Finally, the operations and maintenance burden of a filtration system was considered cost prohibitive when compared to the operational efficiencies of treating the same volumetric and mass loads at the downstream JWPCP (the next subsection discusses wastewater treatment surcharge costs).

3.3.2 Operational Cost-Benefit Analysis

The proposed BMP configuration can be operated in a variety of ways to achieve the goals of the DCWMA Group and minimize costs. For example, regulating the flow rate into the BMP or the dewatering rate to the sewer allows the City of Carson to operate the BMP to solely manage their equivalent runoff. The LACSD levies a treatment surcharge for water discharged into the sanitary sewer, so operational flexibility also enables minimization of treatment costs by targeting nightly discharge (which does not incur a costly peak flow charge). Although the 24/7 dewatering scenario was also modeled, it is not recommended nor reported herein because treatment costs were computed orders of magnitude higher than the nightly dewatering scenario due to the peak flow surcharge.

To evaluate different operational scenarios, and to investigate potential cost sharing opportunities, the treatment surcharge was calculated for the alternative configurations shown above in Figure 13 and Figure 14 using the methods in the LACSD *2015-2016 Long Form Wastewater Treatment Surcharge Statement.* Treatment surcharges were calculated for both an average water year (based on 10 years of modeled runoff capture) and the 90th percentile wet year (Water Year 2011) to investigate the range of potential annual costs. The annual sewer discharge volumes were calculated for the average and wet year conditions using the modeling system discussed in section 3.2.2. For simplicity of future surcharge computations, mass loading of chemical oxygen demand and suspended solids were calculated using median stormwater concentrations (53 mg/L and 58 mg/L, respectively) reported in the National Stormwater Quality Database (Pitt et al. 2004).

Treatment costs are reported in Figure 15 and Table 6 for the optimum solution and also for the lowest cost operational scenario that exclusively manages the City of Carson's contributing area. The lowest cost scenario was determined by minimizing the discharge rate to the sewer in the modeling system until only the equivalent design storm runoff from the City of Carson was captured. Iterative modeling suggested that the minimum discharge rate for the 11-ac-ft BMP to exclusively capture the City of Carson's design storm was 3 cfs (assuming a 30-cfs maximum inflow diversion rate). The configuration was then modeled over the average year and wet year using the maximum discharge rate of 3 cfs to estimate the *annual* volume discharged to the sewer in each scenario. The results suggest that, under the optimum operation scenario, the City of Carson would carry the financial burden of treating runoff from other jurisdictions, whereas under the exclusive operational scenario the City of Carson could operate the facility such that it only treats their equivalent design storm runoff.

Options for apportionment of treatment surcharge costs between contributing jurisdictions is discussed in section 5.2.

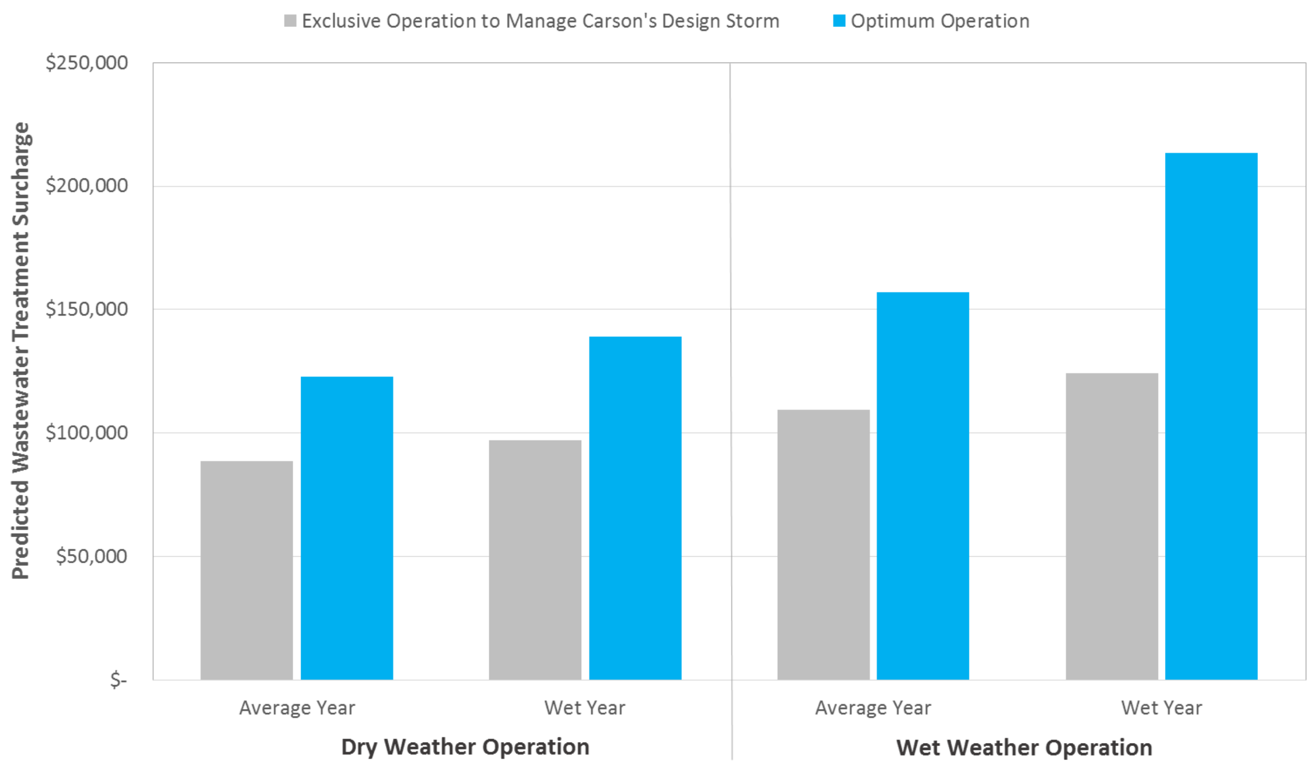


Figure 15. Predicted treatment surcharge costs under various operational scenarios and rainfall conditions

Table 6. Tabulation of predicted treatment surcharge costs under various operational scenarios and rainfall conditions

Operational Scenario	Evaluation Period	Estimated BMP Diversion Volume (3 cfs max. dewatering rate) (AF)	Approximate Annual Treatment Cost if Exclusively Operated for City of Carson (3 cfs max. dewatering rate)	Estimated BMP Diversion Volume (20 cfs max. dewatering rate) (AF)	Approximate Annual Treatment Surcharge at Optimum Operation (20 cfs max. dewatering rate)
Nightly Dry Weather Operation	Average Year	252	$ 88,778	349	$ 122,846
	Wet Year	275	$ 96,998	394	$ 138,938
Nightly Wet Weather Operation	Average Year	310	$ 109,415	446	$ 156,988
	Wet Year	353	$ 124,261	606	$ 213,540

The preceding results were generated using the rule-based logic in the r-bRTC model. Operations were also optimized using Csoft simulations of the proposed configuration, but the model produced nearly identical simulation results for the “wet year” (Water Year 2011) compared to the r-bRTC model. This is attributed to the relatively simple objective function to maximize nightly dewatering based on the given constraints. The production of nearly identical results by the two models validates the utility of Csoft as a decision support tool that can be used in practice to yield maximum water quality performance. In subsequent analyses, the Csoft model’s global optimal and predictive control would have a more significant impact on flow management, with respect to the objectives of catching peak flows and pollutants, if at least one of the following conditions is fulfilled:

- Coordination is required with upstream capture facilities, such as a control measure proposed by the City of Torrance within the drainage area to Carriage Crest
- The pumping capacity significantly exceeds the residual capacity of the sanitary sewer (i.e., such that it is possible to pump more than the storage capacity during a rainfall event)
- The BMP has a smaller storage capacity (i.e., such that during a rainfall event happening during periods where the residual sanitary treatment capacity is null, it is not possible to pump 20 cfs during the entire rainfall event into the BMP)

These results are predicated on limited sewer flow data. Once sewer flows are better characterized, a similar analysis could employ Csoft’s ability to incorporate meteorological forecasts to simulate predictive dewatering of the facility to the sewer such that runoff is not contributed during peak sewer flow.

3.3.3 EWMP Compliance Analysis

As discussed in section 3.1.1, assessing performance using multiple metrics provides higher certainty that the recommended configuration will achieve long-term, comprehensive pollutant load reduction and satisfy the requirements of the MS4 Permit. To evaluate total nitrogen reduction relative to water quality objectives, modeled monthly average total nitrogen concentration for baseline runoff to Carriage Crest Park compared to the Machado Lake objective (1 mg/L). Total nitrogen concentrations were tabulated on a monthly average basis consistent with the TMDL, which expresses monthly average effluent and receiving water limitations. To compute the equivalent annual load reduction required to lower concentrations to the objective (if volume reduction were ignored), the exceedance load for each month of the simulation period was summed and divided by the length of the simulation period. The targeted annual average total nitrogen load reduction using this method was 1,203 pounds, or a 40 percent reduction from baseline (using the in-channel baseline loading). In other words, capturing 40 percent of total nitrogen load on an average annual basis would reduce the same long-term mass loading to Wilmington Drain as would reducing effluent concentrations to the monthly objective of 1 mg/L with no volume reduction. This method was also used to compute a load reduction target for a 90th percentile year (Water Year 2011), consistent with the RAA guidelines.

Table 7 reports the proposed regional BMP performance predicted on the basis of long-term and design-storm targets (for the nightly wet weather operation scenario). The BMP is predicted to meet (and overachieve) the target load reductions corresponding to the average year and the 90th percentile wet year. Recall that the DCWMA EWMP suggests that management of total nitrogen would also manage all other water quality priorities, including bacteria.

Modeling results indicate that the BMP configuration would also capture design storm volumes in excess of the equivalent 85th percentile volume from the City of Carson. The combined results suggest that the recommended system meets the water quality improvement goals for the City of Carson’s contributing area and precludes the need for other BMPs upstream.

