Appendix G

Hydraulic Evaluation

John Anson Ford Park
Infiltration Cistern Project

Hydrologic Evaluation

Prepared for:

City of Bell Gardens
8327 Garfield Avenue
Bell Gardens, California 90201
TEL (562) 806-7789
FAX (562) 806-7789

Prepared by:

1561 E. Orangethorpe Avenue, Suite 240
Fullerton, California, 92831

TEL (714) 526-7500 | FAX (714) 526-7004 | www.cwecorp.com

December 2018

Table of Contents

Appendices

List of Figures

List of Tables

Acronyms

BMP	Best Management Practice
cfs	Cubic Feet Per Second
DA	Drainage Area
DBL RCB	Double Reinforced Concrete Box
EPA	United States Environmental Protection Agency
fps	Feet Per Second
GLAC	Greater Los Angeles County
GWMA	Gateway Water Management Authority
IRWM	Integrated Regional Water Management
LACDPW	Los Angeles County Department of Public Works
LACFCD	Los Angeles County Flood Control District
LAR	Los Angeles River
MODRAT	Modified Rational Method
MS4	Municipal Stormwater Sewer System
NPDES	National Pollutant Discharge Elimination System
RAA	Reasonable Assurance Analysis
RCB	Reinforced Concrete Box
SWMM	Storm Water Management Model
SWMP	Stormwater Management Program
TMDL	Total Maximum Daily Load
UR2	Upper Reach 2
WMA	Watershed Management Area
WMP	Watershed Management Program
WMS	Watershed Modeling System
WQO	Water Quality Objective

1. Project Scope

The City of Bell Gardens (City) is implementing the John Anson Ford Park Infiltration Cistern Project (Project) to capture, retain, infiltrate, and replenish stormwater associated with dry- and wet-weather. The project will assist the City in complying with the Los Angeles River (LAR) Upper Reach 2 (UR2) Watershed Management Area (WMA) Watershed Management Program (WMP) Plan and comply with requirements for Municipal Separate Storm Sewer System (MS4) discharges. The discharge requirements are set forth by the National Pollutant Discharge Elimination System (NPDES) Permit No. CAS004001 (Permit). The WMP Plan establishes stormwater enhancement goals based on downstream Total Maximum Daily Loads (TMDLs); it identifies water quality priorities, discusses existing control measures, summarizes water quality modeling results, and proposes additional control measures to be implemented at a specified schedule. The WMP identifies six regional Best Management Practice (BMP) projects and a series of residential and commercial low impact development, or “LID Street” renovations that member cities of the WMA must implement over the next two decades.

The John Anson Ford Park Infiltration Cistern Project is the largest and costliest of the six regional BMP projects identified in the WMP Plan and has the earliest implementation date of January 2024. It is a key project identified in the LAR UR2 WMP and is also a component of the Stormwater Management Program (SWMP) Plans for both the Gateway Water Management Authority (GWMA) and Greater Los Angeles County (GLAC) Integrated Regional Water Management (IRWM) Plans, as the Project catchment falls within both jurisdictional management areas. The project is intended to address metals and bacteria, which were identified as the highest priority pollutants in the WMP.

As conceptualized, the project will be designed to meet both dry-weather TMDL compliance targets and wet-weather TMDL final compliance dates by providing for future expansion of the treatment/capture/infiltration of the project facility. At final completion, the Project is anticipated to provide compliance with existing Water Quality Objectives (WQOs) for the entire Rio Hondo watershed portion of the LAR UR2 WMA.

This hydrologic evaluation details existing hydrologic conditions pertinent to the Project and provides the hydrologic analyses necessary for the design of Project components. This includes the infiltration cistern as well as any necessary pretreatment, diversion structures, pumps, and pipes.

2. Project Design

The proposed project is intended to capture dry-weather and storm runoff from a catchment area of 2,295 acres. A feasibility study completed by Tetra Tech in 2017 found that capturing 42 acre-feet of stormwater at the Project site will allow for LAR UR2 WMA WMP's MS4 targets to be achieved. As such, 42 acre-feet is the ultimate water quality design volume for the Project. The 2017 Feasibility Study further showed a design storm flow rate of 70 cubic feet per second (cfs).

The Project proposes a subsurface infiltration cistern below John Anson Ford Park. **Figure 2-1** illustrates the location of the site relative to the City. Anticipated budget will guide the construction of the structure over various phases. The first phase will involve the construction of a diversion structure sized to divert the design storm flow rate of 70 cfs. This diversion will connect to the proposed subsurface infiltration cistern sized to hold a volume between 3 and 8 acre-feet. Future phases will expand upon the subsurface infiltration cistern until it can hold the total water quality design volume of 42 acre-feet. The ultimate project size may be increased beyond the required water quality design volume to achieve maximum feasible water supply benefits through subsurface infiltration and recharging of the groundwater aquifer.

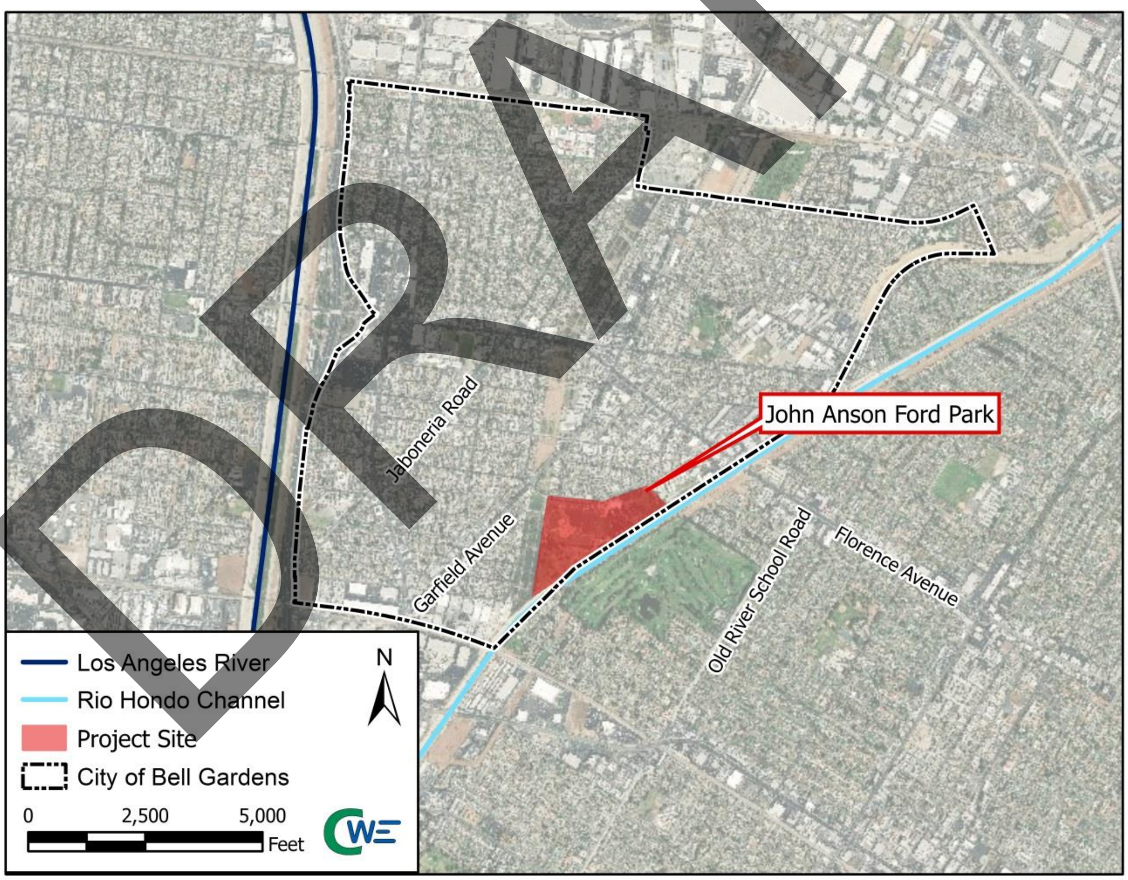


Figure 2-1 Project Site

Figure 2-2 presents a preliminary concept drawing of the proposed Project components. The drawing shows a proposed diversion structure connected to an existing storm drain. Shown in red is the footprint of the portion of the subsurface infiltration cistern that will be constructed during Phase 1 of the project. Shown in blue is the additional footprint required for the cistern to capture the design volume of 42 acre-feet. This portion of the cistern will be constructed in the Interim Phase. The drawing also shows the potential expansion of the cistern to provide additional storage. This portion can be constructed as future funding allows during the Full Build-Out phase. Phasing is further described in **Section 2.1**.

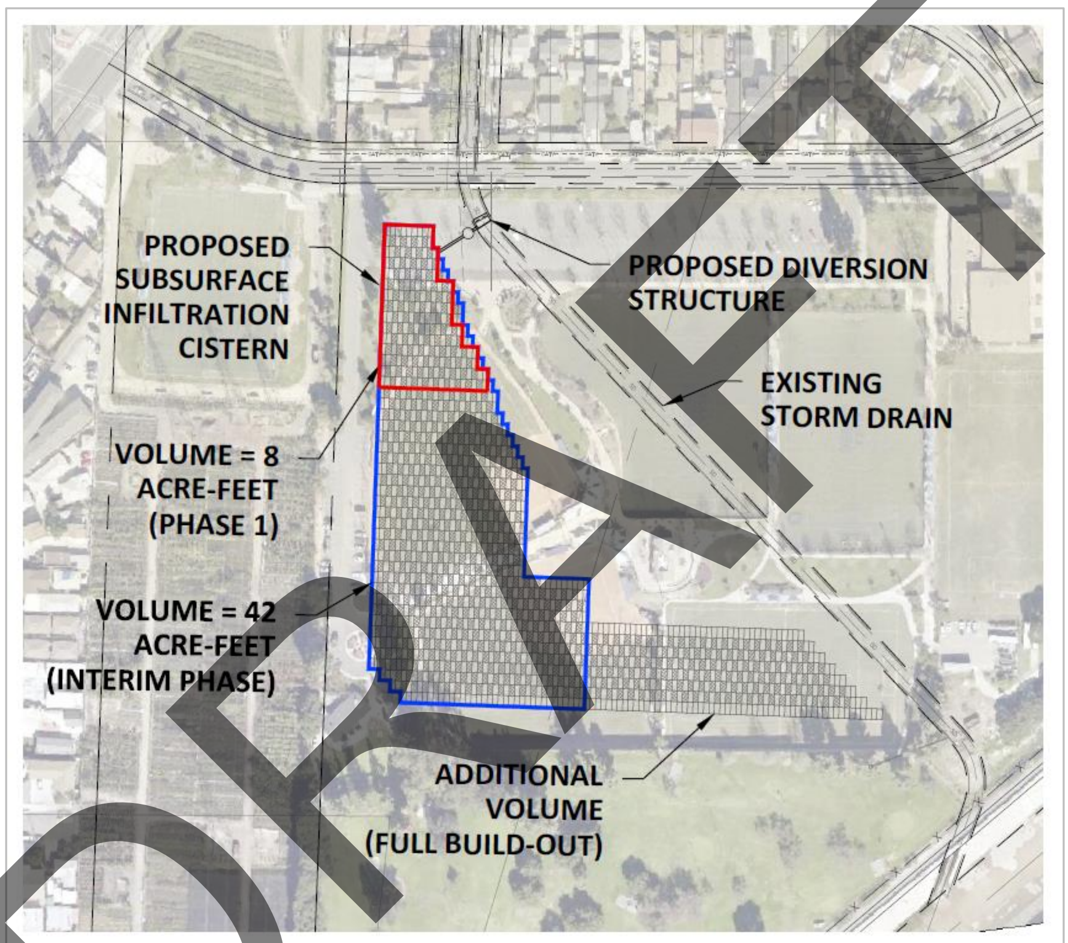


Figure 2-2 Preliminary Concept Drawing

2.1 Phasing and Phasing Scenarios

The Project will be carried in multiple phases: Phase 1, an Interim Phase, and the Full-Build-Out. A summary of the phases is provided in **Table 2-1**.

Table 2-1 Summary of Project Phases

Phase	Components	Cumulative Storage Capacity (ac-ft)
Phase 1	Diversion, pretreatment, pumps (as necessary), precast infiltration cells	2.77 – 8.23
Interim Phase	Additional precast infiltration cells	42.2 – 46.8
Full-Build Out	Additional precast infiltration cells	48.4 – 88.2

CWE has developed phasing scenarios A, B, and C, to compare the components and costs associated with these phases. The volume of stormwater infiltrated to groundwater due to the construction of each of these scenarios was analyzed using a continuous hydrologic simulation model, described further in **Section 5**.

2.1.1 Scenario A: Phase 1

Scenario A involves the components associated with Phase 1. The components include construction of the diversion structure, pretreatment structures, pumps (as necessary), and the first precast concrete infiltration cells. Phase 1, and consequentially Scenario A, were designed to keep costs at or below $8 million. This cost constraint produces design alternatives that vary in terms of pump utilization and runoff capture capacity.

2.1.2 Scenario B: Phase 1 and Interim Phase

Scenario B includes all components associated with Phase 1. The components include construction of the diversion structure, pretreatment structure, pumps (as necessary), and the first set of precast concrete infiltration cells. Scenario B includes construction of the additional Interim Phase precast concrete infiltration cells. Design alternatives in Scenario B achieve at least 42 ac-ft of stormwater storage which is the necessary volume cited in the 2017 Feasibility Study. Costs associated with proposed alternatives vary greatly with capacity as the limiting constraint.

2.1.3 Scenario C: Phase 1, Interim Phase, and Full Build-Out

Scenario C includes all components associated with Phase 1, the Interim Phase, and the final Full Build-Out. This includes enough additional infiltration cells to cover the full feasible area underneath the existing ball fields on the west side of the storm drain. Alternatives analyzed for this phasing scenario provide the greatest variance in cost and storage capacity.

3. Existing Conditions

Hydrologic analyses require specific knowledge about the site location, topography, soil properties, land use, and the design storm event. This section defines the existing conditions related to the hydrologic analysis for the project, including project location, tributary area, existing storm drains, drainage patterns, present soils, and impervious area.

3.1 Location

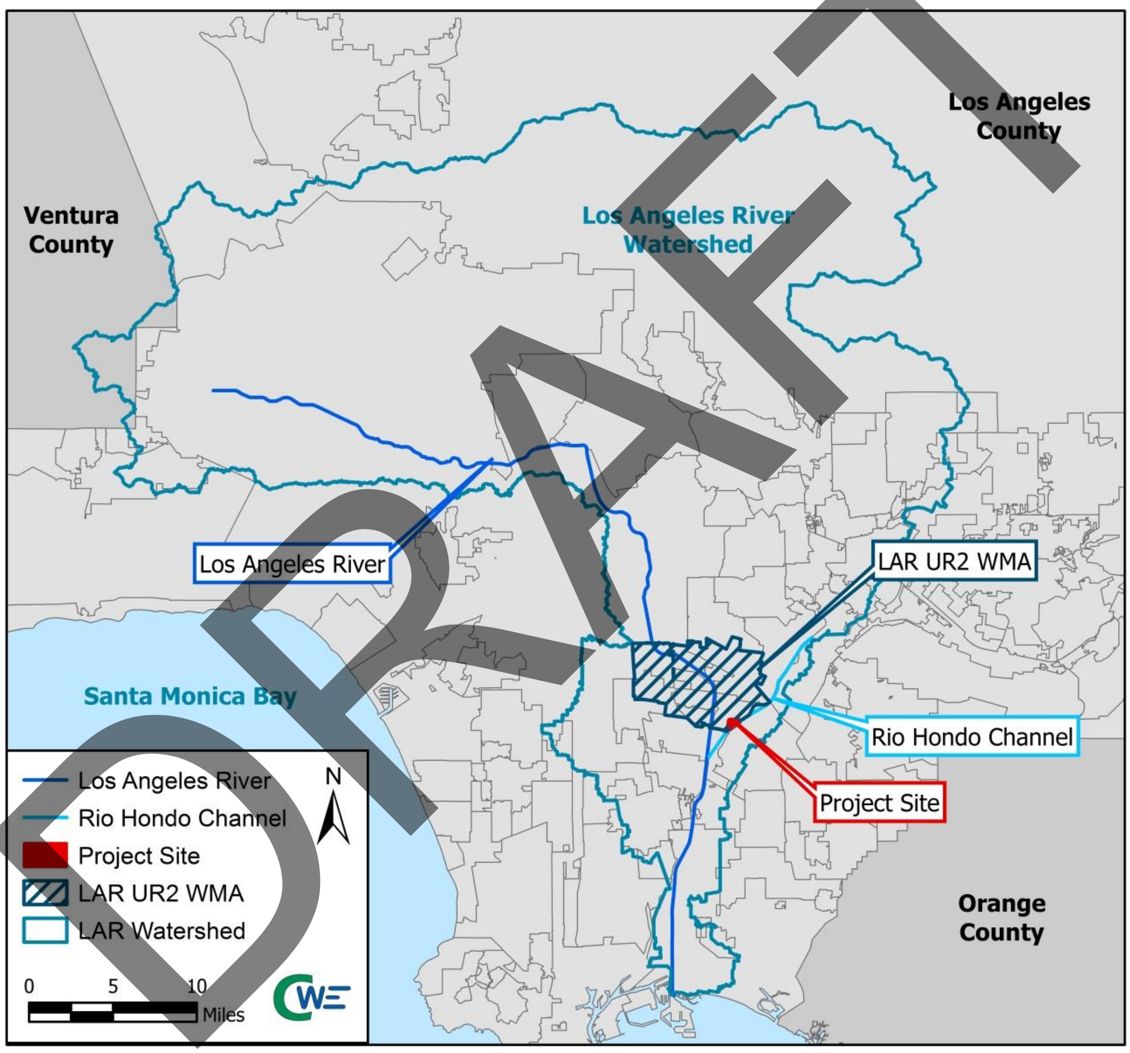


Figure 3-1 Location Map

The project is located at John Anson Ford Park in Bell Gardens which lies within the Los Angeles River (LAR) Watershed, as shown in **Figure 3-1**. The project site drains directly into the concrete-lined Rio Hondo Channel which is tributary to the LAR. It is a part of the LAR Upper Reach 2 (UR2) Watershed Management Area (WMA).

3.2 Tributary Area

Approximately 2,295 acres of land drain to the project site. As presented in **Figure 3-2**, the tributary area is comprised of portions of Bell Gardens and Commerce. The area also includes Unincorporated Los Angeles County and Montebello, which are not a part of the LAR UR2 WMA.