Table 7. Comparison of EWMP Compliance Metrics

Metric	Target Reduction	Predicted Reduction	Percentage of Target Met	Commentary
Long-Term Metrics				
10-Year Average Annual Load Reduction	1,203 lb (40%)	1,471 lb (49%)	**122%**	The proposed configuration overachieves target reductions for annual metrics; residual load reductions can be credited to other areas of Wilmington Drain watershed.
90^{th} %-ile Year (2011) Load Reduction	1,922 lb (39%)	2,310 (47%)	**120%**	
Design Storm Metrics				
85^{th} %-ile, 24-hour Storm Volume Reduction (All Cities)[1]	38 ac-ft (100%)	26 ac-ft (70%)	**70%**	The 85^{th} percentile storm for the entire contributing area was also substantially managed and the City of Carson's equivalent design storm runoff was fully captured.
85^{th} %-ile, 24-hour Storm Volume Reduction (City of Carson Area Only)	15 ac-ft (100%)	26 ac-ft (173%)	**173%**	

[1] Drainage-area-wide 85^{th} percentile capture volume targets were established on the basis of baseline flows predicted in the storm drain, which slightly differs from the raw land surface runoff ("edge of stream") reported in section 3.1.1 due to in-channel storage and losses simulated during the design storm in the WMMS.

3.4 SUMMMARY OF DECISION SUPPORT MODELING

Hydrology and water quality were analyzed to inform data-driven project design and to provide regulators and stakeholders with assurance that the Carriage Crest Park project will substantially contribute towards compliance with water quality drivers outlined in the DCWMA EWMP. Optimization modeling and engineering judgement suggest that the following BMP configuration and operation will enable cost-effective runoff and pollutant capture:

- **11 acre-feet of BMP storage (in addition to in-channel storage afforded by the diversion structure)**
- **30 cfs diversion from the storm drain**
- **20 cfs maximum discharge rate to the sanitary sewer**
- **Nightly wet weather operation (relying on sensors in the sewer to discharge only when sufficient capacity is available**

Progress towards satisfying the goals of the DCWMA EWMP were estimated using an array of metrics, including the 85^{th} percentile, 24-hour design storm and long-term annual pollutant load reduction. The modeling suggested that the recommended configuration can capture runoff volumes and peak flows equivalent to the City of Carson's 85^{th} percentile design storm (in accordance with the MS4 Permit sizing criteria for EWMP projects), and will also reduce long-term total nitrogen and bacteria loading to Wilmington Drain, and ultimately, Machado Lake. Excess stormwater capture by the recommended configuration (above and beyond requirements exclusively for the City of Carson) can potentially be used to justify cost sharing of annual O&M costs.

The variability and potential limitations of shorter-term metrics (e.g., 90^{th} percentile critical months and critical days) was also discussed to guide future project planning throughout the watershed.

4.0 BMP DESIGN COMPONENTS

This section presents the engineering and design components recommended for Carriage Crest Park on the basis of preceding decision support modeling to capture both dry weather and wet weather flows from the drainage network.

4.1 DIVERSION STRUCTURES

As previously discussed, the project site is located in the proximity of a confluence of multiple storm drain systems, which enables the opportunity to capture runoff volume from multiple tributary drainage areas and provide multi-jurisdictional partnerships. In order to maximize the amount of runoff volume conveyed to Carriage Crest Park, multiple diversion structures are being proposed. The first diversion will be located within the LACFCD double 10’9” wide by 6’7” high reinforced concrete box (RCB) also referred to as “BI 1201 – Line A.” The proposed diversion structure within the RCB will consist of two inflatable rubber dams, similar to the gates manufactured by Obermeyer Hydro Inc., within each side of the double RCB. The rubber dams are proposed to be 2 to 3 feet tall when fully inflated and match the width of each side of the RCB. The center and east walls of the RCB will be cored at the invert of the RCB, just upstream of the rubber dams, to enable runoff to be diverted into the pretreatment device located within the park. The rubber dams will allow for the impoundment of approximately one to two acre-feet of water. The water impounded will extend approximately 1,922 feet within the LACFCD RCB (BI 1201 – Line A) and approximately 810 feet in the LACFCD Carriagedale Drive 69” RCP Lateral (see Appendix C for the delineated extent of the impoundment). The diversion cores proposed within the RCB will be sized to capture dry and wet weather flows. It will serve as the main inlet to convey flows to the pretreatment device. The diversion will look similar to Figure 16. The rubber dam controls will be located with the pump station control panel(s) also located within the park.

Grated drop inlets are commonly used for diversion structures within channels and were considered as an option for this project. In order to divert runoff from both sides of the double RCB there would either need to be a drop inlet constructed within each side of the double RCB and connected to each other below the invert of the structure, or a section of the RCB would need to be reconfigured to allow the drop inlet to extend across the entire invert of the structure and through the center wall of the double RCB. Both of these configurations would require the removal and replacement of the top and bottom of the existing RCB, which would create constructability challenges and potential structural concerns. Although this approach is feasible, coring through the existing walls of the RCB is preferred, as it limits the impact on the existing structure.

The storm drain system at the point of diversion was analyzed using Los Angeles County’s Water Surface Pressure Gradient (WSPG) model to evaluate whether the proposed diversion structure would disrupt the water surface profile and impact upstream flooding during the 50-year average recurrence interval peak flow of 883 cfs. If adverse impacts were predicted, the diversion structure height would be iteratively decreased until an acceptable water surface profile was achieved. The modeling suggested no adverse impacts would be expected from installation of a two- or three-foot rubber dam that deflates to a height of four inches (water surface elevations increase by less than 3 inches). The design storm flow was also simulated with a three-foot-high weir to investigate the impacts of a situation where the rubber dam fails to deflate in high flows; the water surface pressure gradient still did not exceed the ground surface elevation with a three-foot weir, suggesting that flood risk is managed by this design.

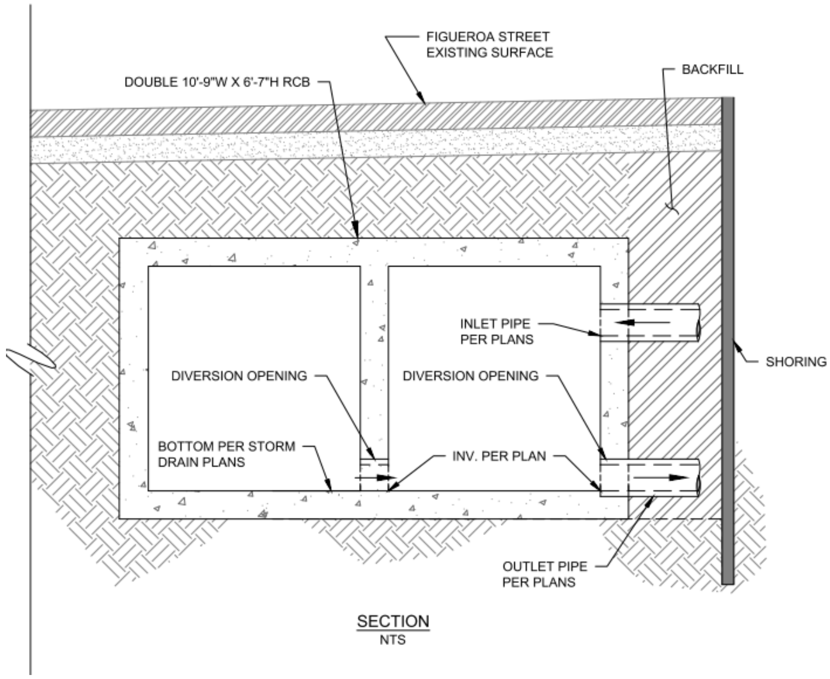


Figure 16. RCB Diversion Structure

The second and third diversion structures will be located adjacent to the upstream side of the existing catch basins located at the northeast corner of the intersection of West Sepulveda Boulevard and Figueroa Street. The catch basins will either include pretreatment filters or drain directly to a central pretreatment device before draining into the storage system. The catch basin outlets will be sized to convey both dry weather and wet weather runoff. These diversion structures will look similar to one shown in Figure 17.

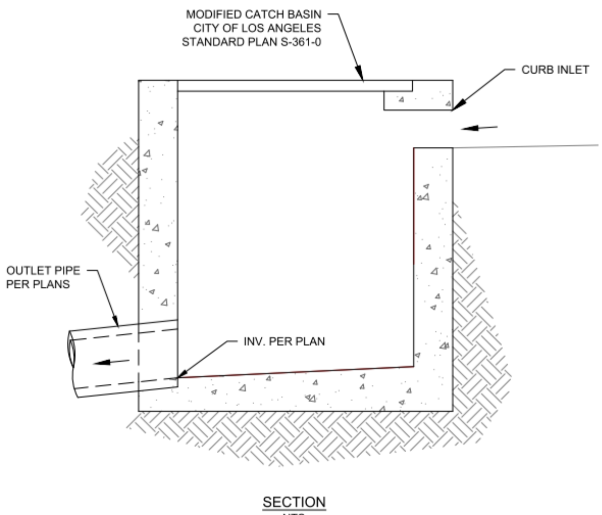


Figure 17. Catch Basin Diversion Structure

4.2 PRETREATMENT

Stormwater runoff transports sediment, metals, nutrients, trash, and debris that can compromise the performance of stormwater facilities and pollute receiving waters. Pretreatment will be an integral component of the treatment strategies to extend the life of the system. It will be prescribed in order to reduce the maintenance frequency of the Carriage Crest Park stormwater facilities, focus maintenance efforts to a concentrated area, and bolster compliance.