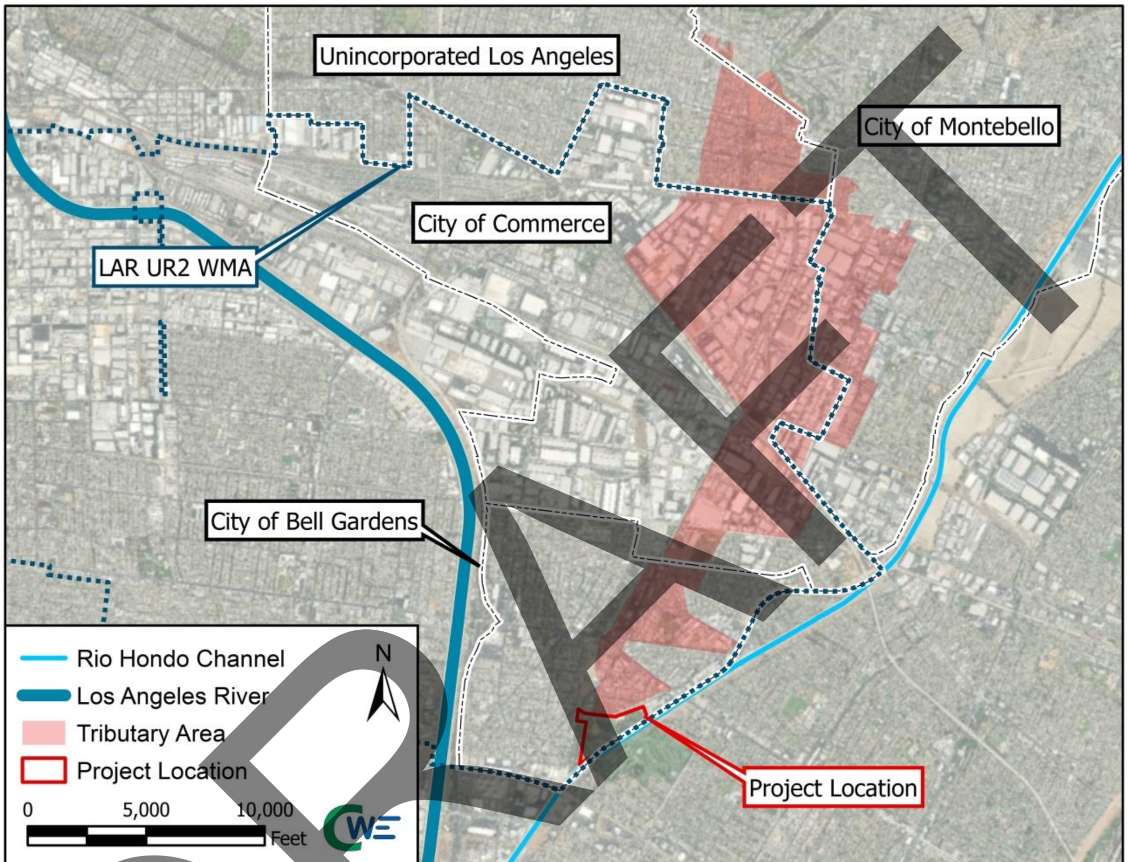


Figure 3-2 Tributary Area

Table 3-1 separates the tributary drainage area by city. The City of Bell Gardens has 276 acres within the area tributary to the Project and 1,539 acres within the LAR UR2 WMA.

Table 3-1 Tributary Area by City

City	Drainage Area (ac)	Percent of Total
City of Bell Gardens	276	12%
City of Commerce	1,260	55%
City of Montebello	447	20%
Unincorporated Los Angeles County	310	13%

3.2.1 Drainage Areas

Of the 2,295 acres of land tributary to the project site, four major drainage areas exist. Drainage Area (DA) 1 is comprised of 402 acres, DA2 is 817 acres, DA3 is 470 acres, and DA4 is 606 acres. **Figure** 3-3 presents these drainage areas and identifies the jurisdictions they lie within.

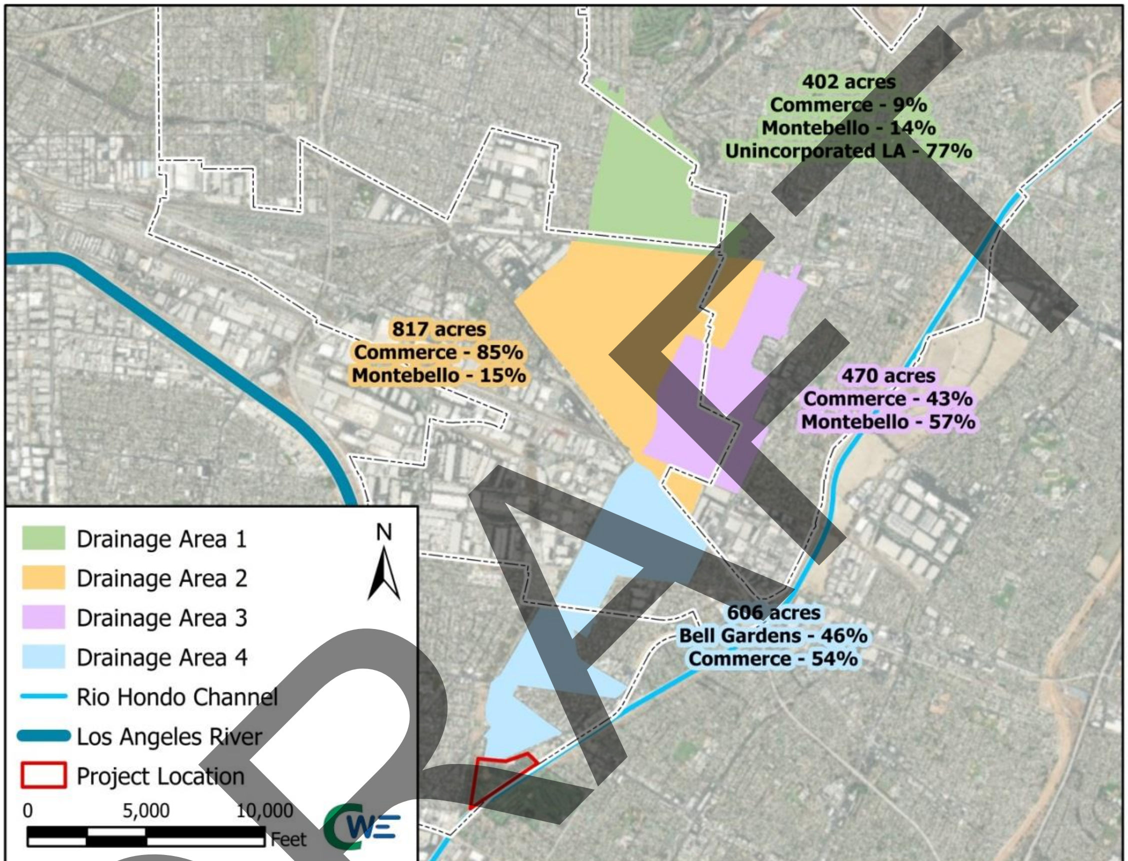


Figure 3-3 Drainage Areas

3.3 Storm Drains

The subsurface infiltration basin(s) proposed by the Project will divert stormwater flows from an existing storm drain (BI 0539 – Line A), maintained by the Los Angeles County Flood Control District (LACFCD). A multitude of lateral lines collect runoff and discharge into Line A of BI 0539. The storm drain segments at the outlet of each drainage area are identified to simplify modeling, which is further described in **Section 4**. The outlets are summarized in **Table 3-2**. DA1 outlets into DA2 via BI 1261 – Unit 2 Line B. DA2 outlets into DA4 via BI 0539 – Line A. DA3 outlets into DA4 via BI2501 – Unit 1 Line A. Finally, DA4 is conveyed via BI 0539 Line A beneath the Project site and into the Rio Hondo Channel. Identified segments of Unit 2 Line B and Unit 1 Line J consist of single reinforced concrete boxes (RCBs). Identified segments of Line A include sections comprised of a single RCB as well as sections with varied-dimension double (DBL) RCBs. **Figure 3-4** presents the main line, Storm Drain BI 0539 – Line A, along with its tributary laterals.

Table 3-2 Summary of Conveyances

Storm Drain Name	Segment	Size and Material
BI 1261 – Unit 2 Line B	DA1 Outlet	9.5' x 5.5' RCB
BI 0539 – Line A	DA2 Outlet	9.75' x 13' RCB
BI 2501 – Unit 1 Line J	DA3 Outlet	10' x 6' RCB
BI 0539 – Line A	DA4 Outlet	10' x 10' DBL RCB
BI 0539 – Line A	DA4 Outlet to Rio Hondo Channel	9.5' x 11' DBL RCB

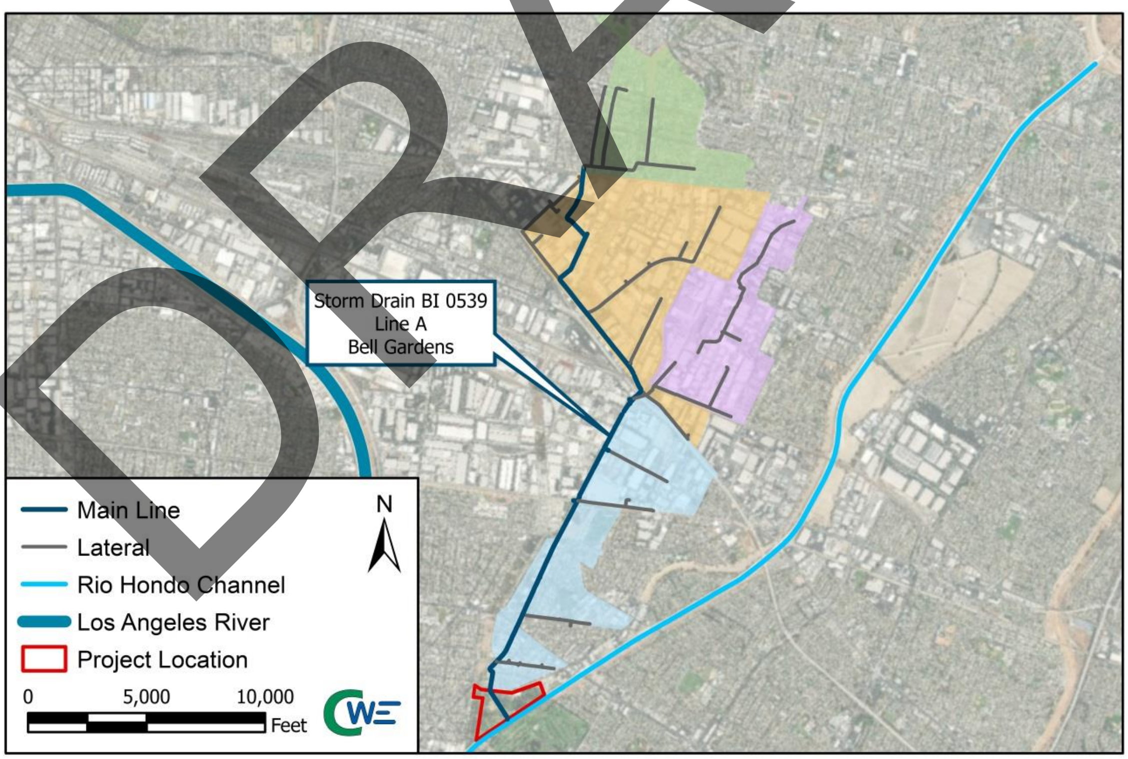


Figure 3-4 Existing Storm Drains

3.4 Flow Paths

The time of concentration in a drainage area is a function of the length of the most hydrologically distant (usually the longest) flow path tributary to the outlet of the catchment. The longest flow path for each DA was determined by analyzing flow paths along streets and within storm drain systems. Slopes were determined by identifying the change in surface elevation between the upstream and downstream points along the longest flow path for a given drainage area. The length L (in feet) and slope S (in vertical feet per horizontal foot) of the longest flow path in each of the four DAs is provided in **Figure 3-5.**

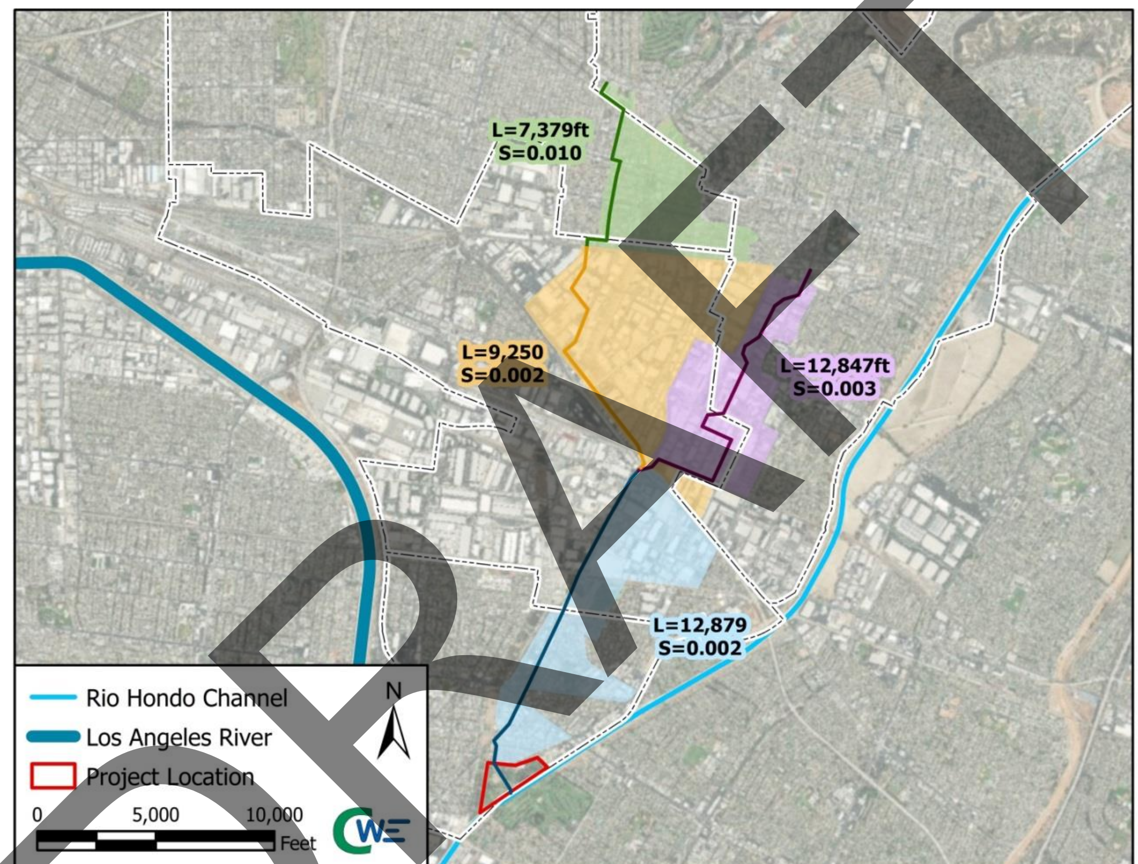


Figure 3-5 Flow Paths

3.5 Soils

The Los Angeles County Department of Public Works (LACDPW) Hydrology Manual (2006) includes a runoff coefficient curve for each of the 179 soil types found within the county. The Hydrology Manual assigns a number to each of the soils that correspond with each soil type. There are six different soil types found within the project's drainage area, as illustrated in **Figure 3-6**. Soil Type 013 – Ramona Loam is the dominant soil type in each DA.

Figure 3-6 Soil Types within Drainage Areas

3.6 Land Use

The amount of impervious area within a drainage area is a key factor in determining the runoff volume produced from a rain event. The impervious area is related to the land use type, with transportation, industrial, and commercial land uses containing more impervious area and low density residential land uses containing less impervious area. The drainage area of the project contains several types of land uses, from developed parks and recreation to manufacturing, assembly, and industrial services. Most of the land uses have an attributed imperviousness of 90 to 100%.

Figure 3-7 Land Use and Impervious Area

The land uses and the amount of impervious area in each of the four DAs are summarized in **Table 3-3** .

Table 3-3 Land Use and Impervious Area

	Land Use Category	% Impervious	Area (acres)	% of Catchment
Drainage Area 1	Communication Facilities	82	2	< 1
	Developed Local Parks and Recreation	10	13	3
	Electrical Power Facilities	47	< 1	< 1
	Electrical Power Facilities-Powerlines (Urban)	2	< 1	< 1
	Elementary Schools	82	5	1
	High-Density Single Family Residential	42	242	60
	Junior or Intermediate High Schools	82	14	3
	Low-Rise Apartments, Condominiums, and Townhouses	86	40	10
	Manufacturing, Assembly, and Industrial Services	91	11	3
	Mixed Transportation	90	< 1	< 1
	Modern Strip Development	96	1	< 1
	Nurseries	15	31	8
	Older Strip Development	97	24	6
	Open Storage	66	< 1	< 1
	Religious Facilities	82	6	1
	Senior High Schools	82	8	2
	Truck Terminals	91	4	1
	Wholesaling and Warehousing	91	< 1	< 1
	Total:	**52** (weighted average)	**402**	**100**
Drainage Area 2	Bus Terminals and Yards	91	3	< 1
	Commercial Recreation	90	29	3
	Electrical Power Facilities	47	2	< 1
	Electrical Power Facilities-Powerlines (Urban)	2	11	1
	Fire Stations	91	1	< 1
	Freeways and Major Roads	91	10	1
	High-Density Single Family Residential	42	< 1	< 1
	Hotels and Motels	96	8	< 1
	Low- and Medium-Rise Major Office Use	91	< 1	< 1
	Manufacturing, Assembly, and Industrial Services	91	584	71
	Mixed Residential	59	< 1	< 1
	Mixed Transportation	90	5	< 1
	Modern Strip Development	96	23	3
	Natural Gas and Petroleum Facilities-Petroleum Refining and Processing	91	12	1
	Nurseries	15	7	< 1
	Open Storage	66	5	< 1

	Retail Centers (Non-Strip With Contiguous Interconnected Off-Street Parking)	96	12	1
	Truck Terminals	91	6	< 1
	Vacant Undifferentiated	1	4	< 1
	Wholesaling and Warehousing	91	94	11
	Total:	**89** (weighted average)	**817**	**100**
Drainage Area 3	Commercial Storage	90	2	< 1
	Communication Facilities	82	25	5
	High-Density Single Family Residential	42	11	2
	Low- and Medium-Rise Major Office Use	91	4	< 1
	Low-Rise Apartments, Condominiums, and Townhouses	86	21	4
	Maintenance Yards	91	9	2
	Manufacturing, Assembly, and Industrial Services	91	275	59
	Modern Strip Development	96	< 1	< 1
	Natural Gas and Petroleum Facilities-Petroleum Refining and Processes	91	2	< 1
	Retail Centers (Non-Strip With Contiguous Interconnected Off-Street Parking)	96	< 1	< 1
	Senior High Schools	82	11	2
	Trailer Parks and Mobile Home Courts, High-Density	91	10	2
	Truck Terminals	91	49	11
	Vacant Undifferentiated	1	3	< 1
	Wholesaling and Warehousing	91	47	10
	Total:	**88** (weighted average)	**470**	**100**
Drainage Area 4	Cemeteries	10	34	6
	Developed Local Parks and Recreation	10	19	3
	Electrical Power Facilities	47	< 1	< 1
	Electrical Power Facilities-Powerlines (Urban)	2	< 1	< 1
	Elementary Schools	82	22	4
	Fire Stations	91	1	< 1
	Freeways and Major Roads	91	18	3
	Government Offices	91	9	2
	High-Density Single Family Residential	42	11	2
	Junior or Intermediate High Schools	82	16	3
	Low- and Medium-Rise Major Office Use	91	2	< 1
	Low-Rise Apartments, Condominiums, and Townhouses	86	4	< 1
	Maintenance Yards	91	9	1
	Manufacturing, Assembly, and Industrial Services	91	245	40

	Mixed Commercial and Industrial	91	4	< 1
	Mixed Residential	59	108	18
	Modern Strip Development	96	22	4
	Nurseries	15	< 1	< 1
	Older Strip Development	97	6	< 1
	Open Storage	66	2	< 1
	Police and Sheriff Stations	91	1	< 1
	Religious Facilities	82	2	< 1
	Retail Centers (Non-Strip With Contiguous Interconnected Off-Street Parking)	96	4	< 1
	Truck Terminals	91	9	2
	Vacant Undifferentiated	1	8	1
	Wholesaling and Warehousing	91	49	8
	Total:	**76** (weighted average)	**606**	**100**

4. Hydrology

A hydrologic analysis was performed to identify the quantity (volume and flow rate) of runoff tributary to the Project site. The hydrologic analysis identifies the required capture volume and flow rate used to design the proposed stormwater structures. This section describes the methodology and results of the hydrologic analysis.