Depending on the configuration of the storm drain diversions and pump station location, two pretreatment alternatives are being considered. The first alternative incorporates two pretreatment devices combined with a designed capacity of up to 30 cfs. Options for the centralized devices include, but are not limited to, the following: Contech CDS (Continuous Deflective Separation) unit, the Stormceptor, and the Bio Clean Nutrient Separating Baffle Box. The second alternative would incorporate the same type of unit as well as potential catch basin inlet inserts to provide pretreatment for the catch basins diverting runoff from Figueroa Street and West Sepulveda Boulevard. All of these units are described in the following sections. Other similar units are also readily available. The final selection will be made during the design phase.

4.2.1 Hydrodynamic Separators

A typical hydrodynamic separator collects the stormwater runoff on one or more sides of the structure where it then directs the water into a separation chamber where water begins swirling, forcing the particles out of the runoff. One hundred percent of floatables and neutrally buoyant debris larger than the screen aperture (2400 microns or 2.4 mm) is collected and settle in the isolated sump of the system, eliminating scour potential. Hydrodynamic separators typically have an 80 percent removal rate of total suspended solids (TSS). With the chambered system, hydrocarbons float to the top of the water surface and are prevented from being transported downstream. Systems such as the Contech CDS units are designed with a hydrocarbon baffle to contain hydrocarbons within the device. A target flow rate for each of the devices will be based on the final design of the diversion structure. Currently a total of 30 cfs is anticipated to be diverted to up to two pretreatment devices. Each will be designed to have the capacity to treat the maximum flow diverted to each unit. The size of the unit will also be based on the estimated sediment that is anticipated to be removed to minimize the routine maintenance required. Figure 18 represents a typical Contech CDS type hydrodynamic separator.

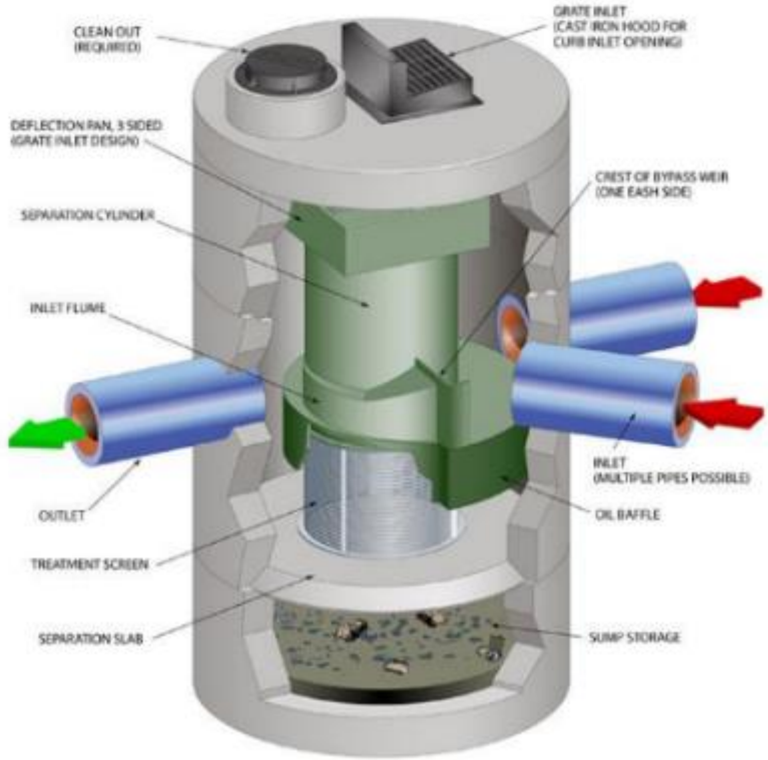


Figure 18. Typical Hydrodynamic Separator (Source: Contech Engineered Solutions)

As a consideration for the quality of water that will be sent to the sanitary sewer system (and to protect the pumping systems from fouling), a Nutrient Separating Baffle Box (NSBB) by BioClean Environmental Services is also being considered as a pretreatment solution. At a total flow rate of up to 30 cfs, the NSBB is available in two models varying in the level of treatment (i.e., 150 microns vs. 250 microns). The NSBB system uses screens that are suspended above the sedimentation chambers that capture and store trash and debris. TSS is removed by routing the flows through a triple chambered system. An oil skimmer with hydrocarbon booms traps and absorbs oil. The NSBB system can remove more than 80 percent of TSS. Figure 19 illustrates the typical operation of a NSBB system.

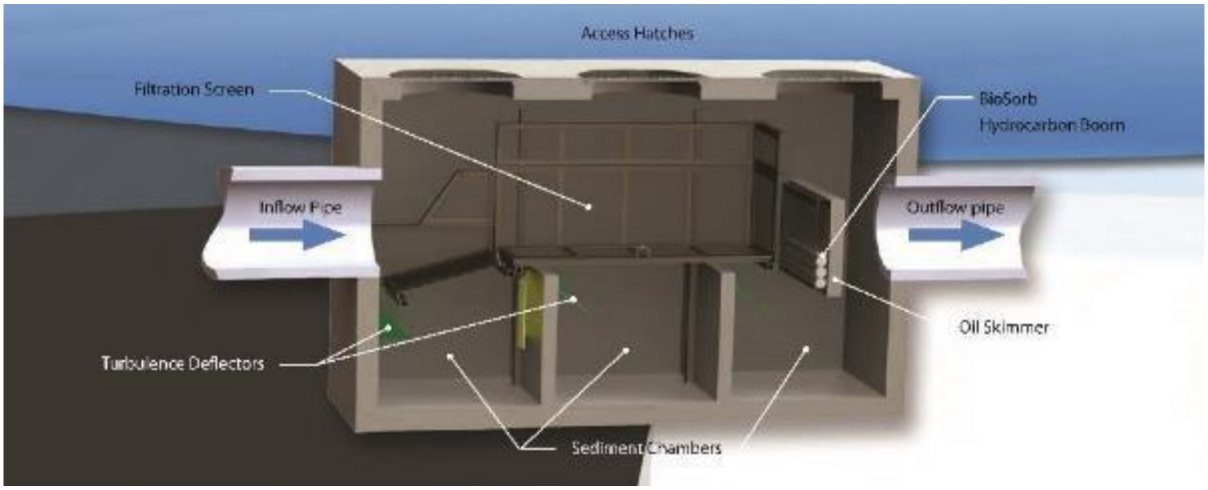


Figure 19. Typical NSBB System (Source: BioClean Environmental, Inc.)

4.2.2 Catch Basin Inlet Inserts

A typical catch basin inlet insert collects the stormwater runoff at the catch basin opening. As runoff enters the catch basin from the curb and gutter it flows into the inlet insert where runoff passes through a filter liner basket for removal of sediment, trash, and debris. Most filters have optional media sorbent materials located within the filter basket to capture hydrocarbons and/or metals. The inlet inserts are designed to allow excess flows to bypass near the top of the units. A target flow rate for these units will be based on the 85th percentile storm event and the size of the unit will be based on the estimated sediment that is anticipated to be removed and to minimize the routine maintenance required. Figure 20 represents a typical catch basin inlet insert.

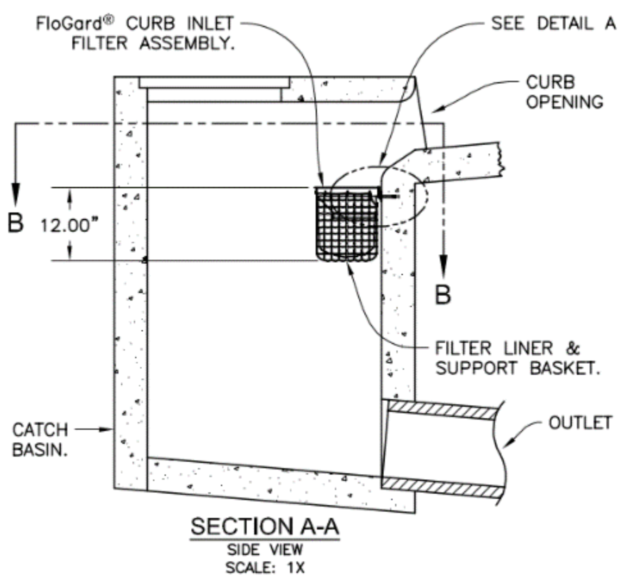


Figure 20. Typical Catch Basin Insert Filter (Source: Oldcastle Stormwater Solutions)

The inlet inserts do not use sedimentation chambers as part of their treatment process. This provides a benefit relative to that of some of the hydrodynamic separators in that they capture and store trash and debris in a dry state, thus reducing potential nutrient leaching and bacteria growth. However the removal of TSS is much lower relative to the other pretreatment devices as the filter liner basket does not have a high removal rate for suspended solids. It is important to note that these inlet inserts are limited in the treatment capacity they can provide. And therefore, although these units are a viable pretreatment option, diverting runoff to a centralized pretreatment device such as a CDS unit will most likely be recommended as they have the capacity to treat larger flow rates that exceed the 85^{th} percentile storm event.

A summary comparison of the four pretreatment devices is provided in Table 8.

Table 8. Comparison of Pretreatment Devices

	Contech CDS	Stormceptor	Bio Clean NSBB	Oldcastle FloGard
100% Gross Solids Removal (Full Capture Device)	Yes	No	No	No
Internal Bypass	Yes	Yes	Yes	Yes
Maximum Prefabricated Sediment Storage Sump Capacity	5.6 cy	> 70 cy	31.7 cy	2.1 to 3.1 cf
Effective up to 30 cfs	Yes	Yes	Yes	No

4.3 PROPOSED STORMWATER BMPS

Underground storage reservoirs act as detention and/or retention BMPs that harvest and temporarily store stormwater runoff. These BMPs are designed to harvest a specified design volume and can be configured as online or offline systems. Online BMPs require an overflow system for managing extra volume created by larger storms. Offline BMPs do not always require an overflow system but do require some freeboard (the distance from the overflow device and the point where stormwater would overflow the system) and a diversion structure. The water harvested at Carriage Crest Park cannot be infiltrated due to soil contamination, so discharge to the sanitary sewer for treatment would provide the primary treatment mechanism.