4.1 Methodology

Hydrologic studies within Los Angeles County are required to use the Modified Rational Method (MODRAT) developed by the Los Angeles County Flood Control District (LACFCD). The LACDPW Hydrology Manual outlines the methodology used for conducting a hydrologic analysis.

Table 10.1.1 in the Hydrology Manual lists the data necessary for conducting hydrologic modeling, which is summarized in **Table 4-1** below. The table indicates what Section within this Study the required data is further described.

Table 4-1 Hydrologic Modeling Data Requirements

Required Data	Description	Section
Subarea Size	The surface area inside the subarea (catchment) boundaries	**3.2**
Flow Path Length	Length of the conveyance between catchment collection points	**3.4**
Flow Path Slope	Slope of the flow path used for calculating the time of concentration (Tc)	**3.4**
Conveyance Data	A description of the flow conveyance between catchment collection points	**3.3**
Soil Types	A soil classification identifying the hydrologic characteristics of the catchment's surface soils	**3.5**
Land Use/ Imperviousness	A classification of impervious surface area based on development types within the catchment	**3.6**
Design Storm Definition	Each catchment has a unique design storm based on the location and the rainfall recurrence interval being modeled	**4.1.1**
Time of Concentration	The time required for runoff from the most hydrologically remote point in a catchment to reach the collection point	**4.1.2**

Subarea size, flow path length and slope, soil types, and land use/imperviousness are identified in **Section 3**. The design storm for the project was determined through the process described in **Section 4.1.1**. Time of concentration was determined through a process defined in **Section 4.1.2**.

4.1.1 Design Storm Depth

Water quality projects in Los Angeles County are deemed to comply with MS4 NPDES permit requirements if they are sized to capture the volume of stormwater expected during the 85th percentile 24-hour storm and the peak flow rate of stormwater during such a storm. Compliance can also be proven through more detailed water quality and hydrologic analyses, but the 85th percentile storm is typically a large conservative baseline storm event; if a project can capture the 85th percentile storm, it likely will have captured a high enough concentration of pollutants of concern.

The shape of the hyetograph of the 85th percentile storm is prescribed in the LACDPW Hydrology Manual. The ordinate values are fixed in time and vary only by the total rainfall depth. Thus it is possible to determine a volume of stormwater with the shape of the 85th percentile storm given a flow rate, and vice versa. The WMP Plan assumed that TMDL compliance could be met if the Project treated a design storm of 0.60 inches and had the capability of storing 72 acre-feet of stormwater. The 2017 Feasibility Study demonstrated that TMDL compliance could be met if the Project was sized to be capable of diverting a flow rate of 70 cfs and storing only 42 acre-feet of stormwater, but it did not cite a design storm depth. In this study, a hydrologic evaluation was performed using MODRAT to determine the magnitude or proportion of the 85th percentile storm volume and flow rate associated with the 2017 Feasibility Study's metrics of a 70 cfs diversion and 42 acre-feet of storage.

4.1.2 Time of Concentration

Time of concentration was calculated by determining flow velocities within each drainage area using Manning's equation. This required flows in each drainage area to be modeled as open channel flow along a given cross section. Each drainage area was assumed to have a cross section that included an 8-inch curb height and 1-foot gutter width. The cross slope of the gutter was assumed to be 4% and the street cross slope was assumed to be 2%. A Manning's n of 0.015 was used for the gutter while 0.016 was used for the street. The distance from the curb to the centerline of the street varied between drainage areas as did the longitudinal slope. To calculate a flow velocity, this calculation assumed a flow depth of 8 inches, the full height of the curb.

Calculated flow velocities – in feet per second (fps) – were divided by the longest flow path length – presented in **Section 3.4** – to determine time of concentration. Results are summarized **Table 4-2**.

Table 4-2 Time of Concentration

Drainage Area	Flow Velocity (fps)	Time of Concentration (min)
	fps	min
DA1	5.6	22
DA2	2.0	76
DA3	3.1	70
DA4	2.0	106

4.2 Findings

The Los Angeles County 85th percentile isohyetal map shows the rainfall depth as ranging from 0.88 inches at the most upstream portion of the drainage area to 0.94 inches downstream at John Anson Ford Park. A value of 0.90 inches which occurs near the centroid of the drainage area tributary to the Project site was assumed to apply to the entire tributary area as the 85th Percentile, 24-hour rain depth. This is more than the value cited in the WMP Plan, which was 0.60 inches.

Determining the storm depth associated with the 2017 Feasibility Study's peak flow rate of 70 cfs and volume of 42 acre-feet required an iterative process that involved running the model until the design flow rate was achieved. Upon determining time of concentration, which is described in **Section 4.1.2**, the model was run using varying storm depths until a peak flow rate of 70 cfs was achieved. The resulting storm depth was 0.30 inches. This finding suggests that a design storm depth of 0.30 inches would be sufficient in complying with water quality objectives set forth in the LAR UR2 WMP.

Table 4-3 provides the peak flow rate and the total runoff volume from the MODRAT hydrologic analysis performed in accordance with the LACDPW Hydrology Manual. Detailed input and output for the model is included in **Appendix A**.

Table 4-3 Hydrologic Analysis Results

Event Description	Storm Depth	Peak Flow Rate (cfs)	24-hour Runoff Volume (acre-feet)
	in	cfs	acre-feet
Design Storm	0.30	70	38
Feasibility Study	0.60	147	77
85th Percentile	0.90	227	117

As discussed in **Section 4.1.1**, the results provided by **Table 4-3** are associated with three different storm events. The rainfall depth from a storm that produces a peak flow rate of 70 cfs is only 0.30 inches, which is one third of the depth from the 85th percentile storm. The volume of runoff associated with a storm of that size is 38 acre-feet, 4 acre-feet less than the 42 acre-feet assumed in the 2017 Feasibility Study.

The WMP Plan assumed a required capture volume of 72 acre-feet from a design storm of 0.60 inches. This analysis found a volume of 77 acre-feet using such a design storm. The 0.60-inch storm is two thirds of the depth from the 85th percentile storm.

For full capture of the 85th percentile storm, the Project would need to be capable of storing 117 acre-feet of runoff from a diversion sized to capture 227 cfs. In relation to the 42 acre-feet suggested by the 2017 Feasibility Study, a BMP sized to capture the full 85th percentile storm would be oversized by 179%.

The design storm varies depending on which analysis one deems as correct. Intrinsic to all design storm analyses is the assumption that the critical storm resembles the hyetograph specified by the LACDPW Hydrology Manual. A more precise estimate of the critical storm expected within a given catchment can be found through a continuous hydrologic simulation using long-term rain gage data with intra-day logging capabilities. This type of analysis is discussed further in **Section 5**.

5. Continuous Hydrologic Simulation Model

CWE performed a long-term hydrologic simulation of the drainage area tributary to BI 0539 – Line A at the location of the proposed diversion. The purpose of long-term hydrologic modeling is to examine the performance of a hydrologic system using real-world rainfall data, not just from a theoretical event-based design storm. In this way, long-term modeling volumes of runoff can be estimated, which is useful in determining a location-specific critical storm sequence with which to size the diversion structure and the infiltration cistern. The following subsections discuss the model, the rain gage data on which the modeling was based, the determination of the critical storm sequences, and the quantification of the mean annual volume of water that can be captured and used to augment the regional water aquifers for each design scenario. A summary report for the model is included in **Appendix B**.

5.1 Hydrologic Model

The hydrologic model used in the continuous simulation was the Storm Water Management Model (SWMM) developed by the United States Environmental Protection Agency (EPA), version 5.0. EPA-SWMM is widely used throughout the industry for single event or long-term simulations of water runoff quantity and quality primarily in urban areas. It was developed to help support stormwater management objectives to reduce runoff through infiltration and retention, and to help reduce discharges that cause impairment of receiving water bodies (EPA, 2018).

5.1.1 Model Setup

EPA-SWMM uses a set of parameters for each subcatchment and for each conduit within the model. The parameters used in the John Anson Ford Park analysis are described in the following subsections.

5.1.1.1 Subcatchment Hydrologic Parameters

EPA-SWMM uses mass balance principles to partition precipitation over a catchment over a given time period into an infiltration component, an evaporation component, and a runoff component. The volume of each of these components depends on intrinsic hydrologic characteristics of each subcatchment. The analysis for the John Anson Ford project used the Natural Resource Conservation Service (NRCS) Curve Number method to calculate the infiltration component, and assumed negligible evaporation.

The 2,295-acre drainage area tributary to BI 0539 – Line A at the location of the proposed diversion was divided into four subcatchments as described in **Section 3.2**. The four subcatchments were modeled using the parameters listed in **Table 5-1**.

Table 5-1 Subcatchment Hydrologic Parameters

Subcatchment Parameter	DA1	DA2	DA3	DA4
Area (ac)	402	817	470	606
Width (ft)	8,493	10,873	5,530	4,803
Slope	1.0%	0.2%	0.3%	0.2%
Imperviousness	52%	89%	88%	76%
Manning's n – impervious portion	0.013	0.013	0.013	0.013
Manning's n – pervious portion	0.025	0.025	0.025	0.025
Depression storage depth (in)	0.05	0.05	0.05	0.05
NRCS Curve Number	78	93	93	88
Drying time (days)	10	10	10	10

The subcatchment parameters used by the EPA-SWMM model are described in detail as follows. Area, slope, and imperviousness were defined as discussed in **Section 3**. The surface roughness parameters for the impervious portion (0.013) and the pervious portion (0.025) of each subcatchment were set to typical values for impervious paving and short grasses respectively. Accumulated precipitation above the depression storage depth becomes runoff in the EPA-SWMM model, and a depth of 0.05 inches is within the range of a typical value. The soil drying time is a parameter used to compute the regeneration of soil storage capacity, and a value of 10 days is a typical conservative value.

EPA-SWMM conceptualizes a subcatchment as a rectangular surface that has a uniform width so that the Manning equation can be used to calculate the flow rate as if the subcatchment were an extremely wide uniform rectangular channel. As such it is difficult to measure the property of width if the subcatchment deviates too much from the rectangular assumption, as most subcatchments do. Therefore the subcatchment width was used as the primary calibration parameter, and the values listed in **Table 5-1** represent the values after calibration was performed. Calibration is discussed in more detail in **Section 5.1.2**.

An average NRCS Curve Number was calculated for each subcatchment based on the soil type and the percent imperviousness of land uses. The dominant soil type for each subcatchment, Type 013 – Ramona Loam, is typified by high infiltration rates similar to a hydrologic soil group type A or B. The curve number for pervious areas of each subcatchment was therefore set to a typical value for urban landscaping covers for type B soils under an antecedent moisture condition (AMC) level of II, as found in various hydrology manuals in southern California. This value was set to 56. For the impervious area curve number, the value was set to a typical value of 98. The curve numbers were then area-weighted to develop a single curve number value for the entire subcatchment area, as listed in **Table 5-1**.

5.1.1.2 Conduit Hydrologic Parameters

EPA-SWMM uses dynamic wave routing to determine the timing and magnitude of the runoff component as runoff flows downstream. The analysis for the John Anson Ford project uses conduit geometry as found in as-built plans for BI 0539 – Line A in a generalized sense. Three conduits were incorporated into the EPA-SWMM model: Conduit 1 routes flows downstream from DA1 to the junction with DA2 and DA3, Conduit 2 routes flows downstream from the junction with DA2 and DA3 to the junction with DA4, and Conduit 3 connects the junction with DA4 to the outlet at the Rio Hondo River. Conduit 3 represents the storm drain beneath John Anson Ford Park where the diversion will be placed, so it was the conduit from which flows were analyzed. The three conduits were modeled in EPA-SWMM using the parameters listed in **Table 5-2**.

Table 5-2 Conduit Hydrologic Parameters

Conduit Parameter	Conduit 1	Conduit 2	Conduit 3
Length (ft)	9,557	13,215	100
Roughness – Manning's n	0.013	0.013	0.013
Shape – dimensions of each barrel	Single box - 9.75 ft. wide by 13 ft. high	Double box – 10 ft. wide by 10 ft. high	Double box – 9.5 ft. wide by 11 ft. high
Upstream invert elevation	155.90	122.69	100.92
Downstream invert elevation	122.69	100.92	100.00

5.1.2 Model Calibration

The goal of any hydrologic model is to accurately compute real world flow rates and volumes in a given channel at a given location, but given the uncertainty and simplification in the quantification of hydrologic parameters, models may not accurately represent the physical processes in the first run. Hydrologic models must be calibrated to conform to known data points to achieve this goal. Unfortunately, no streamflow monitoring data is available for BI 0539 – Line A at the point of the proposed diversion. Therefore, the model was calibrated using MODRAT calculations for each subwatershed as described in **Section 4**.

The calibration run of the EPA-SWMM model used the 24-hour 85th percentile hyetograph at a time step of one minute. The shape of the hyetograph was constructed using the temporal distribution of the design storm unit hyetograph from Appendix A of the LACDPW Hydrology Manual (2006). The volume of the hyetograph was set to 0.90 inches over the 24-hour period, as described in **Section 4.1.1**.

The width of each subcatchment was altered until the EPA-SWMM model produced peak flow rates for each subcatchment equivalent to the flow rates determined by MODRAT for the 85th percentile storm analysis. These flow rates are included in **Table 5-3** and in **Appendix A**.

Table 5-3 Design Storm Results

	DA1	DA2	DA3	DA4
Area (ac)	402	817	470	606
Imperviousness	52%	89%	88%	76%
Subcatchment Width (ft)	8,493	10,873	5,530	4,803
85th Percentile Peak Flow Rate (cfs)	55.54	99.12	58.66	56.60

The peak flow rate at the location of the proposed diversion during the 85th percentile rain event was calculated to be 226.88 cubic feet per second (cfs) using downstream routing procedures from the LACDPW Hydrology Manual (2006). The EPA-SWMM model calculated this value as 224.38 cfs using dynamic flow routing methods. The difference at the downstream location is only 2.50 cfs, or 1.1%, which is a negligible difference. Therefore the subcatchment and conduit parameters used in the calibration run of the EPA-SWMM model were deemed acceptable for the continuous run of the model.

5.2 Precipitation Data

Precipitation data for the continuous model originated from the Los Angeles County Automatic Local Evaluation in Real Time (ALERT) Rain Gage AL383 located in the County's Imperial Yard at the confluence of the Rio Hondo River and the Los Angeles River. The Imperial Yard gage is located approximately two miles away from John Anson Ford Park. The Imperial Yard gage is a tipping bucket gage that can record rainfall to a precision of 0.01 inches and time to a precision of 1 second.

The County provided CWE with Imperial Yard tipping bucket gage data for the entire length of their records, which only consisted of ten water years between 2008-2009 and 2017-2018. The tipping bucket data was compiled into a continuous hyetograph with a regular interval of five minutes, represented in graphical format in **Figure 5-1**. This 10-year hyetograph was used to calculate runoff using the EPA-SWMM continuous model.

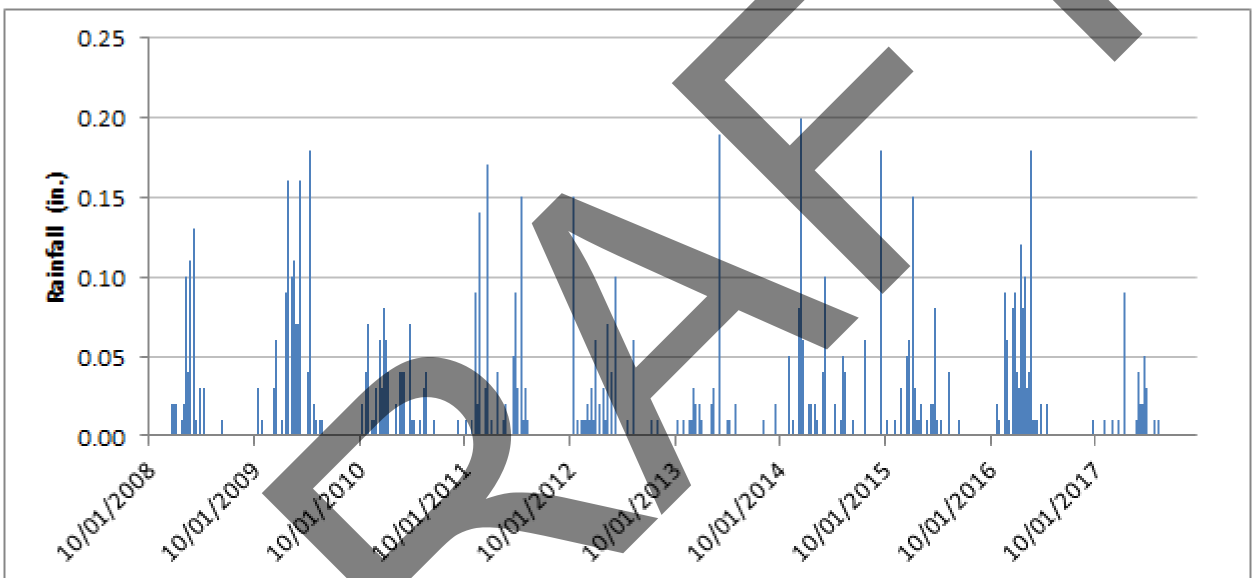


Figure 5-1 10-Year Hyetograph, 5-Minute Interval

5.3 Model Output

The EPA-SWMM model produced a continuous hydrograph at the proposed diversion location at an interval of 5 minutes for the entire 10-year period of record of the Imperial Yard ALERT gage. The output was over a million data points. A couple of interesting portions of the continuous hydrograph are shown below.

The highest peak flow rate, according to the EPA-SWMM model, occurred on January 22, 2017, on a day when the Imperial Yard ALERT rain gage recorded 2.96 inches of rain over the entire day. **Figure 5-2** shows the peak flow rate of 1,583 cfs at the location of the proposed diversion.

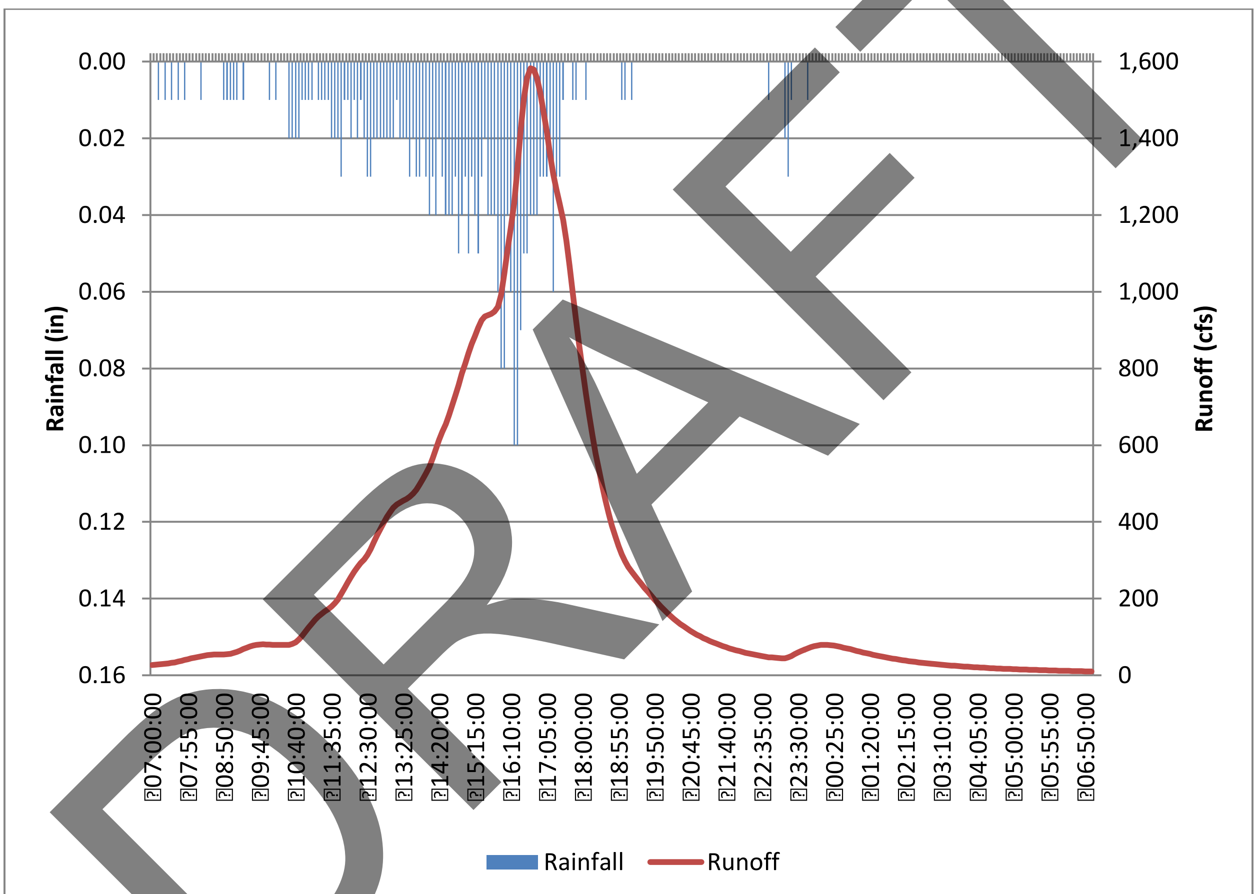


Figure 5-2 Hydrograph for January 22, 2017 Storm

The highest peak intensity rainfall within the modeled dataset occurred between 3:40 am and 3:45 am on December 12, 2014, when 0.20 inches of rain fell at Imperial Yard over five minutes. However, due to dry antecedent soil conditions, the EPA-SWMM model predicted that the cloudburst only resulted in a peak flow rate of 524 cfs at 4:35 am, 50 minutes after the peak intensity rainfall. Later that morning, a lower intensity burst of rain produced an even higher peak runoff, 534 cfs, as shown in **Figure 5-3**. The EPA-SWMM model using the real-time ALERT rain gage data can capture these sorts of intra-storm details in a way that larger watershed-scale modeling used in past studies could not.

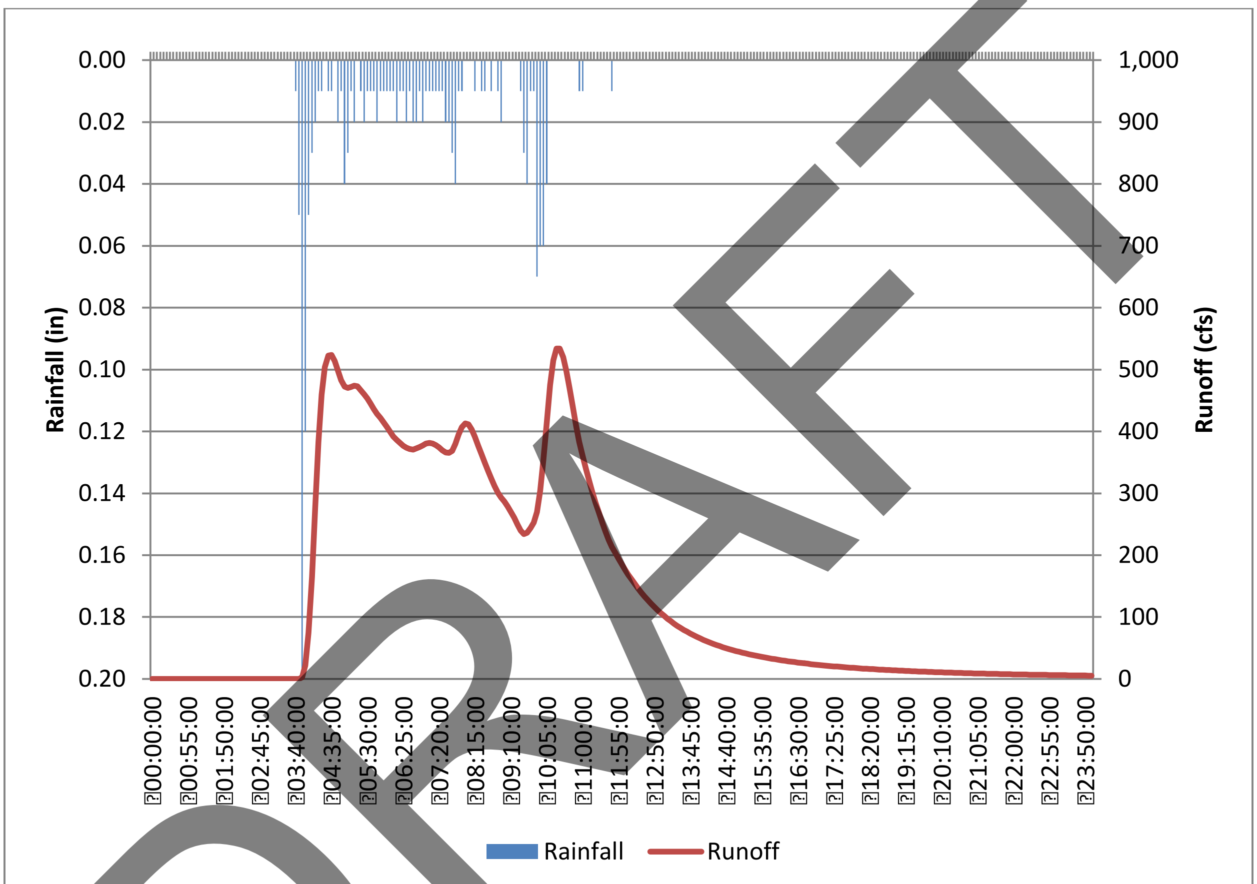


Figure 5-3 Hydrograph for December 12, 2014 Storm

5.4 Critical Storm Sequence

The John Anson Ford Park project was identified as a potential regional BMP project in the LAR UR2 WMA WMP Plan (CWE, 2015). The LAR UR2 WMA WMP Plan included a Reasonable Assurance Analysis (RAA) of the LAR UR2 watershed based on physical characteristics and pollutant assumptions, approved by the Regional Board, supporting the assertion that implementation of the approved WMP Plan would result in the attainment of regional water quality objectives. For storm runoff, the purpose of the RAA was to demonstrate that the WMP Plan would achieve water quality objectives (WQOs), water quality-based effluent limitations (WQBELs), and receiving water limitations (RWLs) during critical design storm conditions, for the priority pollutants of concern.

The critical design flow condition in the RAA for the LAR UR2 WMA WMP plan was set at the 90th percentile daily flow rate for the two subwatersheds in the plan that drained to the Los Angeles River and the Rio Hondo River respectively. The critical design flow condition was consistent with LARWQCB RAA Guidelines (2014), which defines critical conditions for baseline estimates of flow rates as either the 90th percentile of long-term estimated/modeled flow rates, or the runoff volume from the 85th percentile, 24-hour rainfall event where retention-based BMPs will capture 100% of the volume, or other critical conditions established in any applicable TMDL. However, the watershed-based scale of the RAA limited the applicability to designing the John Anson Ford Park project regarding the capacity of the diversion structure and the storage volume of the infiltration cistern.

The 2017 Feasibility Study refined the design of the project by including hydrologic and pollutant load modeling using the EPA System for Urban Stormwater Treatment and Analysis Integration (EPA-SUSTAIN) model. The 2017 Feasibility Study examined a ten-year period of rainfall from 2002 to 2011 from a network of rain gages. The applicable rain gage for the subcatchment tributary to the John Anson Ford Park project was the LA County gage D1256 – South Gate Transfer Station, according to the Theissen polygons included with the Watershed Model Calibration document (Tetra Tech, 2010). This gage is not part of LA County's real-time ALERT system, so the County tallies rainfall from the gage on a daily basis, rather than logging the data as rainfall occurs. Therefore any analysis on a sub-daily level required algorithmic averaging and estimating of rainfall data, which reduces the accuracy of the output flow rates.

This analysis refines the definition of the critical storm design flow condition by focusing the analysis specifically on the subcatchment tributary to the proposed diversion, and by using actual, non-averaged rainfall data from the Imperial Yard ALERT gage.

The RAA for the LAR UR2 WMA WMP plan used the 90th percentile flow rate per the LARWQCB RAA Guidelines, but on a 24-hour basis. The LARWQCB RAA Guidelines do not specify the unit of time on which to base the flow intensity percentiles, nor do they specify the lower threshold of flow values to exclude from the percentile analysis. This analysis assumes that dry-weather runoff is excluded from the flow percentile analysis. This analysis evaluates critical storm sequence events with three different time periods: one hour, six hours, and 24 hours.

5.4.1 Dry-Weather Flow Analysis

Most of the time, only dry-weather flows exist in the major storm drain systems of Southern California. A 90th percentile flow rate analysis that does not exclude periods of dry weather would find an unreasonably low flow rate. Therefore dry-weather flows must be excluded. This subsection describes how dry-weather flow time periods were determined for the BI 0539 – Line A storm drain.

Over the past twenty years, local agencies in southern California have implemented various low flow diversion projects that collect dry-weather flow from channels and storm drains and send it to wastewater treatment facilities. The diverted runoff must first be metered to measure the quantity of flows, and some agencies have shared this flow rate data publicly. The data varies by area, by location, and by season. Additionally, other studies have been conducted showing relationships between watershed size and the flow rate of dry-weather runoff in southern California, in particular in Stein and Ackerman (2007) which showed a value of 81 gallons per acre per day for the Ballona Creek watershed.

Figure 5-4 shows the average dry-weather flow rate from three datasets by month. Each data series represents the average of several low flow diversions in a region. The average dry-weather flow rate mostly varies between about 100 and 300 gallons per day (gpd) per acre, except in the Santa Monica Bay area during fall months.

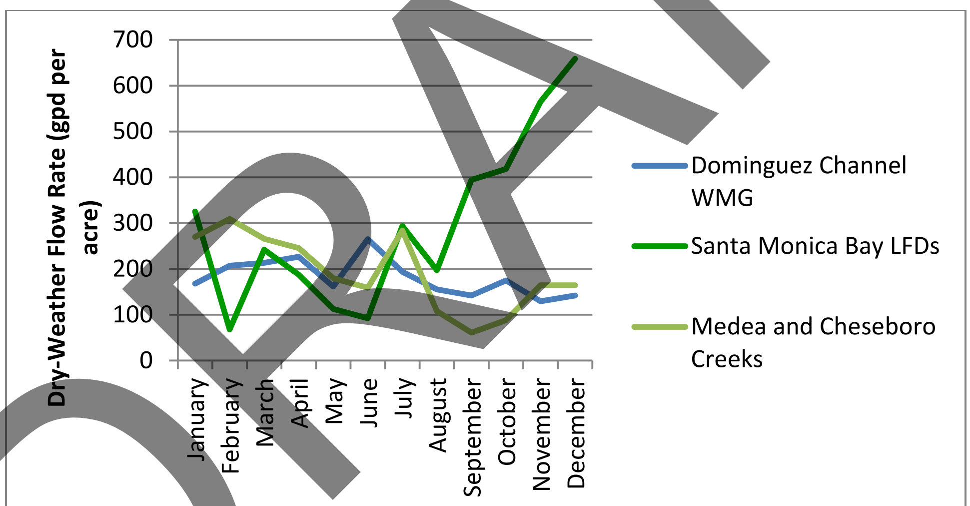


Figure 5-4 Dry-Weather Flows by Season

The average dry-weather flow from 35 different low flow diversions around southern California on an annual average is 352 gpd per acre. This value is skewed by two low flow diversions with dry-weather flow greater than 1,000 gpd per acre; the median flow rate is only 117 gpd per acre. To account for the seasonal variability of flow and to eliminate the skewing effects of the arithmetic mean, a value equal to the 80th percentile of the average dry-weather flow rate was established as a reasonable estimate. This value is 307 gpd per acre.

For the John Anson Ford Park project, 2,295.4 acres are tributary to BI 0539 – Line A at the location of the proposed diversion. The dry-weather flow threshold was set to 307 gpd per acre, or 1.09 cfs. Any flow rate above 1.09 cfs was considered wet-weather flow and included in the critical storm sequence analysis; any flow rate below 1.09 cfs was excluded from the critical storm sequence analysis.

5.4.2 Time Interval Sequencing

The first step to finding the critical storm sequence was breaking the 10-year 5-minute hydrograph into discrete time periods of lengths of one hour, six hours, and 24 hours and calculating the volume of runoff that passes through the location of the proposed diversion on BI 0539 – Line A. The volumes of runoff were sorted in order from largest to smallest, and the volumes lower than 1.09 cfs over the entire time step were eliminated.

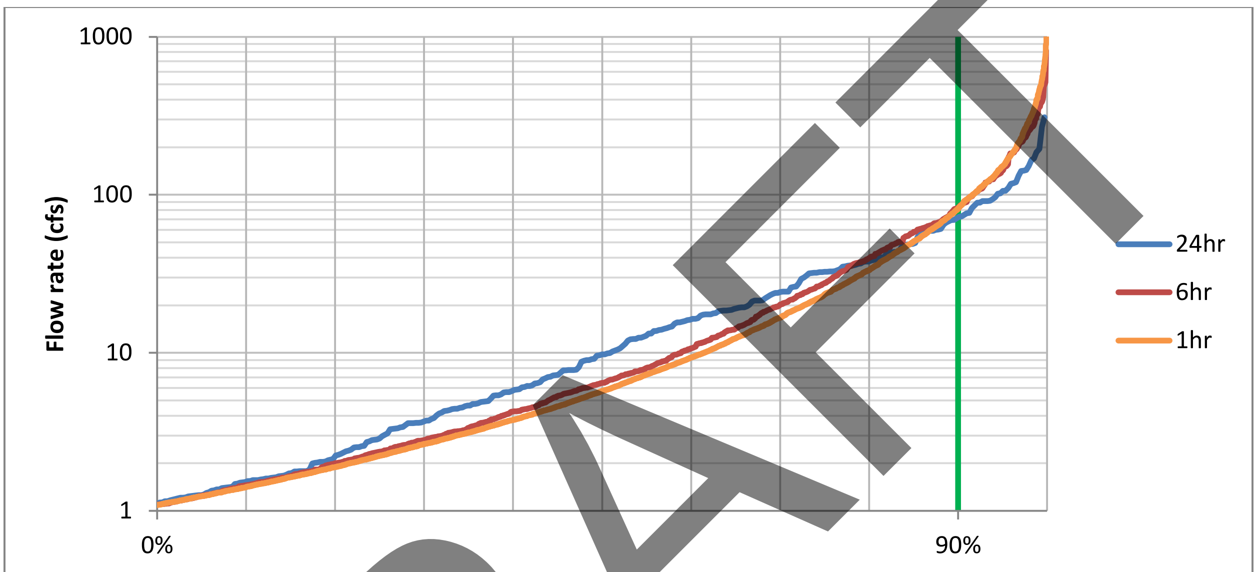


Figure 5-5 Flow Distribution Curves

Figure 5-5 shows the flow distribution curves that resulted. Though the maximum value differs drastically depending on the time interval, the 90th percentile flow rate averaged across the entire time step is roughly the same across all three analyzed time periods. **Table 5-4** reveals some of the statistics of the flow rate.

Table 5-4 Flow Rate Statistics

Statistic	1 hour	6 hours	24 hours
90th percentile flow rate	81.15 cfs	82.35 cfs	70.54 cfs
Number of periods with wet-weather flow	6,510	1,140	344
Maximum flow rate intensity	1,383 cfs	817 cfs	310 cfs

This analysis shows that a diversion structure sized to accept 70 to 82 cfs would conform to the intent of the RAA Guidelines and be sufficiently sized to treat pollutants of concern.

5.5 Volume of Captured Stormwater

CWE examined each John Anson Ford Park subsurface storage system design alternative as described in **Appendix C** to calculate how much water could infiltrate through the soils to recharge the groundwater aquifer.

5.5.1 Calculation Procedure

The volume of stormwater at each time step was partitioned according to conservation of mass equations. **Figure 5-6** depicts the procedure used to calculate the volume of water at the end of each time step. Diverted stormwater from the BI 0539 – Line A storm drain enters the proposed infiltration cistern as long as the flow rate does not exceed the capacity of the diversion, which was assumed to equal 70 cfs for all design alternatives. The diverted stormwater joins the volume of water already in the infiltration cistern. From this maximum potential stormwater volume, the volume of infiltrated stormwater is subtracted at each time step. The infiltration volume is the minimum of either the surface area multiplied by the infiltration rate, which was assumed to be 1.7 inches per hour as specified in the 2017 Feasibility Study, or the remaining volume of water in the cistern. If there is excess volume after infiltration has been subtracted, the remaining stormwater is partitioned into either outflow back to the BI 0539 – Line A storm drain (for when excess volume exceeds the maximum capacity of the infiltration cistern) or existing cistern volume for the next time step.

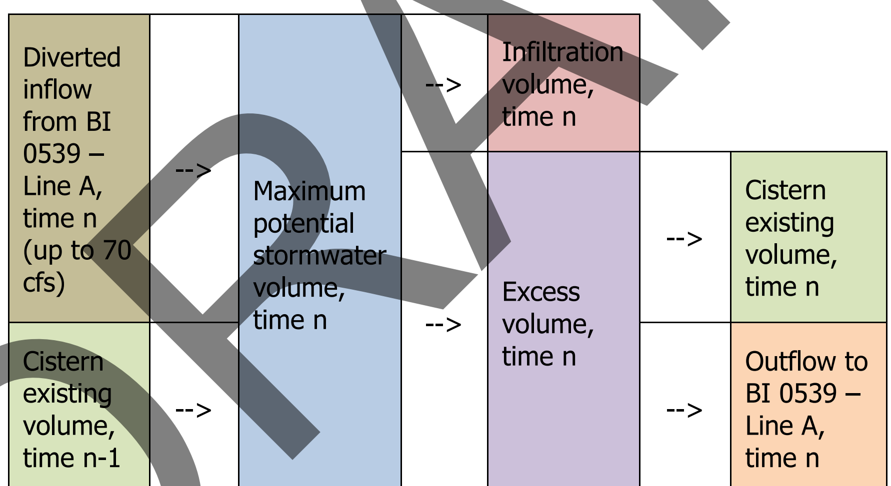


Figure 5-6 Calculation Procedure Diagram

5.5.2 Average Rain Year

This analysis examined the volume of water available for infiltration at each 5-minute time step for the entire ten years of gaged rainfall data from the Imperial Yard ALERT gage. Ordinarily the average volume of infiltration expected on an annual basis could be defined as the total volume infiltrated over the entire period of record divided by the number of years in the record. However, the timespan between 2008 and 2018 included some of the driest years of recorded rainfall in southern California. **Table 5-5** shows a comparison of rainfall at the Imperial Yard ALERT gage with rainfall recorded at the County's downtown Los Angeles gage on Ducommun Street, where reliable recorded daily rainfall data has been continuously measured since 1877 (145 years of data). The ten years of data from the Imperial Yard ALERT gage include the second driest year, the fourth driest year, and the eleventh driest year ever recorded at the Ducommun gage.