4.3.1 Regional BMP Layout

This Preliminary Design Report includes an engineered evaluation of the BMP system to determine if a gravity system or pumping system is most appropriate for conveyance to the 3.6 MG underground storage reservoir. The two alternatives, consisting of one utilizing gravity and the other a pump station, were analyzed and are discussed in the following sections. Appendix D provides detailed drawings and site layouts of the two alternatives.

4.3.1.1 Alternative Site Layouts

Both alternatives will consist of three diversion structures, pretreatment, an underground storage reservoir and a pump station to convey flows to the sanitary sewer system and/or to an on-site treatment system where the water will undergo treatment and be used for on-site irrigation. The reservoir will be located beneath the existing baseball fields, which will need to be removed and replaced. The footprint for the underground storage reservoir is approximately 60,000 square feet. The major difference between the two alternatives is the configuration of the diversion storm drains conveying runoff from the diversion structures to the underground reservoir and the inclusion of additional pumps to get the runoff into the storage reservoir.

Alternative 1 includes the diversion of dry and wet weather runoff from all three diversion structures into a centralized pretreatment device prior to discharging into the underground storage reservoir. This pretreatment device would most likely be inundated and experience backflow due to its low elevation relative to the underground reservoir's maximum water surface elevation. Because of this backflow condition special design consideration will need to be taken when choosing an appropriate pretreatment device as some pretreatment devices will not work as effectively when subject to backflow. Captured water will be detained and then have the option to be pumped to either an existing 60" diameter sanitary sewer line for additional use by LACSD, or back to the LACFCD RCB storm drain in order to provide additional capacity in the underground storage reservoir. An additional discharge option is also being considered that will pump stored water into an on-site treatment system and be used as-needed for on-site irrigation.

Alternative 2 includes one pump station similar to alternative one, however there will be an additional pump which will feed runoff from the diversion structures into the underground reservoir at a rate of up to 30 cfs similar to Alternative 1. Similar to alternative one, captured water will be detained and then have the option to be pumped to either an existing 60" diameter sanitary sewer line for additional use by LACSD, or back to the LACFCD RCB storm drain in order to provide additional capacity in the underground storage reservoir. An additional discharge option is also being considered that will pump stored water into an on-site treatment system and be used as-needed for on-site irrigation.

Each of the alternatives will require minimal tree and utility removal and replacement. Refer to Figure 21 and Figure 22 for the overall concept site plans for both alternatives. The footprint of the underground storage unit will not require removal of any trees, however will require the removal and replacement of all the turf, irrigation systems, and any other utilities within the excavation footprint (Figure 23). The existing decomposed granite access path will also need to be widened to allow for maintenance access to the pump station and pretreatment devices. An additional access gate and driveway entrance has been proposed along Sepulveda Avenue as shown in Figure 24.

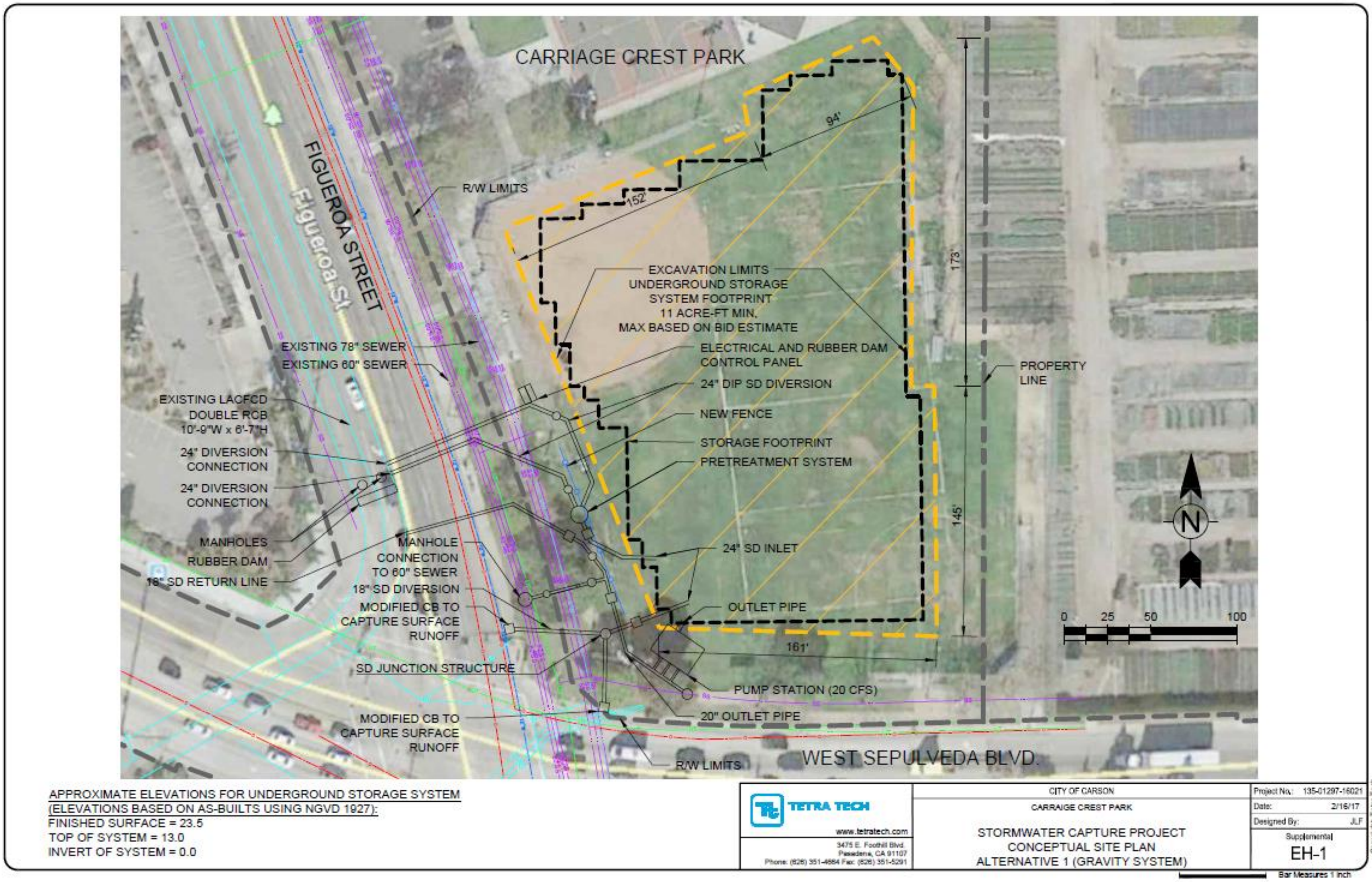


Figure 21. Carriage Crest Park Alternative 1 BMP Layout

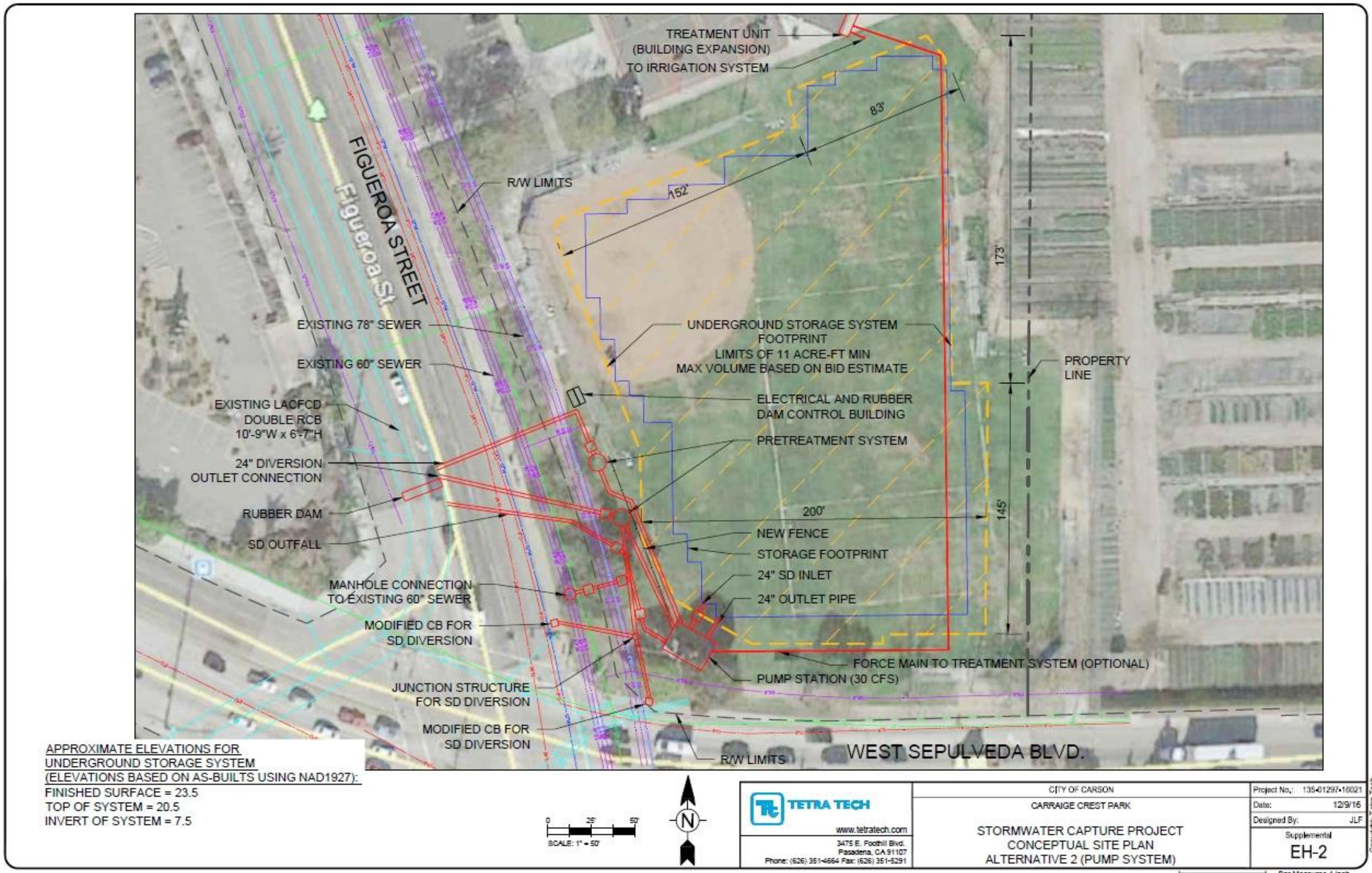


Figure 22. Carriage Crest Park Alternative 2 BMP Layout

Figure 23. Carriage Crest Park Surface Improvements

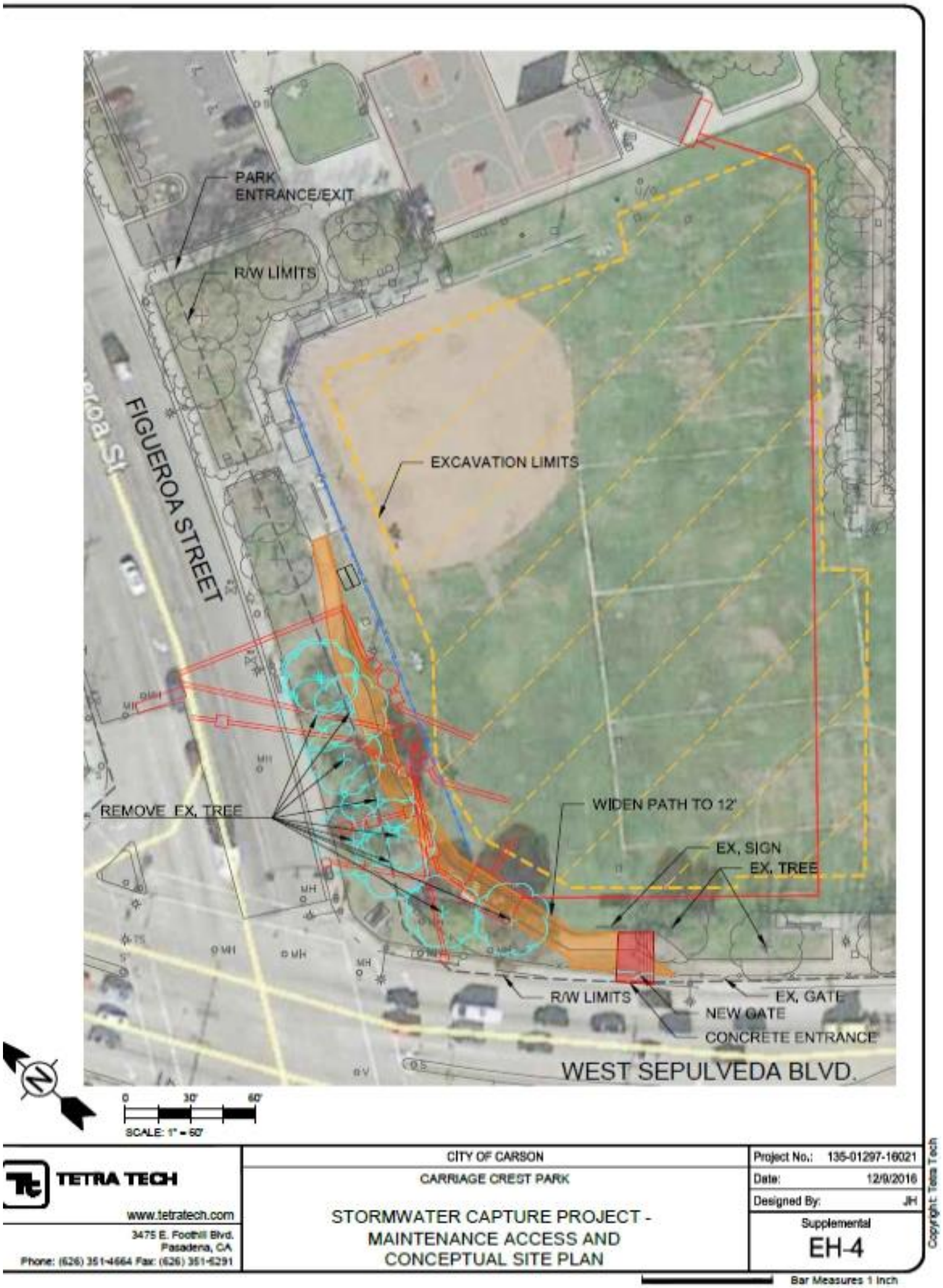


Figure 24. Recommended access driveway for operation and maintenance

4.3.2 BMP Structure Alternatives

Underground storage tanks provide initial stormwater detention and allow for implementation where surface space is limited such as around paved streets, parking lots, and buildings. A 3.6 MG storage reservoir is proposed for Carriage Crest Park. Options for underground storage reservoirs include modular designs and cast-in-place concrete structures. The following sections provide a comparison of different modular and cast-in-place designs for the underground storage reservoir.

4.3.2.1 Modular Design

Precast concrete storage systems, such as the StormTrap, Oldcastle and Jensen StormVault systems, made from durable, reinforced, and high-strength concrete would be the most appropriate modular unit for this project (vis-à-vis plastic modular units). They can be designed to exceed HS-20 loading, have varying depths of cover, and overcome buoyancy forces. Internal heights can vary to meet the desired storage volume. The StormTrap system can be seen in Figure 25.

Figure 25. Example StormTrap system

4.3.2.2 Cast-in-Place Design

For the cast-in-place option, the roof and walls for both storage tanks would be supported on a concrete mat foundation that would all be structurally tied together and designed for HS-20 and other prescribed code loadings. The construction of the 3.6 MG storage tank, excluding the mobilization, excavation, and demobilization of the site, would take approximately 20 weeks to construct and cure. The main disadvantages of cast-in-place compared to precast is the amount of time it takes between stages for the concrete to set and cure which directly increases the cost of the system. This is especially critical for backfilling, as the wall is required to reach 70 percent compressive strength before proceeding. The advantage of the cast-in-place structure is flexibility of design and watertight characteristics that may be limited with the precast option.

It is assumed that the precast option will be brought to the site in several pieces and connected together in the field. This would be in the form of precast box culverts and/or rigid frames that are essentially linked together. Depending on the final configuration, a cast-in-place foundation may be required, along with the precast structure, to resist buoyant forces that the structure will experience. Although the precast option can be constructed with an accelerated schedule, the joints at which each segment would be connected are more susceptible to leakage, and special design consideration would need to be considered by the manufacturer to ensure a water tight seal. For the precast 3.6 MG storage tank, the construction schedule would be cut by 30% to 50%.

In addition to the concern related to the increased construction schedule for the cast in place method, is the project funding allocation schedule. The project is funded through an agreement with CALTRANS which requires the project to procure and invoice portions of the construction contract by specific milestones. The first milestone requires the contractor to procure or complete an invoice of $3.2 million by March 1, 2017. The second milestone requires the contactor to demonstrate how the remaining portion of the budget will be spent by January 12, 2018 and invoiced by February 1, 2018. If a specific milestone is not met the project loses a portion and possibly all of funding allocated to the project. The prolonged schedule associated with the cast in place alternative makes this method potentially not viable. The pre-cast option allows the contractor to preorder the units enabling a timely purchase order to be invoiced and meet the funding schedule. Funding is critical to the completion of the project and the precast units allow the allocation schedule to be met.

4.3.2.3 Reservoir Design Overview

The underground storage BMPs will tie to new pump stations, which will convey stored stormwater to the sanitary sewer system or storm drain system when the reservoir needs to be drained quickly. Refer to the Carriage Crest Park Pump Stations Operations Manual for details on the proposed pumping strategies. Table 9 compares the installation duration and construction costs associated with cast-in-place and precast concrete storage systems.

Table 9. Comparison of Cast-in-Place and Precast Concrete Systems for the Carriage Crest Park BMPs

Carriage Crest Park: 3.6 MG BMP		
	Cast-In-Place	**Precast**
Installation Duration[1]	12 weeks	7 weeks
Construction Cost	$9,350,000 ($2.21/gal)	$4,130,000 ($0.98/gal)

[1] Installation duration does not include mobilization, excavation, shoring, and demobilization. This time frame only includes the duration to construct the storage tank, allow for curing (only applicable in the cast-in-place option) and to backfill.

4.4 STORMWATER PUMPING STATION DESIGN & HYDRAULIC ANALYSIS

Due to the depth of the existing drainage facilities, existing utilities, the adjacent land grades, existing soil types, existing contaminated soil and groundwater, and the types of BMPs considered for the project, pumping systems will be required for both of the alternatives. This section presents the preliminary pumping requirements for each of the project alternatives.

4.4.1 Hydraulic Criteria

Flows are anticipated to be highly variable between dry-weather and wet-weather operating events. Larger duty pumps will be provided for the wet-weather flows and a smaller sump pump will be provided for the dry-weather flows. For both types of flows, the pumped flow rate, outlet elevation, pump low level elevation, and force main friction losses are summarized and used to calculate the total design head (TDH). All of these items are summarized in Table 10.

Table 10. Total Dynamic Head (TDH)

Type	Peak Design Flow Rate (CFS)	Discharge Elevation (MSL)	Pump Station Low Level Elevation (ft)	Friction and Minor Losses (est.) (ft)	TDH (ft)
Alternative 1: Dry Weather Flow	1	19.1	-1	2.3	22.4
Alternative 1: Discharge from Storage to Sanitary Sewer	20	19.1	-1	8.7	28.8
Alternative 2: Dry Weather Flow	1	19.1	3.5	2.3	17.9
Alternative 2: Wet Weather Flow Diversion from Stormdrain to Storage	30	18.5	3.5	18.1	33.1
Alternative 2: Discharge from Storage to Sanitary Sewer	20	19.1	3.5	17.5	33.1

For the purposes of this preliminary report, minor losses and friction losses have been roughly estimated using approximate pipe lengths and elevations to determine an approximate pump size and costs. During final design the TDH will be recalculated using the final design piping and structure elevations, and an overall system curve will be developed.