Table 5-5 Annual Rainfall Percentile

Water Year	Rainfall recorded at Imperial Yard (in)	Rainfall Recorded at Ducommun (in)	Percentile Rank of Rainfall at Ducommun
2008-2009	6.52	9.32	**20.0%**
2009-2010	15.50	15.90	**62.7%**
2010-2011	19.30	22.90	**86.8%**
2011-2012	7.74	9.38	**22.0%**
2012-2013	6.20	7.01	**6.8%**
2013-2014	5.16	5.39	**2.0%**
2014-2015	9.43	10.77	**30.3%**
2015-2016	7.46	8.20	**13.7%**
2016-2017	18.20	19.87	**76.5%**
2017-2018	4.29	4.88	**0.6%**

An arithmetic average over the ten years of data from the Imperial Yard ALERT gage would produce an annual volume captured that would be less than the volume that could be expected from an "average" year of rainfall. The closest year to an average year at the Ducommun gage within the ten year dataset was the 2009-2010 water year. Therefore this analysis identifies both the total volume of infiltration and the volume of infiltration that would have occurred in the 2009-2010 water year had the project been constructed at the time.

5.5.3 Analyses of Phasing Scenarios

CWE has developed eight design alternatives, incorporating three different types of precast underground storage chambers, with heights varying by whether the infiltration cistern will be filled by gravity flow or by pumped flow. For each of these eight design alternatives, CWE has developed phasing scenarios A, B, and C, which were introduced in **Section 2.1**. Additional information and results for the hydrologic analyses for each scenario are provided in the sections below.

5.5.3.1 Scenario A

Table 5-6 summarizes the eight alternatives as they pertain to Scenario A and provides the sizing assumptions made for each.

Table 5-6 Description of Design Alternatives - Scenario A

Design Alternative	Cell Description	Pumps?	Infiltrating Surface Area (acres)	Storage Volume (ac-ft)	Approx. Cost
Conspan 1A	14' high precast arch	Yes	0.261	2.95	$8 mil.
Conspan 1B	22' high precast arch	Yes	0.147	2.77	$8 mil.
Conspan 2A	14' high precast arch	No	0.643	7.19	$8 mil.
Conspan 2B	22' high precast arch	No	0.423	7.85	$8 mil.
Oldcastle 1	14' high stacked precast clam shell	Yes	0.250	3.39	$8 mil.
Oldcastle 2	14' high stacked precast clam shell	No	0.626	8.23	$8 mil.
Stormtrap 1	15' high precast box	Yes	0.242	3.31	$8 mil.
Stormtrap 2	22.5' high stacked precast boxes	No	0.400	8.01	$8 mil.

The results of the hydrologic analysis are listed in **Table 5-7**.

Table 5-7 Infiltration Volume - Scenario A

Design Alternative	2009-2010 Water Year			10 Years of Record Gage Data		
	Infiltrated Volume (ac-ft)	Bypass Volume (ac-ft)	Percent of Total Flow Captured	Infiltrated Volume (ac-ft)	Bypass Volume (ac-ft)	Percent of Total Flow Captured
Conspan 1A	96	2,765	3%	882	16,910	5%
Conspan 1B	69	2,791	2%	654	17,138	4%
Conspan 2A	203	2,658	7%	1,790	16,002	10%
Conspan 2B	173	2,687	6%	1,554	16,238	9%
Oldcastle 1	99	2,762	3%	904	16,888	5%
Oldcastle 2	210	2,651	7%	1,865	15,927	10%
Stormtrap 1	96	2,764	3%	884	16,908	5%
Stormtrap 2	170	2,690	6%	1,529	16,263	9%

5.5.3.2 Scenario B

Table 5-8 summarizes the eight alternatives as they pertain to Scenario B and provides the sizing assumptions made for each.

Table 5-8 Description of Design Alternatives - Scenario B

Design Alternative	Cell Description	Pumps?	Infiltrating Surface Area (acres)	Storage Volume (ac-ft)	Approx. Cost
Conspan 1A	14' high precast arch	Yes	3.84	43.5	$36 mil.
Conspan 1B	22' high precast arch	Yes	2.23	42.2	$33 mil.
Conspan 2A	14' high precast arch	No	3.79	42.9	$39 mil.
Conspan 2B	22' high precast arch	No	2.26	43.1	$34 mil.
Oldcastle 1	14' high stacked precast clam shell	Yes	3.43	46.8	$34 mil.
Oldcastle 2	14' high stacked precast clam shell	No	3.31	45.6	$35 mil.
Stormtrap 1	15' high precast box	Yes	3.15	43.0	$34 mil.
Stormtrap 2	22.5' high stacked precast boxes	No	2.14	42.7	$34 mil.

The results of the hydrologic analysis are included in **Table 5-9**.

Table 5-9 Infiltration Volume - Scenario B

Design Alternative	2009-2010 Water Year			10 Years of Record Gage Data		
	Infiltrated Volume (ac-ft)	Bypass Volume (ac-ft)	Percent of Total Flow Captured	Infiltrated Volume (ac-ft)	Bypass Volume (ac-ft)	Percent of Total Flow Captured
Conspan 1A	796	2,064	28%	6,735	11,057	38%
Conspan 1B	650	2,210	23%	5,631	12,161	32%
Conspan 2A	789	2,072	28%	6,679	11,113	38%
Conspan 2B	659	2,201	23%	5,699	12,093	32%
Oldcastle 1	786	2,074	27%	6,649	11,143	37%
Oldcastle 2	769	2,091	27%	6,522	11,270	37%
Stormtrap 1	743	2,117	26%	6,314	11,478	35%
Stormtrap 2	644	2,217	22%	5,576	12,216	31%

5.5.3.3 Scenario C

Table 5-10 summarizes the eight alternatives as they pertain to Scenario C and provides the sizing assumptions made for each.

Table 5-10 Description of Design Alternatives - Scenario C

Design Alternative	Cell Description	Pumps?	Infiltrating Surface Area (acres)	Storage Volume (ac-ft)	Approx. Cost
Conspan 1A	14' high precast arch	Yes	4.93	55.8	$44 mil.
Conspan 1B	22' high precast arch	Yes	4.67	71.4	$61 mil.
Conspan 2A	14' high precast arch	No	4.28	48.4	$42 mil.
Conspan 2B	22' high precast arch	No	3.76	88.2	$54 mil.
Oldcastle 1	14' high stacked precast clam shell	Yes	5.17	66.9	$47 mil.
Oldcastle 2	14' high stacked precast clam shell	No	4.45	59.7	$46 mil.
Stormtrap 1	15' high precast box	Yes	4.98	74.7	$49 mil.
Stormtrap 2	22.5' high stacked precast boxes	No	3.80	85.1	$56 mil.

The results of the hydrologic analysis are included in **Table 5-11**.

Table 5-11 Infiltration Volume - Scenario C

Design Alternative	2009-2010 Water Year			10 Years of Record Gage Data		
	Infiltrated Volume (ac-ft)	Bypass Volume (ac-ft)	Percent of Total Flow Captured	Infiltrated Volume (ac-ft)	Bypass Volume (ac-ft)	Percent of Total Flow Captured
Conspan 1A	933	1,928	33%	7,696	10,096	43%
Conspan 1B	994	1,867	35%	8,049	9,743	45%
Conspan 2A	854	2,006	30%	7,170	10,622	40%
Conspan 2B	1,007	1,854	35%	8,035	9,757	45%
Oldcastle 1	1,003	1,857	35%	8,095	9,697	45%
Oldcastle 2	921	1,939	32%	7,644	10,148	43%
Stormtrap 1	1,026	1,835	36%	8,225	9,567	46%
Stormtrap 2	997	1,863	35%	8,002	9,790	45%

All design alternatives and scenarios analyzed in these sections assume that the infiltration rate is constant with time. This is a reasonable assumption only if proper maintenance is performed on the cistern on a regular basis to ensure that sediment does not clog up the bottom of the basin, which reduces infiltration rates.

5.6 Cost per Unit Volume Infiltrated

The cost on a unit volume basis for each design alternative and each phasing scenario is summarized in **Table 5-12**. The infiltrated volume is based on the 2009-2010 water year, multiplied by an assumed 50-year lifespan of the project. Costs are estimated project construction costs in 2018 dollars.

Table 5-12 Cost Per Unit Volume Infiltrated

Design Alternative	Scenario A			Scenario B			Scenario C		
	Cost (millions of $)	Infiltrated Volume (af/y)	Cost Per Unit Volume ($/af)	Cost (millions of $)	Infiltrated Volume (af/y)	Cost Per Unit Volume ($/af)	Cost (millions of $)	Infiltrated Volume (af/y)	Cost Per Unit Volume ($/af)
Conspan 1A	7.966	96	$1,660	35.925	796	$887	44.208	933	$948
Conspan 1B	7.893	69	$2,288	33.226	650	$1,022	60.954	994	$1,226
Conspan 2A	7.974	203	$786	38.854	789	$985	42.157	854	$987
Conspan 2B	7.996	173	$924	33.684	659	$1,022	53.921	1,007	$1,071
Oldcastle 1	7.924	99	$1,601	34.223	786	$871	47.233	1,003	$942
Oldcastle 2	7.982	210	$760	34.571	769	$899	46.239	921	$1,004
Stormtrap 1	7.985	96	$1,664	33.963	743	$914	48.916	1,026	$954
Stormtrap 2	7.764	170	$913	33.720	644	$1,047	56.152	997	$1,126

When looking only at the Scenario A design alternatives, the versions with no pumps are all more cost effective on the basis of unit volume of groundwater recharge than their counterparts with pumps. The Oldcastle 2 alternative provides the largest volume of infiltrated groundwater and is also the most cost effective option.

When each design alternative is expanded to be capable of storing 42 acre-feet (Scenario B), the versions with pumps tend to become more competitive on a cost per acre foot basis due to requiring less excavation costs. The largest volume of infiltrated groundwater is achieved through the Conspan 1A design alternative, but the most cost effective design alternative is the Oldcastle 1 alternative. Oldcastle 2 also allows for the infiltration of stormwater to groundwater at less than $900 per acre-foot over 50 years.

For the full feasible buildout options (Scenario C), the cost effectiveness tends to decrease for all options even as the volume recharged increases. Oldcastle 1 is the most cost effective option, while Stormtrap 1 provides the largest infiltrated volume.

5.7 Optimization

The design alternatives discussed in the previous sections assumed there would be a diversion from the storm drain with a capacity of 70 cfs and a cistern with a volume determined by the size of the footprint and the type of storage unit. An optimization was performed in the 2017 Feasibility Study that set the optimum size of the diversion and cistern at 70 cfs and 42 acre-feet, respectively. The following sections re-analyze the optimization of the project given the detailed hydrograph generated through the continuous hydrologic simulation.

5.7.1 Diversion

The amount of water that can be infiltrated by the Project is controlled by the capacity of the diversion, the capacity of the cistern, and the infiltration rate. **Figure 5-7** shows the volume of runoff that would infiltrate within the Oldcastle 2 Scenario C design alternative with varying diversion structure capacities between 10 cfs and 300 cfs for the typical water year, 2009-2010. The figure shows that while the total runoff remains the same, 2,860 acre-feet for the year, the proportion of the runoff that is capable of being diverted increases as the size of the diversion structure increases. However, the proportion of this divertible runoff that actually becomes groundwater is relatively constant above a diversion capacity of 70 cfs. For diversions above 70 cfs, the amount of groundwater recharge is no longer limited by the amount of stormwater runoff entering the cistern, but rather by the capacity of the cistern to store flood flows and by the infiltration rate and surface area that controls the volume of infiltrated stormwater at each time step.

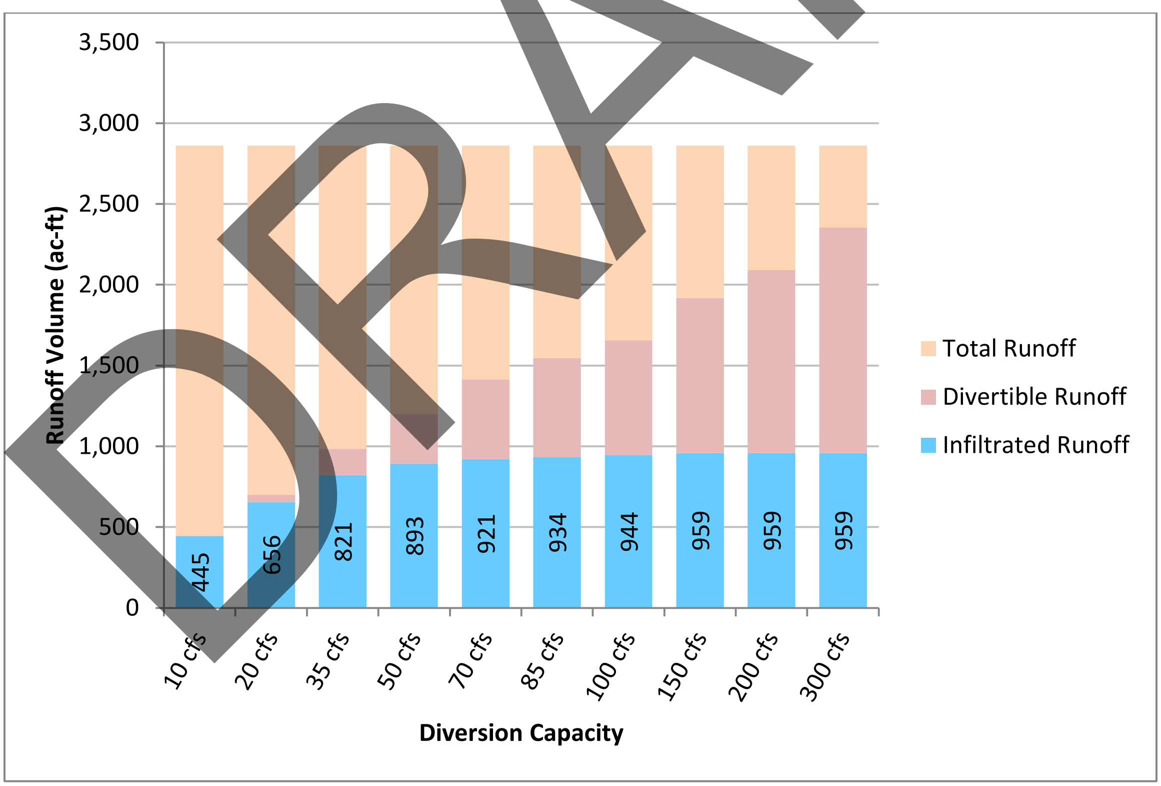


Figure 5-7 Infiltrated Runoff with Varying Diversion Size, 2009-2010 Water Year

5.7.2 Cistern

The same analysis can be applied to optimize the size of the cistern by keeping the diversion capacity constant. **Figure 5-8** shows the infiltrated volume that is possible if the diversion capacity is constant but the cistern size is allowed to vary. The figure was calculated assuming that Oldcastle 2 was the chosen design alternative, with an overall capacity of 13.78 acre-feet per acre of surface area. This is slightly less than the 14-foot interior height of the Oldcastle 2 design alternative and accounts for the storage lost to wall space. The diversion was assumed to be capable of conveying up to 70 cfs to the cistern.

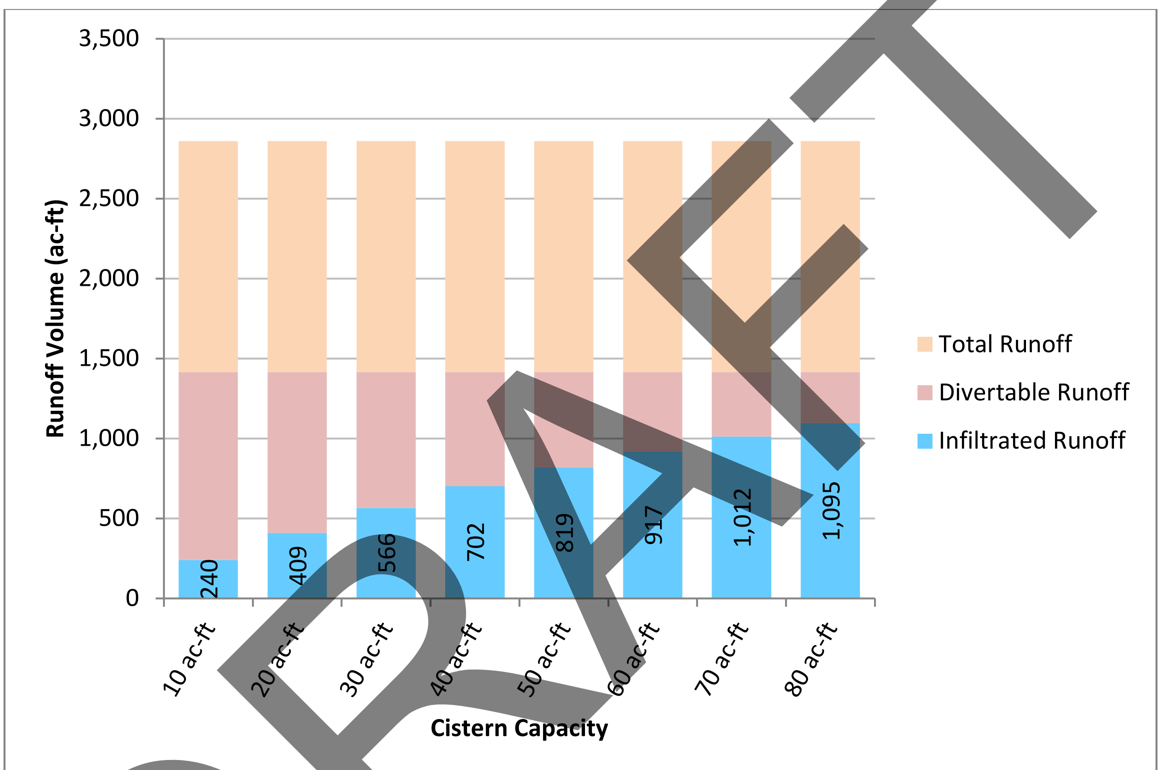


Figure 5-8 Infiltrated Runoff with Varying Cistern Size, 2009-2010 Water Year

Figure 5-8 shows how the infiltrated runoff increases with increasing cistern capacity, though the incremental gain is reduced at larger capacities; the benefit of increasing a 10 acre-foot cistern by 10 acre-feet (169 acre-feet of additional infiltrated runoff per year) is greater than the benefit of increasing a 70 acre-foot cistern by 10 acre-feet (83 acre-feet of additional infiltrated runoff per year).

This analysis can be extended to determining the optimum cistern capacity based on the cost per acre-foot of stormwater and dry-weather runoff infiltrated to groundwater over the assumed 50-year lifespan of the project. The cost of the Oldcastle 2 design alternative was calculated for three data points of varying volume (Scenario A, Scenario B, and Scenario C) as described in **Section 5.5.3**. Using these three data points, a linear best fit relationship was developed to relate the capacity of the cistern to the cost of the project. From this linear equation it was possible to develop a very rough cost for a cistern of any size.