4.4.1.1 Station Configuration

Pump station designs must allow for redundancy within the pumping system to maintain overall system reliability. This reliability will be provided by allowing for a stand-by pump within the pump station configuration. A stand-by pump allows for continuous station operations in the event of pump failure by the active duty pump.

Based upon typical industry practices, two pump station configurations were investigated:

- 2-Pump Configuration: The pump station will have two duty pumps, each capable of pumping the full peak design flow. This configuration allows redundancy if one pump fails or is removed from the station for maintenance.
- 3-Pump Configuration: The pump station will have three duty pumps, each capable of pumping 50 percent of the peak design flow. In the event of a single pump failure or maintenance, the two remaining pumps will be capable of conveying the design flow.

Operations of the pump stations for either configuration will allow for routine cycling of all pumps so as to evenly spread the wear of pumping to each pump equally. Additionally, a single low-flow pump will be provided in either configuration to dewater the pump station to a level below the level permitted by the main duty pumps.

The pump station can be designed as either cast-in-place or through utilization of a precast wet well. Either configuration must be analyzed as part of the design to ensure compliance with Hydraulic Institute (HI) standards. HI standards are necessary to minimize potential for vortex development and internal “eddies” which could short-circuit pump operations and thus impact performance. Cavitation is also a concern whereby entrained air is either introduced within the system or released via localized pressure below the saturation vapor pressure.

Pump station sizing will be developed in greater detail as part of the final station design. Initial assessments indicate that a pump station floor plan approximately 14’ x 17’ will be sufficient to accommodate station operations for two duty pumps and a low-flow pump. It is estimated that a 14’ x 21’ floor plan will be sufficient for three duty pumps and a low-flow pump. It is expected that a separate precast valve vault will also be provided. If the gravity option in alternative one is used, then the pump station could be possibly be located within the underground reservoir. This would save space and reduce the need for an additional subsurface concrete structure. The pump station or wet well storage volume combined with channel storage volume will be sized such that that the number of pump starts per hour will meet the pump manufacturer’s recommendations, typically 4 to 6 times per hour. Final pump station size and location will be determined during final design.

4.4.1.2 Variable Frequency Drives

The use of a variable frequency drive will be implemented for the pump station in order to deliver water at a variable rate. Although the stormwater is to be delivered to the underground detention facility at a constant rate, flows discharged to the sanitary sewer will need to vary based on the capacity of the sewer system at any given time. Capacity in the sewer system will be monitored through a proposed telemetry system which will monitor water levels within the sewer line and govern the allowable discharge rates from the detention system. Variable frequency drives also provide a “soft start” condition which helps reduce the work load required if excessive pump cycling occurs.

4.4.1.3 Pump Sizes

Pump sizes were analyzed to determine the horsepower requirements for both the 2-pump and 3-pump configurations. A 4-pump option was also considered but when compared to a 3-pump configuration was not recommended as it requires a larger pump station footprint and no additional benefit relative to the 3-pump configuration. Pump motors were selected so as to be non-overloading throughout the pumping curve of the proposed pump. The following Table 11 summarize the pumping results with optimum pumping efficiencies.

Table 11. Pumping Requirements

Alternative	Total Dynamic Head	Pump Flows		Horsepower	Efficiency
	ft	*cfs*	*gpm*	*hp*	*%*
Alternative 1: 2-Pump Configuration (to sanitary sewer)	28.8	20	8,977	110	86%
Alternative 1: 3-Pump Configuration (to sanitary sewer)	28.8	10	4,488	60	81%
Alternative 1: Low-Flow Pump (to sanitary sewer)	22.4	1	449	5	68%
Alternative 2: 2-Pump Configuration (to storage)	33.1	30	13,465	170	85%
Alternative 2: 3-Pump Configuration (to storage)	33.1	15	6,733	85	74%
Alternative 2: 2-Pump Configuration (to sanitary sewer)	33.1	20	8,977	170	85%
Alternative 2: 3-Pump Configuration (to sanitary sewer)	33.1	10	4,488	85	74%
Alternative 2: Low-Flow Pump (to sanitary sewer)	17.9	1	449	5	68%

The pumps from Alternative 2 would be operated in two scenarios: to convey water from the stormdrain diversion to the storage facility during storms and from the storage facility to the sanitary sewer during periods when the sanitary sewer system can accept the flow. This would be accomplished through the use of a common header pipe and motor actuated valves that direct flow to the appropriate facility. The 30 cfs pumping system would be installed and, through the use of VFDs, be reduced to meet the 20 cfs sanitary sewer discharge requirement.

Efficiency is presented for illustration purposes only and to demonstrate where the pumps may operate under optimum conditions. Since the duty pumps are not anticipated to operate on a continuous basis (i.e. pumps to operate in a wet-weather event only), efficiency is not recommended to be the overall criteria for pump selection. Instead, proper pump selection was determined based on the pump operating as close to the Best Efficiency Point as possible at the calculated flow conditions.

4.4.2 Pump Selections

The City has several options available for pump station design criteria and pump selections. Pumps can be provided in either a “dry” or “wet” pit configuration for either centrifugal or vertical turbine pump configurations.

Site conditions prescribe that this station be constructed below grade as to allow for maximum site use. Additionally, to minimize noise from pump operations while providing for security, it is recommended that both pump and motors be installed below grade within a secure wet well. Finally, the overall depth of pump station should be minimized so as to keep the construction out of the underlying groundwater table as much as possible, which has the corollary beneficial effect of minimizing the Total Dynamic Head for station operations. For these reasons, a submersible pumping configuration is recommended.

4.4.2.1 Submersible Wet-Pit Solids Handling Centrifugal Pumps

Several vendors supply submersible pumps suitable for this application. The sizing of these pumps (<100 Hp) allows for quick removal, via mobile truck crane, for inspections and maintenance.

An advantage of the submersible pump station design is that the overall station footprint is reduced (i.e. pumps located in wet well), thus minimizing the station construction costs. In most applications, overall pump station construction costs can be reduced by up to 25 percent for a wet well, submersible pump configuration, as less excavation is required.

Submersible pump stations utilize rails for guiding and setting pumps within the wet well. The pumps are controlled under various conditions through the use of ultrasonic sensors and/or float switches. An additional control will also be necessary to monitor the water surface elevation in the LACSD sanitary sewer. This control will be tied directly to telemetry for LACSD MHD225.

Figure 26. Typical submersible pump

Given the abrasive nature of the liquid medium (stormwater with anticipated high solids content), vortex impellers may be necessary to ensure operational performance. If vortex impellers are utilized, then operational efficiency may be reduced.

A typical submersible pump is shown in Figure 26.

4.4.2.2 Pumping Station Operational Controls

For operational controls, an ultrasonic level transmitter is proposed with float switches for backup and alarm. Operational control points provided would be:

- Low level off
- Low level on
- High level on (3-pump configuration only)
- High-High level alarm

These control points would be used by the station's programmable logic controller (PLC). Furthermore, it is expected that the PLC will also receive level information from the underground reservoir and telemetry from LACSD. The telemetry will be tied to a proposed level sensor within LACSD manhole number 225. The sensor will communicate with the LACSD and City of Carson's proposed SCADA systems which will be operated by the proposed PLC's. The City's PLC will communicate with the automated valves and pump station and control the amount of discharge allowed into the sanitary sewer line. The LACSD system will have the option to control the pump station but the City will be responsible for the ongoing monitoring and operation of pump station and the controls.

4.4.2.3 Pumping Station Security

An entry alarm will be included as part of final designs to allow for notification in the event that the wet well hatch is opened.

4.4.2.4 Pumping Station Electrical Loads

All pump motors are to be three phase, 480 V, 60 Hz. Electrical load amperage requirements for preliminarily selected pumps and motors as tabulated below in Table 12**.**

Table 12. Electrical Load, Amps

Alternative	Pump Flows		Horsepower	Rated Starting Current
	cfs	*gpm*	*hp*	*amps*
2-Pump Configuration	20	8,977	110	660
3-Pump Configuration	10 (x2)	4,488	60 (x2)	545
Low-Flow Pump	1	449	5	40

4.4.2.5 Emergency Power Supply

Due to site constraints and limitations, and the lack of critical nature of the pumping station (i.e. stormwater), a back- up emergency generator is not recommended. If power is not available to the site, the automated valves will close, the pump station will not operate, and the stormwater flows will not be diverted to the storage system. Stormwater will continue flowing as it currently does until power is brought back online.

4.4.2.6 Utility Power

It is expected that power for the pump station will be available from a nearby power pole. The connections to utility power will be coordinated with Southern California Edison (SCE).

4.4.2.7 Pump Station Controls

The pump station will be controlled via a Supervisory Control and Data Acquisition (SCADA) system within the control panel. The SCADA system will be operated by a programmable logic controller (PLC). The PLC will provide a graphic display that will be provided as an operator interface to control the pump station. The PLC will be housed in a NEMA 4 cabinet with air conditioning. Operator controls and displays will be mounted on a swing panel inside a lockable cabinet. If available, alarms will be communicated to a SCADA system. A second NEMA 3R cabinet will be provided alongside the PLC cabinet for the pump motor starters.

4.4.2.8 Operational Costs

Annual operational costs for the pumps are calculated in Table 13 below. These costs are based on the following assumptions:

- Average monthly operations based on 8 hours per month (year-round).
- Wet-weather operations based on 24 hours of pumping for 12 storm events per year.
- $0.16 per kilo-watt hour for electrical power consumption.
- Only electrical usage costs are calculated. Other utility charges are not included.