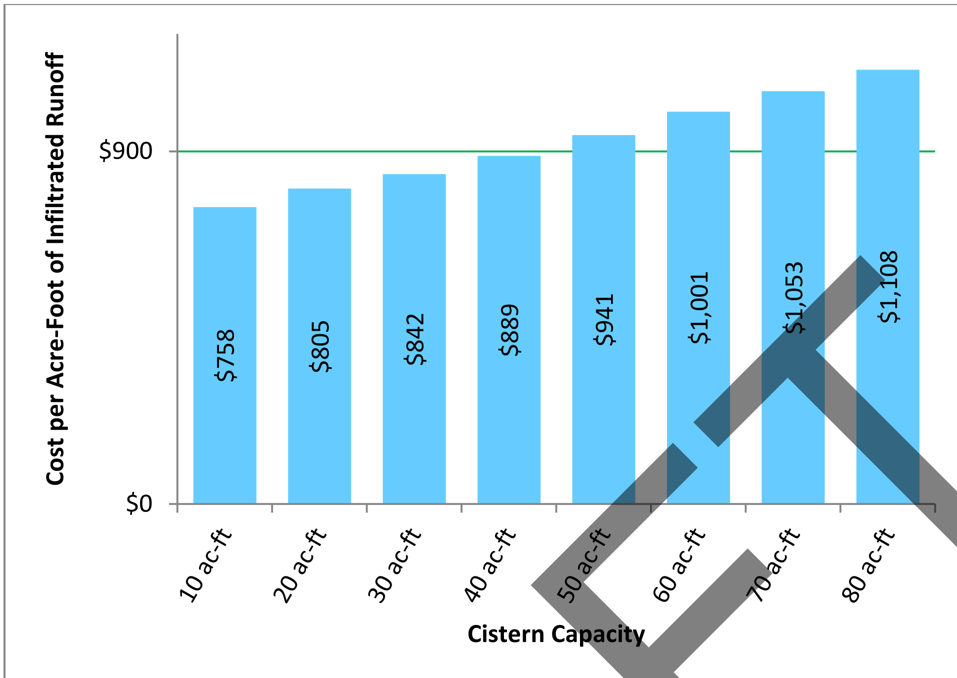


Figure 5-9 Cost per Volume of Groundwater Recharge for Various Cistern Capacities

Figure 5-9 shows the cost per acre-foot of infiltrated runoff for various sizes of cistern over the life of the project, assuming a design similar to the Oldcastle 2 design alternative. The cost on a unit volume of runoff basis increases with larger cistern capacity in part because the incremental benefit at larger cistern capacities is reduced.

The optimum cistern design would be the size at which it would become more expensive to construct the project than it would to purchase the same quantity of water from outside sources. There are several estimates for the cost of an acre-foot of imported water. A California Public Utilities Commission (CPUC) Policy and Planning White Paper found an average cost of about $800 per acre-foot for water in 2016. The Metropolitan Water District (MWD), which delivers water to the member cities of the Central Basin MWD, charged $1,015 per acre-foot for treated water in 2018. A reasonable cost estimate for water would be about $900 per acre-foot based on these sources of information. This can be considered the breakeven cost.

As **Figure 5-9** shows, the breakeven cost is exceeded for cistern capacities of 50 acre-feet and larger. The optimum cistern capacity is somewhere around 42 acre-feet, the same value asserted in the 2017 Feasibility Study.

6. Summary and Recommendations

The hydrologic analyses presented in this report demonstrate that in a typical year, the Project site receives over 2,800 ac-ft of stormwater – more than 900 million gallons. The investigation conducted in **Section 5.7** further demonstrated that capturing up to **42** ac-ft would be most beneficial given economic and size constraints. For these reasons, a diversion flow of **70** cfs is recommended for the John Anson Ford Park Infiltration Cistern Project.

Under the assumptions detailed in **Section 5**, the Project will be able to capture between 644 and 796 acre-feet of stormwater and dry-weather runoff during a typical year and allow the runoff to recharge the groundwater aquifer.

7. References

California Public Utilities Commission (CPUC). January 12, 2016. "What Will Be the Cost of Future Sources of Water for California?"
http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/About_Us/Organization/Divisions/Policy_and_Planning/PPD_Work/PPD_Work_Products_(2014_forward)/PPD%20-%20Production%20costs%20for%20new%20water.pdf

CWE. June 12, 2015. Los Angeles River Upper Reach 2 Watershed Management Area Watershed Management Program (LAR UR2 WMA WMP) Plan.
https://www.waterboards.ca.gov/rwqcb4/water_issues/programs/stormwater/municipal/watershed_management/los_angeles/upper_reach2/Upper_LA_River_R2_FinalWMP.pdf

Los Angeles County Department of Public Works (LACDPW). January 2006. Hydrology Manual.

Los Angeles County Design Division. April 1977. Storm Drain Plans in Tract No. 30144 P.D. No. 1330. Drawing Number PF520877, PF548781.

Los Angeles County Flood Control District (LACFCD). January 1963. Project No. 539 Bell Gardens Lines A, B, C, and 8. Drawing Number 275-539-D2.3, 275-539-D2.4, 275-539-D2.13, PD031277, PD031278, PD031287.

Los Angeles County Flood Control District (LACFCD). March 1975. West Central County Project No. 1261 Unit 2 Lines A and B. Drawing Number 470-1261-D6.4, PD039641.

Los Angeles Regional Water Quality Control Board (LARWQCB). 2014. Guidelines for Conducting Reasonable Assurance Analysis in a Watershed Management Program, Including an Enhanced Watershed Management Program.
https://www.waterboards.ca.gov/rwqcb4/water_issues/programs/stormwater/municipal/watershed_management/tac/doc/RevisedRAAModelingCriteria1-22-14.pdf

Metropolitan Water District of Southern California (MWD). Fiscal Years 2016/17 and 2017/18 Cost of Service for Proposed Water Rates and Charges.
http://www.mwdh2o.com/PDF_Who_We_Are/COS%20FY%202017_2018.pdf

Southern California Association of Governments (SCAG). 2006. Land Use GIS Data. Processed by Los Angeles County Department of Public Works and by CWE.

Stein, Eric D., and Drew Ackerman. April 2007. "Dry Weather Water Quality Loadings in Arid, Urban Watersheds of the Los Angeles Basin, California, USA". *Journal of the American Water Resources Association.*

Tetra Tech, Inc. (Tetra Tech). 2010. Los Angeles County Watershed Model Configuration and Calibration – Part I: Hydrology.
http://dpw.lacounty.gov/wmd/wmms/docs/Final_Phase_I_Modeling_Report_Part_I.pdf

Tetra Tech, Inc. (Tetra Tech). 2017. Feasibility Study For The Los Angeles River Upper Reach 2 Watershed Management Program.

United States Environmental Protection Agency (EPA). 2018. Storm Water Management Model (SWMM). https://www.epa.gov/water-research/storm-water-management-model-swmm

Appendix A

Hydrologic Input/Output

```
BEGTREE 1dadff04-5be9-413b-808f-047d966c56ec
BASIN 1A
OUTLET 2A 1
BASIN 3A
BASIN 4A
OUTLET 5A 3
BASIN 6A
OUTLET 7A 2
ENDTREE
BEGFILES
HYDIN NONE
SOIL "c:\program files\wms 10.1 64-bit\modrat\lasoilx_100.dat"
RAIN rain.dat
RESERVOIR NONE
OUTPUT 18-11-09_60inches2
HYDROINTERVAL 1
EXTENDSIMULATION 1
ENDFILES
  6     1    1A  13 52402322 50                          2 Z1
  6     1    2A  13          505 9250 00200       975    2      012
  6     1    3A  13 89816876 50                          2
  6     1    4A  13 88469770 50                          2
  6     1    5A  13          50512847 00300      1000    2      012
  6     1    6A  13 76605799 50                          2
  6     1    7A  13          50512878 00200      2000    2  2   012
```

File name: 18-11-09_60inches2.lac   Run date: Tue Nov 13 10:01:03 2018

Los Angeles County Flood Control District
Modified Rational Method Hydrology

Storm Day 1   Storm Frequency 50

LOCATION	SUBAREA AREA (ACRES)	SUBAREA Q (CFS)	TOTAL AREA (ACRES)	TOTAL Q (CFS)	TOTAL VOLUME (AC-FT)	CONV TYPE	CONV LNGTH (FT)	CONV SLOPE (FT/FT)	CONV SIZE	CONV Z	CONTROL Q (CFS)	SOIL NAME	TC (MIN)	RAIN (IN)	PCT IMPV
1 1A	402.3	37.03	402.3	37.03	10.211	0	0	0.00000	0.00	0.00	0	13	22	0.60	0.52
1 2A	0.0	0.00	402.3	37.03	10.211	5	9250	0.00200	9.75	0.00	0	13	0	0.60	0.00
1 3A	816.8	66.08	1219.1	85.22	41.216	0	0	0.00000	0.00	0.00	0	13	76	0.60	0.89
1 4A	469.7	39.11	1688.8	121.69	59.451	0	0	0.00000	0.00	0.00	0	13	70	0.60	0.88
1 5A	0.0	0.00	1688.8	121.69	59.451	5	12847	0.00300	10.00	0.00	0	13	0	0.60	0.00
1 6A	605.7	37.73	2294.5	147.34	77.170	0	0	0.00000	0.00	0.00	0	13	99	0.60	0.76
1 7A	0.0	0.00	2294.5	147.34	77.170	5	12878	0.00200	20.00	0.00	0	13	0	0.60	0.00

Normal End of MODRAT

```
BEGTREE a9a8ea15-8392-44b0-8fb0-df81d5581736
BASIN 1A
OUTLET 2A 1
BASIN 3A
BASIN 4A
OUTLET 5A 3
BASIN 6A
OUTLET 7A 2
ENDTREE
BEGFILES
HYDIN NONE
SOIL "c:\program files\wms 10.1 64-bit\modrat\lasoilx_100.dat"
RAIN rain.dat
RESERVOIR NONE
OUTPUT 18-11-09_70cfs
HYDROINTERVAL 1
EXTENDSIMULATION 1
ENDFILES
  6     1    1A  13 52402322 50                          2 Z1
  6     1    2A  13          505 9250 00200      975     2     012
  6     1    3A  13 89816876 50                          2
  6     1    4A  13 88469770 50                          2
  6     1    5A  13          50512847 00300     1000     2     012
  6     1    6A  13 76605799 50                          2
  6     1    7A  13          50512878 00200     2000     2  2  012
```

File name: 18-11-09_70cfs.lac   Run date: Fri Nov 09 15:11:00 2018

Los Angeles County Flood Control District
Modified Rational Method Hydrology

Storm Day 1   Storm Frequency 50

	LOCATION	SUBAREA AREA (ACRES)	SUBAREA Q (CFS)	TOTAL AREA (ACRES)	TOTAL Q (CFS)	TOTAL VOLUME (AC-FT)	CONV TYPE	CONV LNGTH (FT)	CONV SLOPE (FT/FT)	CONV SIZE	CONV Z	CONTROL Q (CFS)	SOIL NAME	TC (MIN)	RAIN (IN)	PCT IMPV
1	1A	402.3	18.51	402.3	18.51	5.106	0	0	0.00000	0.00	0.00	0	13	22	0.30	0.52
1	2A	0.0	0.00	402.3	18.51	5.106	5	9250	0.00200	9.75	0.00	0	13	0	0.30	0.00
1	3A	816.8	33.04	1219.1	40.07	20.443	0	0	0.00000	0.00	0.00	0	13	76	0.30	0.89
1	4A	469.7	19.55	1688.8	57.98	29.560	0	0	0.00000	0.00	0.00	0	13	70	0.30	0.88
1	5A	0.0	0.00	1688.8	57.98	29.560	5	12847	0.00300	10.00	0.00	0	13	0	0.30	0.00
1	6A	605.7	18.87	2294.5	69.44	37.889	0	0	0.00000	0.00	0.00	0	13	99	0.30	0.76
1	7A	0.0	0.00	2294.5	69.44	37.889	5	12878	0.00200	20.00	0.00	0	13	0	0.30	0.00

Normal End of MODRAT

```
BEGTREE 90a6e6ce-e429-43e9-ae3f-27a0cfee7d92
BASIN 1A
OUTLET 2A 1
BASIN 3A
BASIN 4A
OUTLET 5A 3
BASIN 6A
OUTLET 7A 2
ENDTREE
BEGFILES
HYDIN NONE
SOIL "c:\program files\wms 10.1 64-bit\modrat\lasoilx_100.dat"
RAIN rain.dat
RESERVOIR NONE
OUTPUT 18-11-20_85th
HYDROINTERVAL 1
EXTENDSIMULATION 1
ENDFILES
  6     1    1A  13 52402322 50                              2 Z1
  6     1    2A  13          505 9250 00200      975         2     012
  6     1    3A  13 89816876 50                              2
  6     1    4A  13 88469770 50                              2
  6     1    5A  13          50512847 00300     1000         2     012
  6     1    6A  13 76605799 50                              2
  6     1    7A  13          50512878 00200     2000         2  2  012
```

```
File name: 18-11-20_85th.lac         Run date: Tue Nov 20 15:12:03 2018

                               Los Angeles County Flood Control District
                                   Modified Rational Method Hydrology

                                   Storm Day 1    Storm Frequency 50
            SUBAREA  SUBAREA      TOTAL     TOTAL     TOTAL  CONV   CONV    CONV
CONV   CONV   CONTROL  SOIL       RAIN   PCT
LOCATION       AREA        Q       AREA         Q    VOLUME  TYPE  LNGTH   SLOPE
SIZE      Z          Q  NAME  TC          IMPV
            (ACRES)    (CFS)  (ACRES)     (CFS)   (AC-FT)         (FT)  (FT/FT)
                (CFS)       (MIN) (IN)
  1   1A      402.3    55.54     402.3     55.54    15.317     0       0  0.00000
0.00   0.00         0    13  22  0.90  0.52
  1   2A        0.0     0.00     402.3     55.54    15.317     5    9250  0.00200
9.75   0.00         0    13   0  0.90  0.00
  1   3A      816.8    99.12    1219.1    131.30    62.008     0       0  0.00000
0.00   0.00         0    13  76  0.90  0.89
  1   4A      469.7    58.66    1688.8    186.70    89.359     0       0  0.00000
0.00   0.00         0    13  70  0.90  0.88
  1   5A        0.0     0.00    1688.8    186.70    89.359     5  12847  0.00300
10.00   0.00         0    13   0  0.90  0.00
  1   6A      605.7    56.60    2294.5    226.88   116.596     0       0  0.00000
0.00   0.00         0    13  99  0.90  0.76
  1   7A        0.0     0.00    2294.5    226.88   116.596     5  12878  0.00200
20.00   0.00         0    13   0  0.90  0.00

Normal End of MODRAT
```

Appendix B

Continuous Hydrologic Simulation Summary Report

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.010)
--------------------------------------------------------------

WARNING 02: maximum depth increased for Node 1

*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  RDII ................... NO
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ YES
  Water Quality .......... NO
Infiltration Method ...... CURVE_NUMBER
Flow Routing Method ...... DYNWAVE
Starting Date ............ OCT-01-2008 00:00:00
Ending Date .............. OCT-01-2018 00:00:00
Antecedent Dry Days ...... 10.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:01:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 30.00 sec
Variable Time Step ....... YES
Maximum Trials ........... 8
Number of Threads ........ 1
Head Tolerance ........... 0.005000 ft


**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......     19086.750        99.800
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........      1285.231         6.720
Surface Runoff ...........     17794.285        93.042
Final Storage ............         7.663         0.040
Continuity Error (%) .....        -0.002