Table 13. Annual Operational Costs for Pumps

	Alternative 1: 2-Pump Configuration	Alternative 1: 3-Pump Configuration	Alternative 2: 2-Pump Configuration 30 CFS Flow to Storage	Alternative 2: 2-Pump Configuration 20 CFS Flow to Sewer	Alternative 2: 3-Pump Configuration 30 CFS Flow to Storage	Alternative 2: 3-Pump Configuration 20 CFS Flow to Sewer
Annual Service (hrs)	384	384	384	384	384	384
Total Power (HP)	110	120	170	170	170	170
Calculated kW	82	89.5	126.6	126.6	126.6	126.6
Energy Cost ($/kWhr)	$0.16	$0.16	$0.16	$0.16	$0.16	$0.16
Annual Energy Cost	$5,038	$5,499	$15,556		$15,556	

4.4.2.9 Maintenance Requirements

Given that the duty pumps are anticipated to be operated in a wet-weather event only, there is concern that leaving these pumps in the pump station in an idle condition for an extended duration may compromise their seal integrity as well as the bearings. These pumps should be exercised on a monthly basis, at least, during the dry-weather season to ensure their operational performance. In addition, these pumps and the pump station should be carefully cleaned and serviced in advance of each rainy season.

4.4.2.10 Recommended Pump Station Configuration

Due to reduced operation hours on the pumps leading to less wear, the 3-pump configuration is recommended for the project pump station.

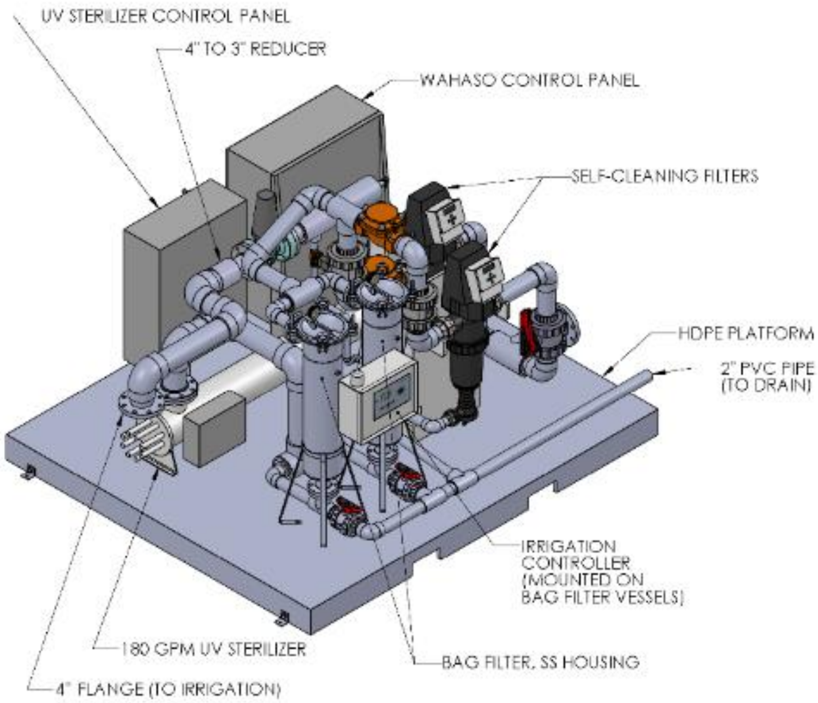
4.5 OPTIONAL ONSITE USE ALTERNATIVE

The primary purpose of this project is water quality improvement; however, the capture of dry and wet weather runoff presents an opportunity to offset potable water demand. Although the analyses herein deemed onsite use an inefficient mechanism for water quality improvement, capturing locally-sourced runoff helps the City and LACSD comply with state-mandated water restrictions, bolsters water resiliency, and could generate additional funding opportunities to support this, and other, multi-benefit projects. This section presents the analysis and design of an *optional* onsite irrigation system to provide multiple benefits from the proposed stormwater BMP.

Modeling data indicate that average dry weather flows (approximately 0.25 cfs to 0.5 cfs) alone could more than offset the onsite potable demand tabulated in section 3.1.3. Using this water onsite would require treatment to comply with Los Angeles County Department of Public Health requirements. Treatment systems, such as those provided by Wahaso, are designed to filter and sanitize greywater and stormwater runoff before it is safe to use for irrigation. The Wahaso system is designed to meet or exceed National Sanitation Foundation, NSF-350 standards for non-potable water, as well as Los Angeles County Department of Health, Tier IV water quality standards. The irrigation will be safe for spray irrigation use during hours when the park is closed to public use. The treated runoff will be used to reduce and potentially eliminate the need for potable water for irrigation purposes.

Dual submersible pumps could provide up to 200 gpm at 80 psi. The pumps shall alternate during normal operations and shall work together during high demand conditions. The pumps shall be contained within a wet well and mounted on a rail system to provide some ease during maintenance.

Treatment would involve a two-step filtration process and sanitation. First, a mechanical filter removes most of the sediment and particulates greater than 50 microns. Then, a second filter removes the remaining particulates down to 5 microns. Finally, the greywater is sanitized using ultraviolet (UV) treatment. The treated water is then distributed to the irrigation system via pumps. An expansion of the existing building at Carriage Crest Park will be required to house the processing skid, similar to that shown in the figure below. The processing skid shall contain the treatment system and the control system and is shown in Figure 27. The building expansion will match the current architecture of the building. New irrigation spray heads and accessories will be included in the project in order to meet County health standards.



Source: Wahaso – Water Harvesting Solutions

Figure 27. Typical Water Treatment Processing Skid

5.0 PERMITTING, COST ESTIMATE, AND SCHEDULE

The cost estimate and project schedule have been created to validate that the preliminary design may be built within the specified budget and within the time allocated to use the funds.

5.1 ENVIRONMENTAL DOCUMENTS AND PERMITS

Consultation with regulatory agencies and acquisition of permits is required before the project components can be constructed. The following sections summarize regulatory permits and approvals relevant to the project.

5.1.1 Los Angeles County Flood Control District

The LACFCD provides flood protection and water conservation within the County of Los Angeles. In order for the LACFCD to fulfill such duties, the LACFCD owns and maintains many debris basins, open channels, and underground storm drain systems throughout the County. Any construction within the LACFCD right-of-way requires a Flood Control Permit. A Flood Control Permit is required to ensure that the constructed project (in particular, the diversion structure) does not interfere with the LACFCD's operations and maintenance responsibilities. The WSPG analysis presented in this report will support the acquisition of a Flood Control Permit.

5.1.2 LACSD

The LACSD require a permit for facilities discharging to the sanitary sewer, and any entities discharging more than 600 million gallons per year are required to pay a treatment surcharge fee; however, the Connection Fee Ordinance passed in October of 2016 waives the need to pay a connection fee.

5.1.3 South Coast Air Quality Management District

Construction activities in the South Coast Air Basin are subject to South Coast Air Quality Management District's (SCAQMD) Rule 403. Rule 403 sets requirements to regulate operations, which periodically may cause fugitive dust emissions into the atmosphere by requiring actions to prevent, reduce, or mitigate fugitive dust emissions. All construction in the South Coast Air Basin must incorporate best available control measures included in Table 1 of Rule 403. Additionally, large operations (defined as active operations on 50 acres or more), or projects with daily earth-moving or throughput volume of 3,850 cubic meters or more, three times during the most recent 365-day period, are further required to submit a large operation notification, identify a certified dust control supervisor, implement measures from Tables 2 and 3 of Rule 403, and maintain daily records.

5.1.4 Local Construction Permits

Depending on the selected concept, the City of Carson may require building and grading permits. Traffic control will play an integral role during the trenching activities for the storm drains and discharge lines within Figueroa as well as the hauling of export from the project during the excavation phase of the project.

5.1.5 Other Environmental Planning and Permits

Contaminated soils that are excavated from the site will be considered hazardous waste due to high concentrations of pesticides, so a Soil Management Plan should be developed to guide the soil handling process during excavation (stockpiling, sampling, disposal). Stockpiles would be segregated based on the concentrations of the pesticide. This would allow for a more cost-effective approach for disposal. At this time, it is not anticipated that permits will need to be obtained from the Army Corps of Engineers, California Fish and Wildlife Service, nor the Los Angeles Regional Water Quality Control Board, however, a Cal EPA ID number will be required for hauling and disposing of any excavated soils.

5.2 PRELIMINARY COST ANALYSIS

The cost analysis is utilized as a tool to ensure preliminary design is within the amount of funds available to the project. If the cost analysis indicates that the project is not feasible, then the design will need to be adjusted to bring it within the project budget while still meeting the project goals. The cost analysis was developed using various sources of information, as well as the Cost Estimator's judgment.

5.2.1 Construction Cost

The construction cost entails the various components of the project that a Contractor would construct for the City. Construction costs do not include items of work not directly performed by the Contractor, such as the City's construction management during construction. The construction costs were developed using various sources of cost information. The estimated construction cost is $9,614,854 for the recommended Alternative 1 and $10,121,929for Alternative 2. Table 14 and Table 13 list the respective breakdowns for each Alternative of the items required to complete the project, and Appendix E provides the corresponding line-item details.