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......     17787.159      5796.211
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........     17786.762      5796.082
Flooding Loss ............         0.000         0.000
Evaporation Loss .........         0.000         0.000
Exfiltration Loss ........         0.000         0.000
Initial Stored Volume ....         0.001         0.000
```

Final Stored Volume	0.001	0.000
Continuity Error (%)	0.002	

****
Time-Step Critical Elements
****

Link 3 (1.85%)

****
Highest Flow Instability Indexes
****

All links are stable.

****
Routing Time Step Summary
****

Minimum Time Step	:	2.28 sec
Average Time Step	:	29.52 sec
Maximum Time Step	:	30.00 sec
Percent in Steady State	:	0.00
Average Iterations per Step	:	2.00
Percent Not Converging	:	0.00

****
Subcatchment Runoff Summary
****

Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Total Runoff in	Total Runoff 10^6 gal	Peak Runoff CFS	Runoff Coeff
DA1	99.80	0.00	0.00	22.35	77.41	845.00	421.50	0.776
DA2	99.80	0.00	0.00	2.41	97.36	2159.78	618.01	0.976
DA3	99.80	0.00	0.00	2.69	97.07	1238.87	361.71	0.973
DA4	99.80	0.00	0.00	5.29	94.47	1554.45	421.40	0.947

****
Node Depth Summary
****

Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days hr:min	Reported Max Depth Feet
1	JUNCTION	0.03	3.67	159.57	557 23:58	3.67

2	JUNCTION	0.08	7.65	130.34	3035	16:37	7.63
3	JUNCTION	0.05	4.39	105.31	3035	16:41	4.39
4	OUTFALL	0.05	4.39	104.39	3035	16:41	4.38

****
Node Inflow Summary
****

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days	hr:min	Lateral Inflow Volume 10^6 gal	Total Inflow Volume 10^6 gal	Flow Balance Error Percent
1	JUNCTION	421.50	421.50	1977	14:50	845	844	-0.008
2	JUNCTION	979.72	1319.16	3035	16:25	3.4e+003	4.24e+003	0.002
3	JUNCTION	421.40	1595.45	3035	16:36	1.55e+003	5.8e+003	0.002
4	OUTFALL	0.00	1584.16	3035	16:41	0	5.8e+003	0.000

****
Node Surcharge Summary
****

No nodes were surcharged.

****
Node Flooding Summary
****

No nodes were flooded.

****
Outfall Loading Summary
****

Outfall Node	Flow Freq Pcnt	Avg Flow CFS	Max Flow CFS	Total Volume 10^6 gal
4	60.87	15.39	1584.16	5795.652
System	60.87	15.39	1584.16	5795.652

****
Link Flow Summary

****

Link	Type	Maximum |Flow| CFS	Time of Max Occurrence days hr:min	Maximum |Veloc| ft/sec	Max/ Full Flow	Max/ Full Depth
1	CONDUIT	391.50	558 00:00	10.63	0.20	0.41
2	CONDUIT	1194.06	3035 16:39	9.93	0.70	0.60