Table 14. Estimated Construction Costs, Alternative 1

Carriage Crest Park BMP Site	
Mobilization/Demobilization (3%) and Active Controls	$369,293
Channel Diversion and Pretreatment	$641,139
Pump Station (3-pump) and Conveyance*	$1,041,062
Site Preparation and Demolition (Existing Park Area)	$16,085
Storage	$5,300,799
Electrical Service, Controls, Instrumentation	$274,200
Landscape and Irrigation	$228,250
Site Amenities and Improvements	$66,500
Start-up, Testing, O&M Manuals, Record Drawings	$75,000
Subtotal	$8,012,378
10% Design Estimating Contingency (20%)	$1,602,476
TOTAL	**$9,614,854**

Table 15. Estimated Construction Costs, Alternative 2

Carriage Crest Park BMP Site	
Mobilization/Demobilization (3%) and Active Controls	$381,601
Channel Diversion and Pretreatment	$590,380
Pump Station (3-pump) and Conveyance*	$1,502,276
Site Preparation and Demolition (Existing Park Area)	$16,085
Storage	$5,300,599
Electrical Service, Controls, Instrumentation	$274,200
Landscape and Irrigation	$228,250
Site Amenities and Improvements	$66,500
Start-up, Testing, O&M Manuals, Record Drawings	$75,000
Subtotal	$8,117,768
10% Design Estimating Contingency (20%)	$1,686,988
TOTAL	**$10,121,929**

5.2.2 Operations & Maintenance Costs

The operations and maintenance costs were developed on the basis that a service contractor would maintain the various components of the system. Operation of the system during wet weather and dry weather events was assumed to be managed by the City; however, O&M costs could potentially be apportioned to other upstream jurisdictions on the basis of equivalent 85^{th} percentile storm volume capture (according to the design storm volumes presented earlier in Table 4).

Operations of the rubber dam diversion will incorporate coordination and notifications to the LACFCD to ensure that there will be no effect to the flood control conveyance system operation. Estimated total annual operations and maintenance costs are presented in Table 16 and Table 17 .

Table 16. Annual Estimated Operations & Maintenance Costs, Alternative 1

	Alternative 1			
Description	Frequency	No. of Times per Year	Unit Price	Total
Active Controls				**$57,400**
Continuous Monitoring and Adaptive Control (Opti System)	Continuous	--	$32,400	$32,400
Continuous Monitoring and Adaptive Control (Overall System)	Continuous	--	$25,000	$25,000
Channel Diversion and Pretreatment				**$27,000**
Rubber Dam System – Inspection and Cleaning	Monthly	12	$750	$9,000
Pretreatment Device – Vacuum	Monthly	12	$1,500	$18,000
Pump Station				**$37,775**
Dry Season Inspection and Cleaning (Vacuum)	Every other Month	3	$750	$2,250
Wet Season Inspection and Cleaning (Vacuum)	As needed	6	$750	$4,500
Electrical Usage	Monthly	12	$300	$3,600
Valve Maintenance	As needed	1	$1,000	$1,000
Control Panel Maintenance	As needed	1	$1,000	$1,000
Pump Replacement	Every 20 Years	1	$25,425	$25,425
Storage				**$16,000**
Dry Season Inspection and Cleaning (Vacuum)	Quarterly	2	$4,000	$8,000
Wet Season Inspection and Cleaning (Vacuum)		2	$4,000	$8,000
Sampling				**$31,000**
*Sampling and Lab Analysis	Weekly	52	$500	$26,000
Sampling Equipment Maintenance	Every 3-5 Years	--	$5,000	$5,000
Annual Sanitary Sewer Discharge (Nightly Discharge, Wet Weather[1], Average Year)				**$156,988**
Total				**$326,163**

* Assumes testing will be done internally by LACSD

[1] Wet weather refers to condition in the sewer. The project will discharge to the sewer as long as sewer capacity is available even during a rain event.

Table 17. Annual Estimated Operations & Maintenance Costs, Alternative 2

	Alternative 2			
Description	Frequency	No. of Times per Year	Unit Price	Total
Active Controls				**$57,400**
Continuous Monitoring and Adaptive Control (Opti System)	Continuous	--	$32,400	$32,400
Continuous Monitoring and Adaptive Control (Overall System)	Continuous	--	$25,000	$25,000
Channel Diversion and Pretreatment				**$27,000**
Rubber Dam System – Inspection and Cleaning	Monthly	12	$750	$9,000
Pretreatment Device – Vacuum	Monthly	12	$1,500	$18,000
Pump Station				**$67,850**
Dry Season Inspection and Cleaning (Vacuum)	Monthly	6	$750	$4,500
Wet Season Inspection and Cleaning (Vacuum)	As needed	6	$750	$4,500
Electrical Usage	Monthly	12	$500	$6,000
Valve Maintenance	As needed	1	$1,000	$1,000
Control Panel Maintenance	As needed	1	$1,000	$1,000
Pump Replacement	Every 10 Years	1	$50,850	$50,850
Storage				**$16,000**
Dry Season Inspection and Cleaning (Vacuum)	Quarterly	2	$4,000	$8,000
Wet Season Inspection and Cleaning (Vacuum)		2	$4,000	$8,000
Sampling				**$31,000**
*Sampling and Lab Analysis	Weekly	52	$500	$26,000
Sampling Equipment Maintenance	Every 3-5 Years	--	$5,000	$5,000
Annual Sanitary Sewer Discharge (Nightly Discharge, Wet Weather[2], Average Year)				**$156,988**
Total				**$356,238**

* Assumes testing will be done internally by LACSD

[2] Wet weather refers to condition in the sewer. The project will discharge to the sewer as long as sewer capacity is available even during a rain event.

5.2.3 Project Costs

Project costs include all the necessary items to provide a finished product. Costs include predesign, design, construction, construction management, and post construction work. The estimated project capital budget for Alternative 1 and Alternative 2 are $11.9 million and $12.5 million. Although the capital costs are relatively similar between the alternatives, the additional operations and maintenance associated with Alternative 2 amount to substantially higher long-term costs, as demonstrated in Table 18.

Table 18. Comparison of total project capital costs and long-term operations and maintenance costs

Cost Component	Alternative 1	Alternative 2
Construction	$9,614,854	$10,121,929
Predesign (3.5% of construction)	$336,520	$354,268
Design (10% of construction)	$961,485	$1,012,193
Construction Management (10% of construction)	$961,485	$1,012,193
Capital Cost Subtotal	**$11,874,344**	**$12,500,583**
10-Year Operations and Maintenance	$1,691,750	$1,992,500
10-Year Wastewater Treatment Surcharge	$1,569,880	$1,569,880
10-Year Operations and Maintenance Subtotal	**$3,261,630**	**$3,562,380**
10-Year Total Project Cost	**$15,135,974**	**$16,062,963**

5.3 FUNDING SOURCE AND IMPLEMENTATION SCHEDULE

As stated in the Cooperative Implementation Agreement, the City is required to bill Caltrans for funding reimbursement on April 30, 2018 for the Caltrans Fiscal Year 2015-2016 funding allocation and April 30, 2019 for the Caltrans Fiscal Year 2016-2017 funding allocation. As a result, construction of the facility must be completed by August 30, 2019. The preliminary implementation schedule is provided in Table 19, and a detailed schedule can be found in Appendix F.

Table 19. Preliminary Implementation Schedule

Description	Start Date	Finish Date
PHASE 1: Project Engineering Study Report	9/1/2016	12/1/2016
Environmental Documentation	11/7/2016	5/15/2017
PHASE 2: Detailed Design Documents / Bid and Award	12/6/2016	9/19/2017
PHASE 3: Construction Implementation	10/19/2017	8/19/2019
Caltrans Cooperative Implementation Agreement	8/2/2016	8/30/2019

Table 20. Preliminary Caltrans Funding Allocation Schedule

Amount	Funding Period (Fiscal years)
$2,500,000	2015-2016
$3,000,000	2016-2017
$2,500,000	2017-2018
$2,500,000	2018-2019
$2,500,000	2019-2020

6.0 CONCLUSIONS & RECOMMENDATIONS

This preliminary engineering design report was prepared for Carriage Crest Park to advance progress towards complying with the MS4 permit requirements. The existing utilities, geotechnical conditions, hydrology, and water quality were first characterized, then an optimization analysis informed data-driven selection of cost-effective solutions. Modeling suggested that a BMP designed to divert up to 26 acre-feet of stormwater from an 85th percentile, 24-hour design storm (11 acre-foot underground storage facility, fed by a 30-cfs diversion from the adjacent storm drain, and dewatered to the sanitary sewer at a maximum nightly rate of 20 cfs) could provide optimal long-term pollutant removal within the budgetary constraints of the available funding. This recommended configuration satisfies the terms of the Caltrans funding agreement by providing 11 acre-feet of storage, collecting all dry weather flow, and capturing runoff in excess of the minimum diversion rates specified in the original concept.

The predicted BMP performance demonstrates that long-term pollutant reduction targets can be achieved based on several key compliance metrics, including average-annual reduction (from which the BMP's size and operating parameters could be optimized), as well as over the course of a "wet year". The modelled BMP will likewise meet reduction targets for a range of critical-months, and has capacity to capture runoff equivalent to the City of Carson's 85th percentile design storm.

This report recommends Alternative 1's site configuration and pumping specifications. This alternative entails a slightly higher construction cost than Alternative 2 due to additional excavation to accommodate gravity flows into the diversion system, but utilizing only one pump for dewatering will reduce long-term operating and maintenance costs. In addition, a mechanically simpler facility would reduce the required disturbance to the existing BMP's site and operations should future modifications to the BMP system be implemented. This enhanced feasibility is particularly valuable at Carriage Crest Park, as the BMP's dewatering pathways will likely evolve as the project proceeds, such as augmentations to the BMP's synergies with the receiving wastewater treatment plant. Considering that the BMP's size is restricted to the physical boundaries of Carriage Crest Park, designing for adaptability to expand pollutant reduction capacity beyond the limits of the system's storage capacity is vital for the long-term success of this BMP project.

The water quality analyses herein employed some of the best available analytical tools for simulating actively managed systems. Despite use of a global optimal and predictive control strategy to attempt to enhance pollutant capture, no substantial performance enhancement was elicited because the control logic was relatively simple (i.e., dewater at night if sewer capacity is available) and because long-term performance is generally governed by the relatively high dewatering rate to the sewer. Should additional constraints be introduced, or if the BMP proposed by the City of Torrance upstream from Carriage Crest is pursued, global optimal and predictive control will likely enhance overall system performance by optimizing operations to meet multiple goals.

7.0 REFERENCES

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