3	CONDUIT	1584.16	3035 16:41	19.00	0.37	0.40

****
Flow Classification Summary
****

Conduit	Adjusted /Actual Length	Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Norm Ltd	Inlet Ctrl
		---------- Fraction of Time in Flow Class ----------								
1	1.00	0.07	0.23	0.00	0.70	0.00	0.00	0.00	0.88	0.00
2	1.00	0.02	0.05	0.00	0.93	0.00	0.00	0.00	0.04	0.00
3	1.00	0.07	0.00	0.00	0.79	0.14	0.00	0.00	0.76	0.00

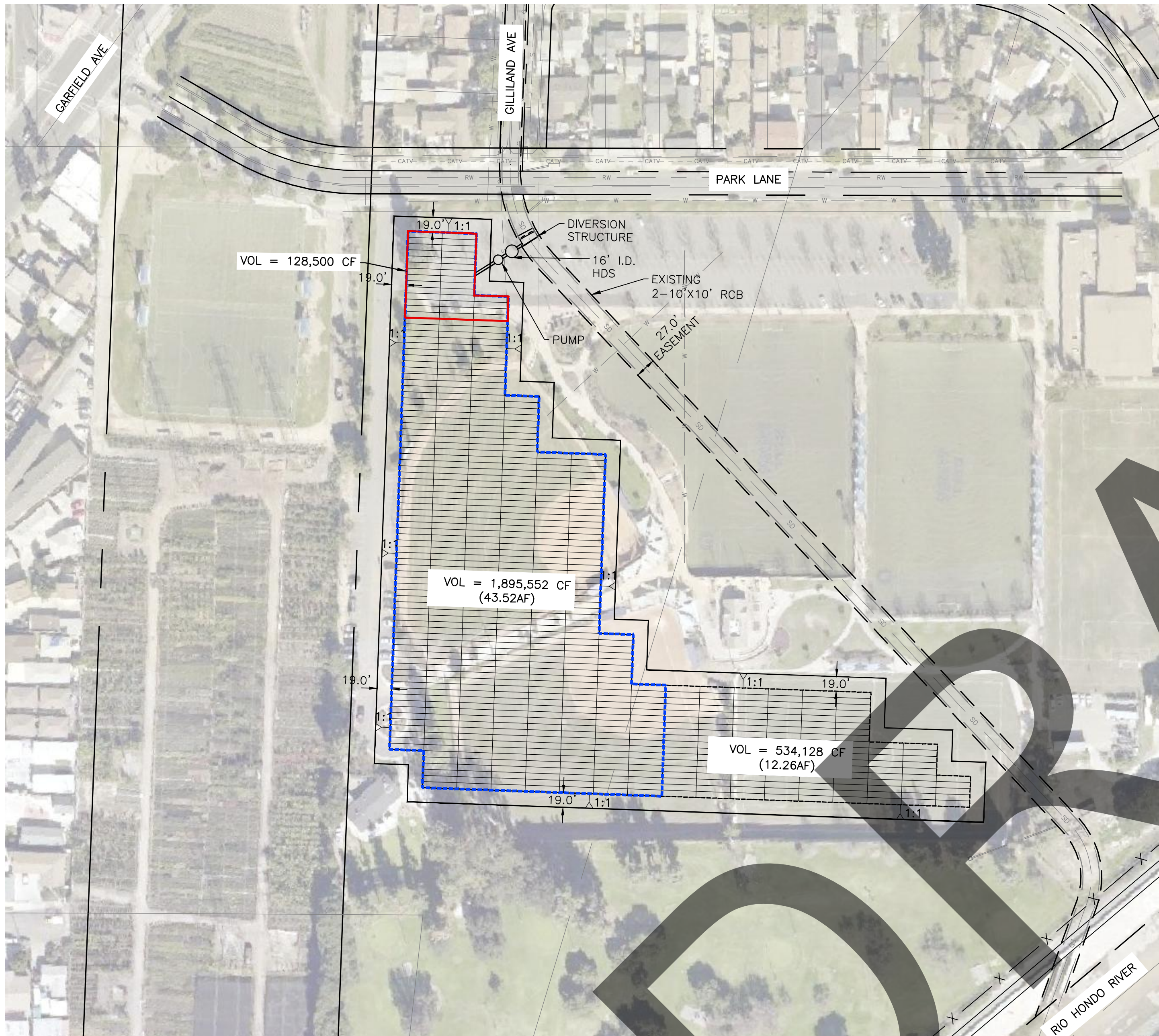
****
Conduit Surcharge Summary
****

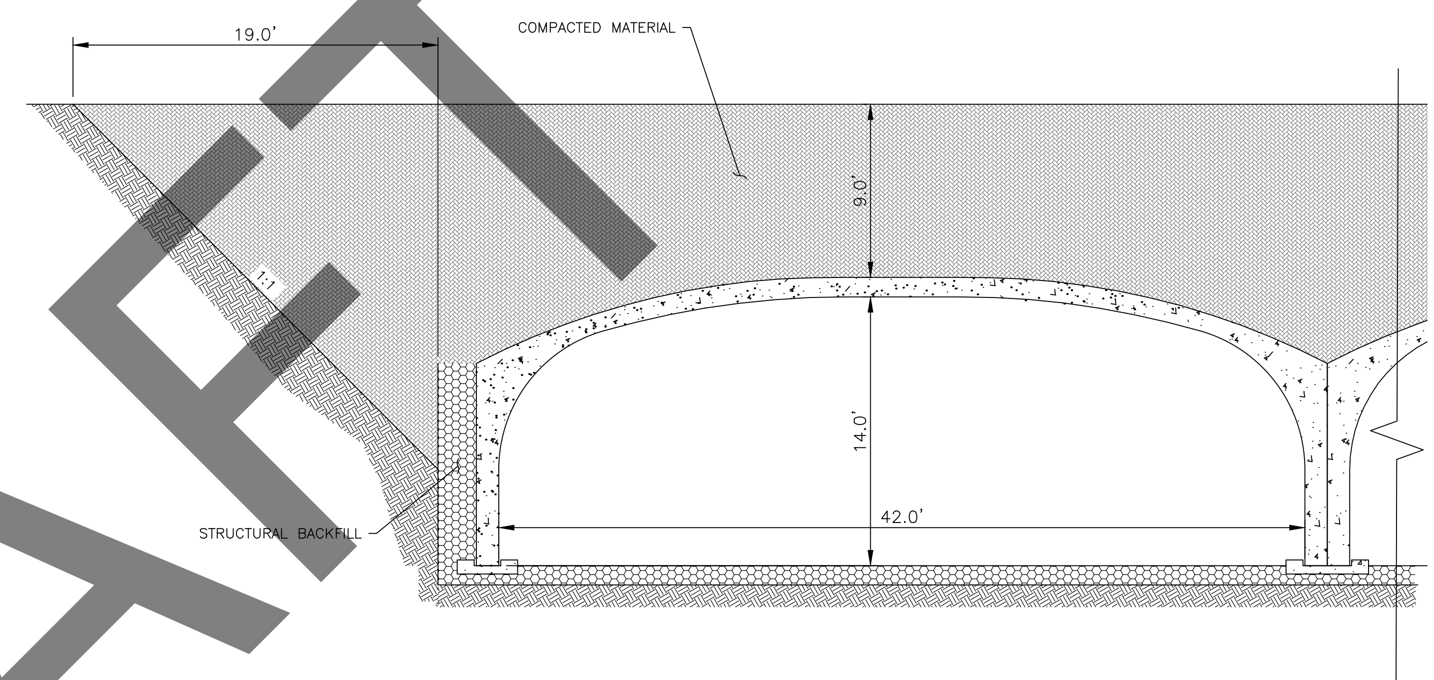
Conduit	Hours Full Both Ends	Hours Full Upstream	Hours Full Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited
2	0.01	0.01	0.01	2.62	0.01

Analysis begun on: Mon Nov 26 15:01:17 2018
Analysis ended on: Mon Nov 26 15:02:30 2018
Total elapsed time: 00:01:13

Appendix C

Subsurface Storage System Design Alternatives





TYPICAL INFILTRATION CELL SECTION

SCALE: 1"=10'

200' 100' 0 200'

SCALE: 1"= 200'

PREPARED BY:

CWE

1561 E. ORANGETHORPE AVE.
SUITE 240
FULLERTON, CA 92831
TEL (714) 526-7500
www.cwecorp.com

PROJECT TITLE

JOHN ANSON FORD PARK

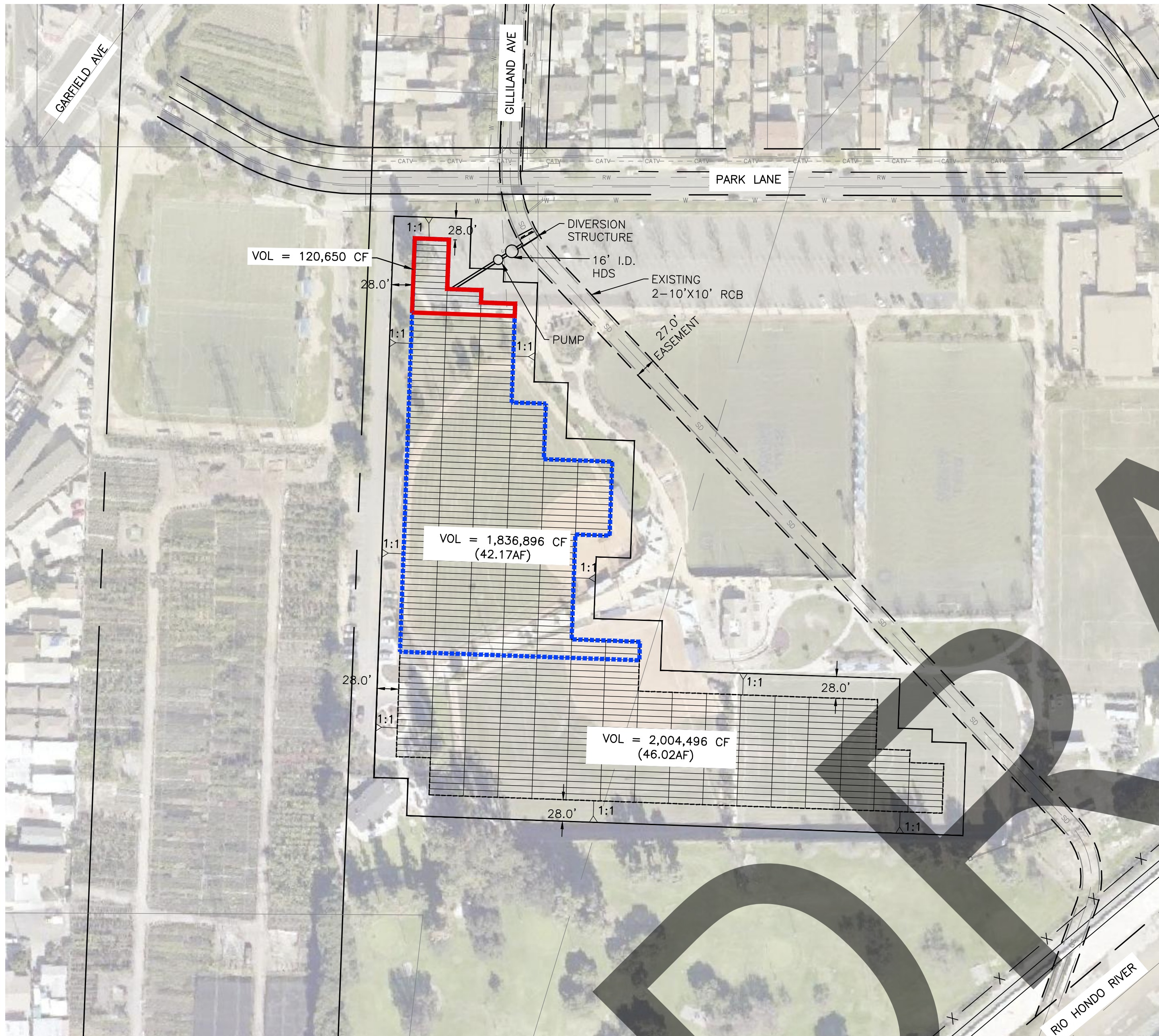
INFILTRATION CISTERN PROJECT

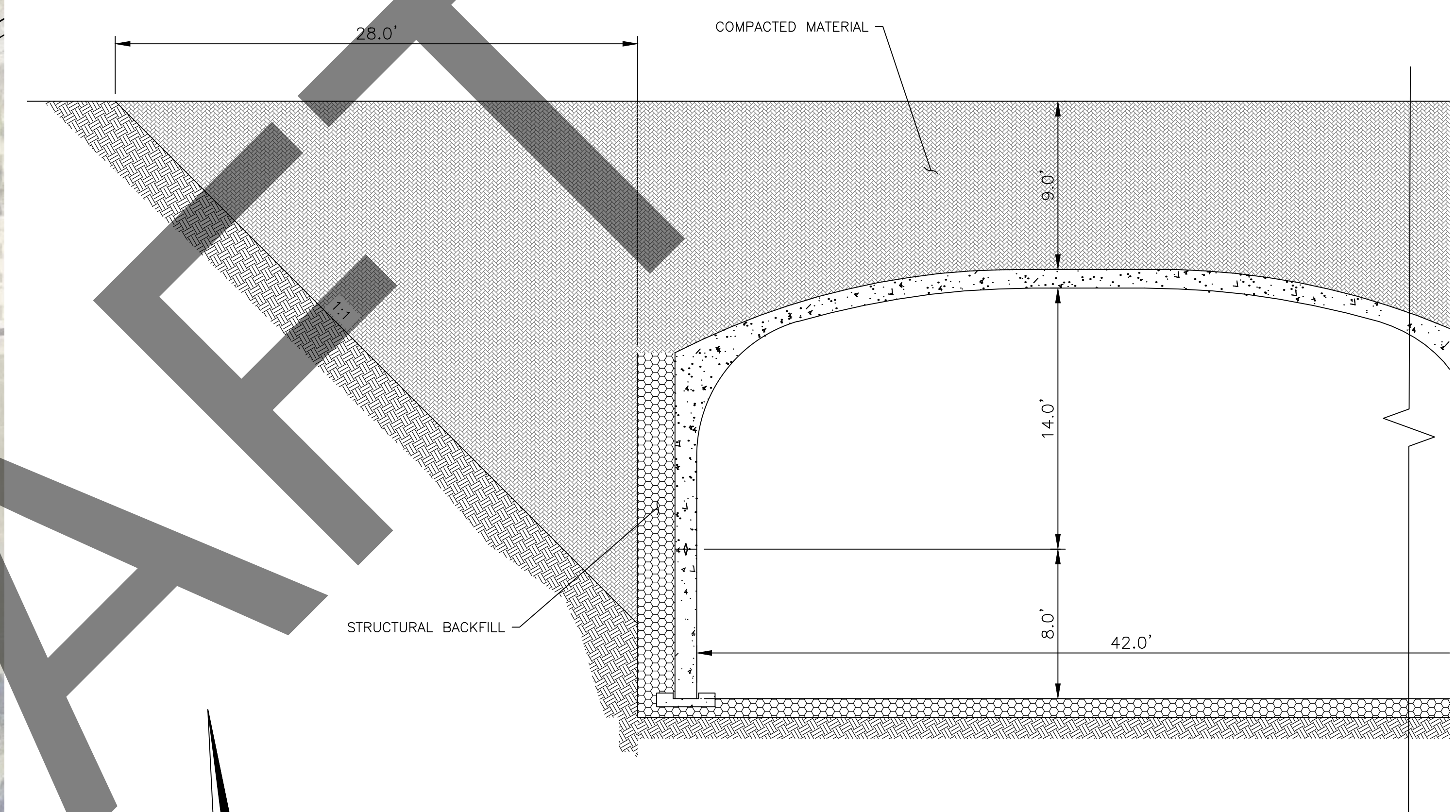
SHEET TITLE

AVAILABLE AREA WITH PUMPING
ARCH EXHIBIT NO. 1A (Conspan 1A)

PROJECT NO. 18292

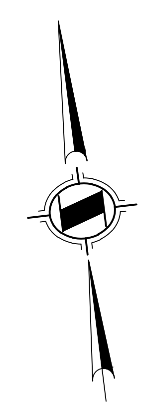
SHEET 1 OF 4





TYPICAL INFILTRATION CELL SECTION

SCALE: 1"=10'



SCALE: 1"= 200'

PREPARED BY:

CWE

1561 E. ORANGETHORPE AVE.
SUITE 240
FULLERTON, CA 92831
TEL (714) 526-7500
www.cwecorp.com

PROJECT TITLE

JOHN ANSON FORD PARK

INFILTRATION CISTERN PROJECT

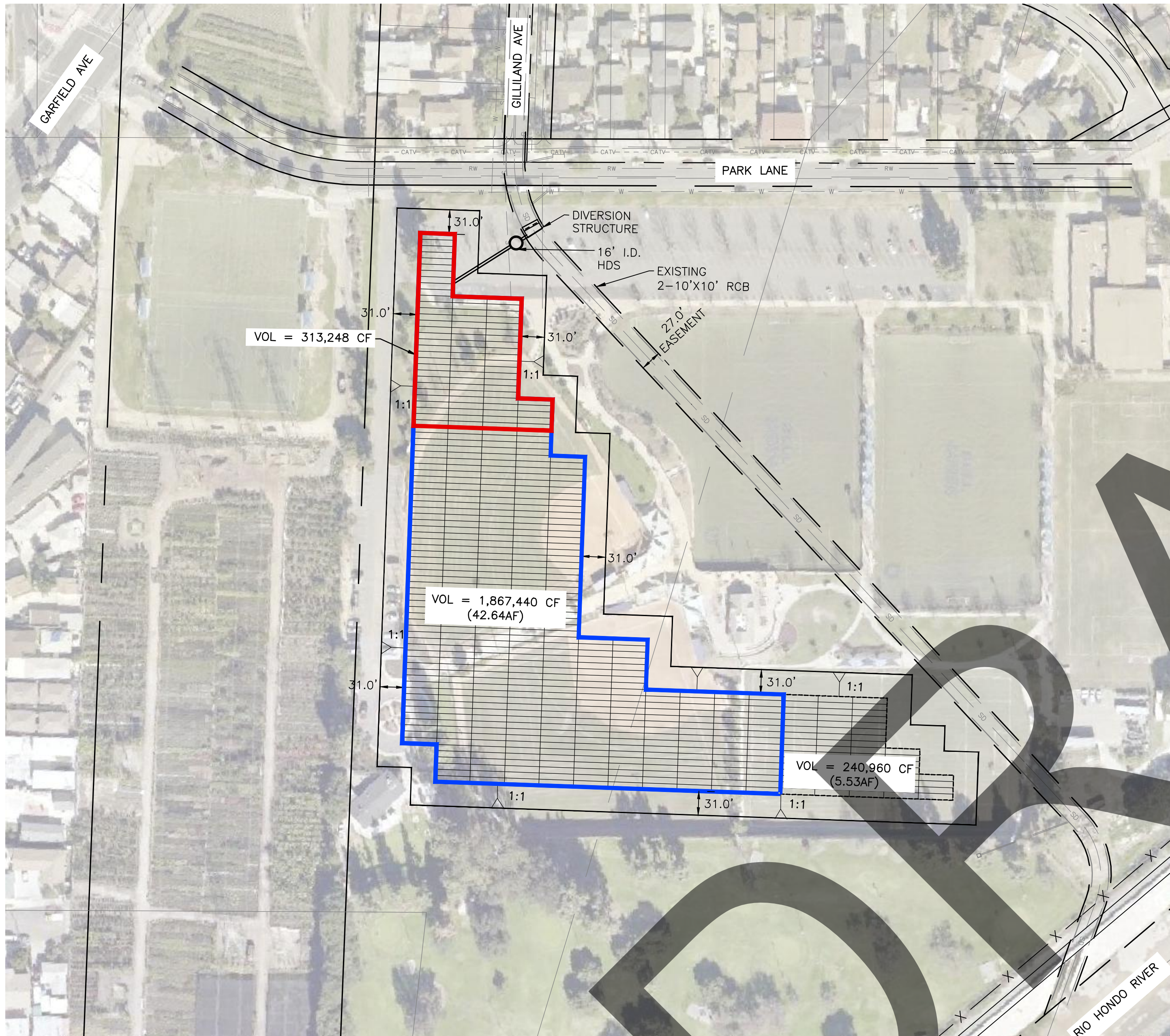
SHEET TITLE

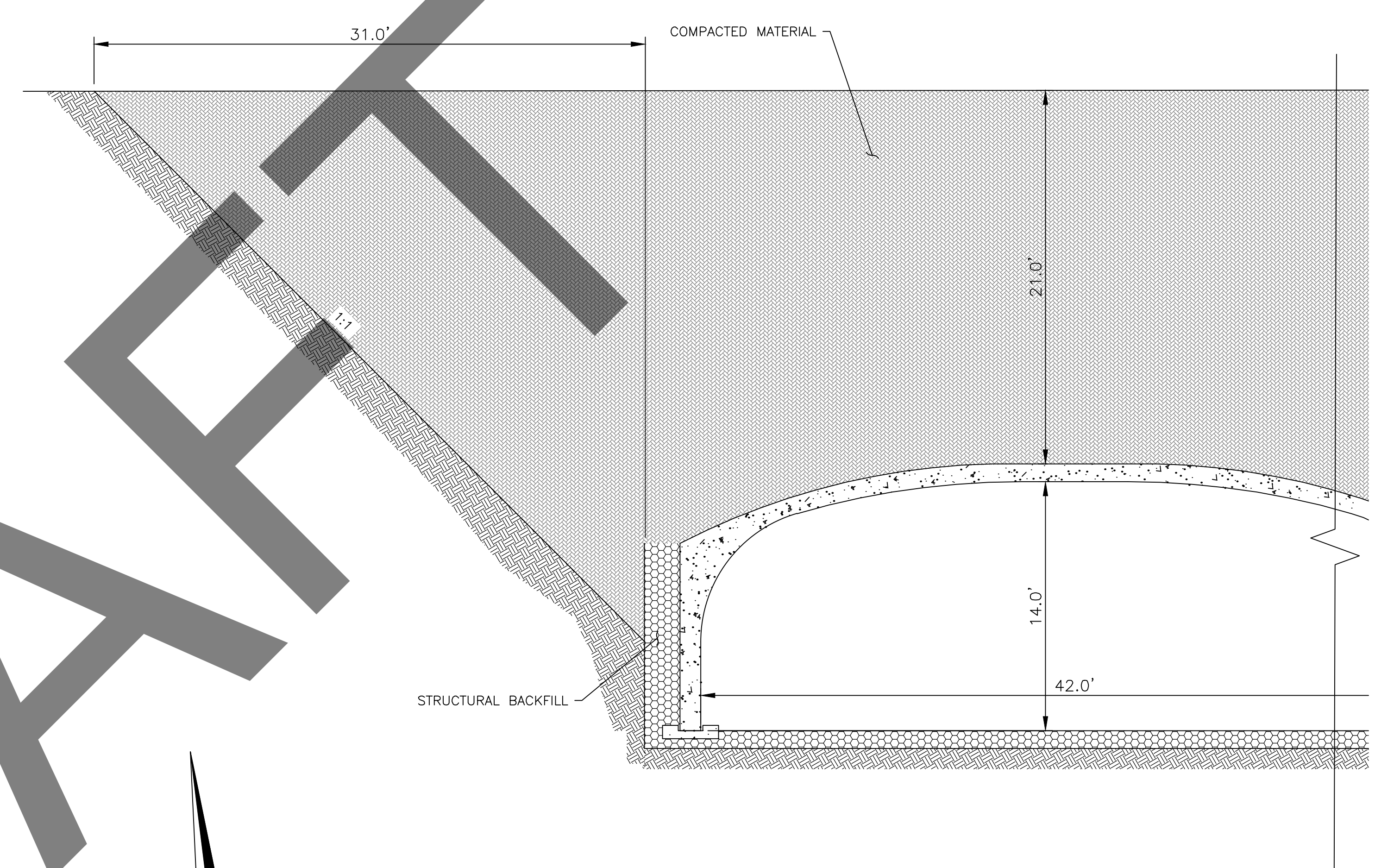
AVAILABLE AREA WITH PUMPING
ARCH EXHIBIT NO. 1B (Conspan 1B)

PROJECT NO.
18292

SHEET 2

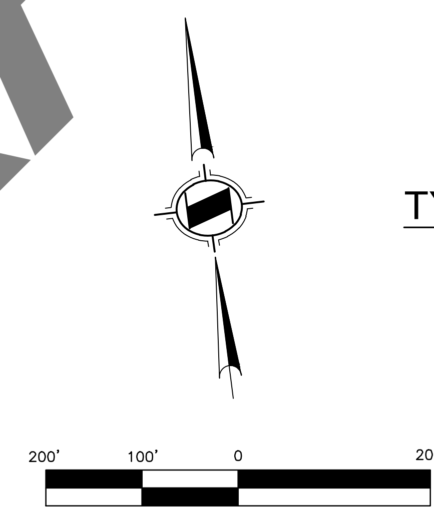
OF 4





TYPICAL INFILTRATION CELL SECTION

SCALE: 1"=10'



PREPARED BY:
CWE
1561 E. ORANGETHORPE AVE.
SUITE 240
FULLERTON, CA 92831
TEL (714) 526-7500
www.cwecorp.com

PROJECT TITLE

JOHN ANSON FORD PARK

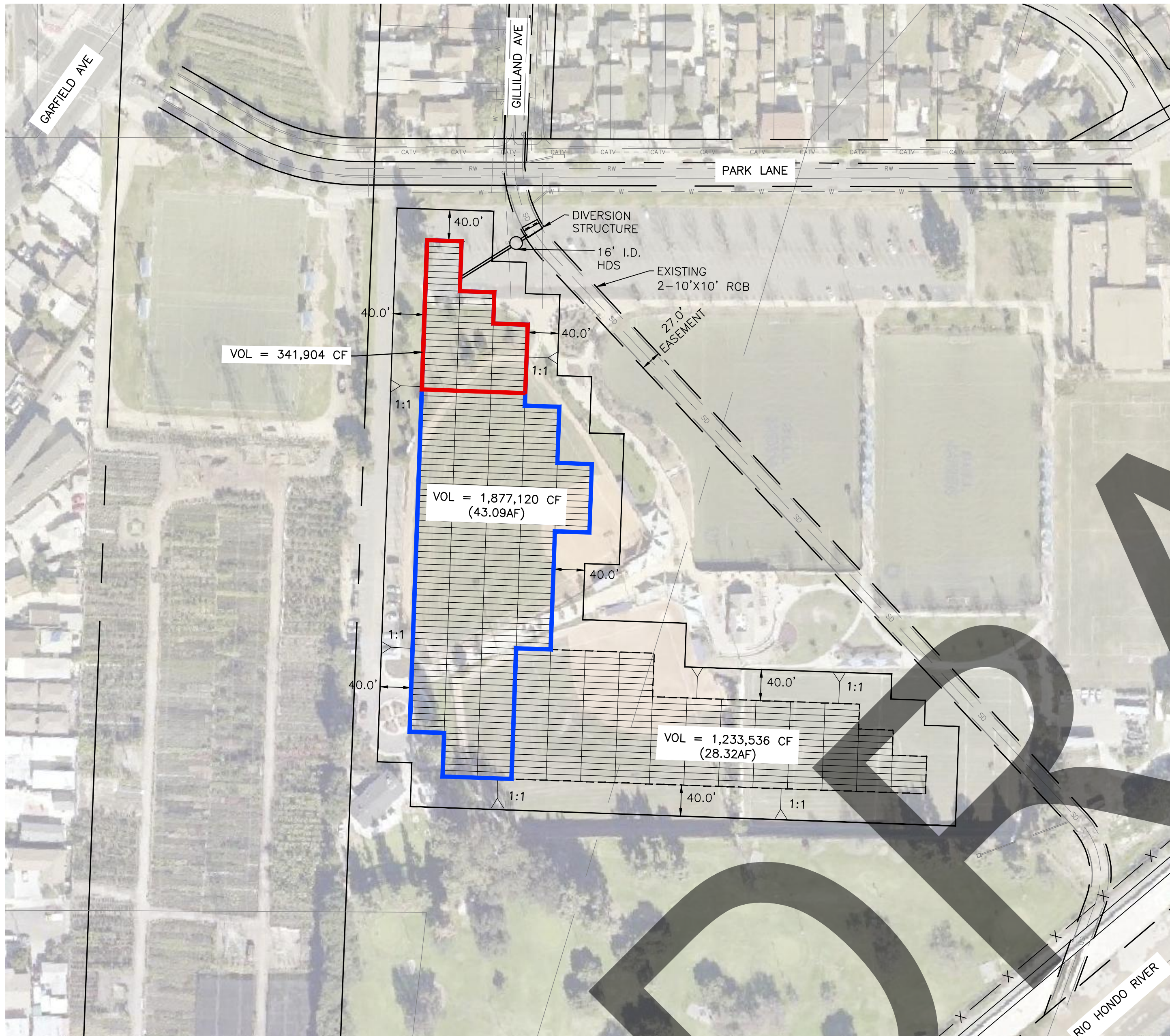
INFILTRATION CISTERN PROJECT

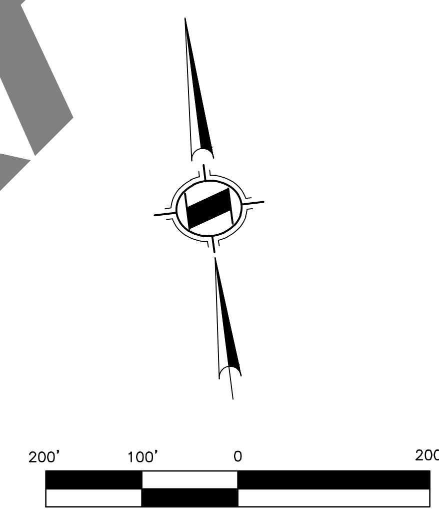
SHEET TITLE

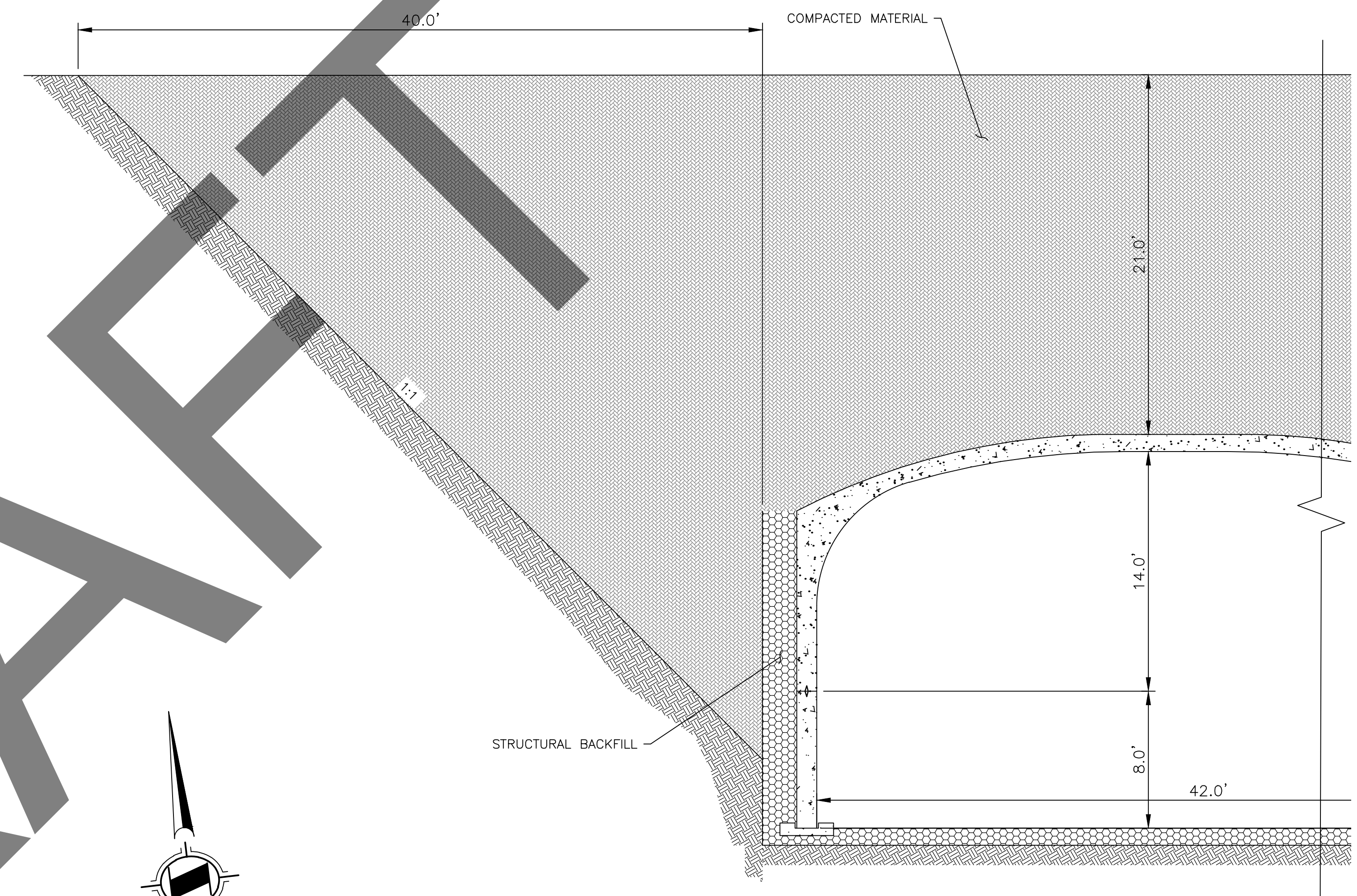
AVAILABLE AREA WITHOUT PUMPING
ARCH EXHIBIT NO. 2A (Conspan 2A)

PROJECT NO. 18292

SHEET 3 OF 4





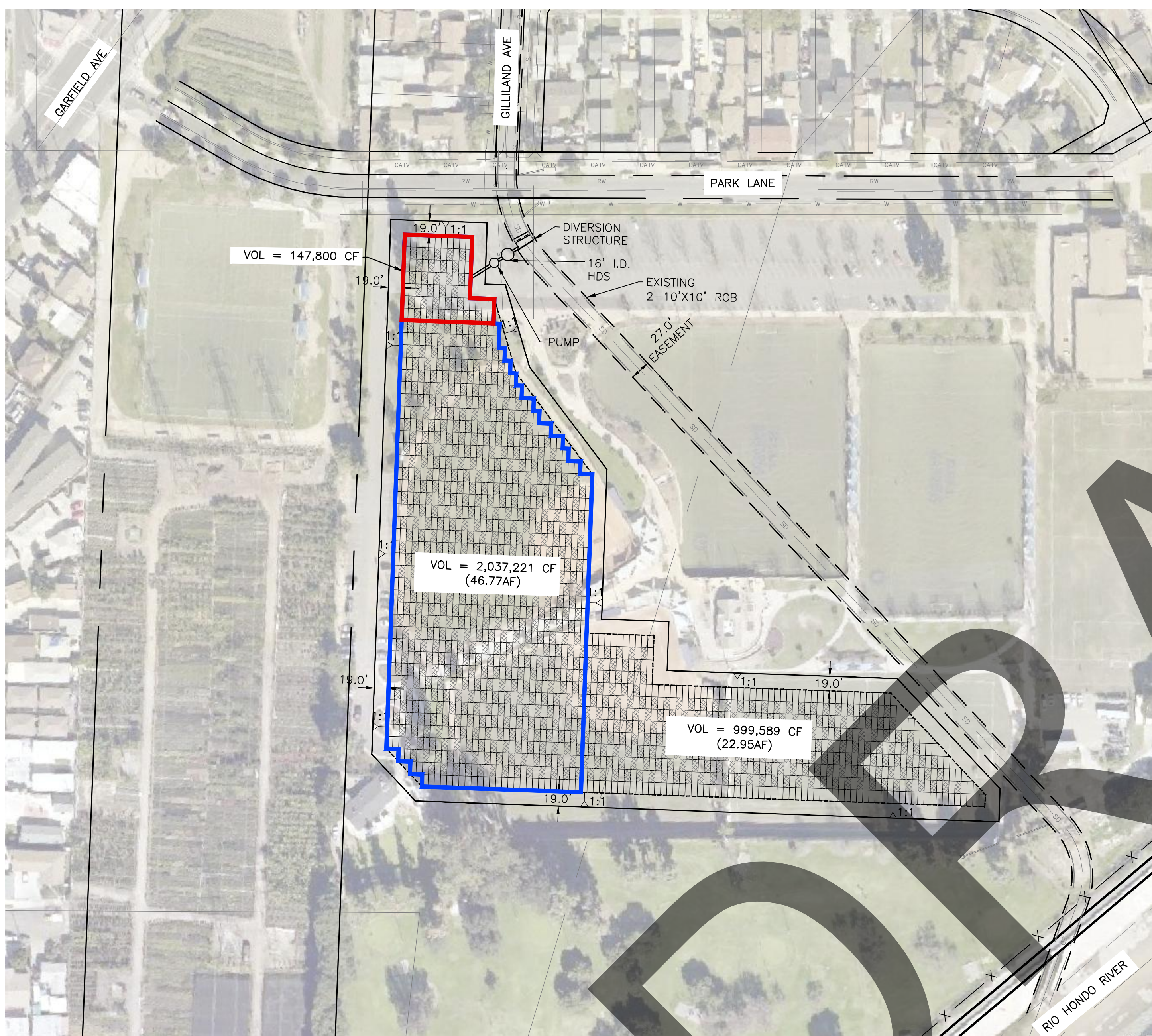


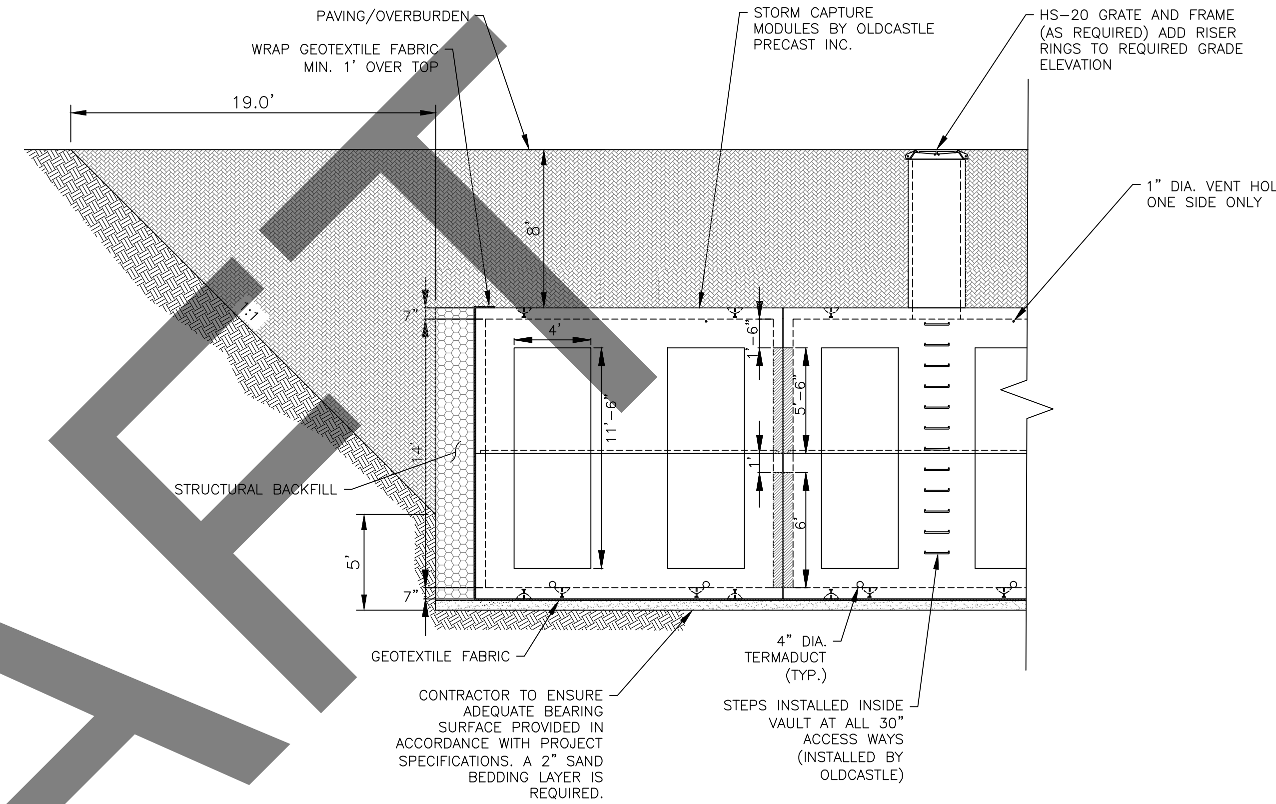
TYPICAL INFILTRATION CELL SECTION

SCALE: 1"=10'

DRAFT

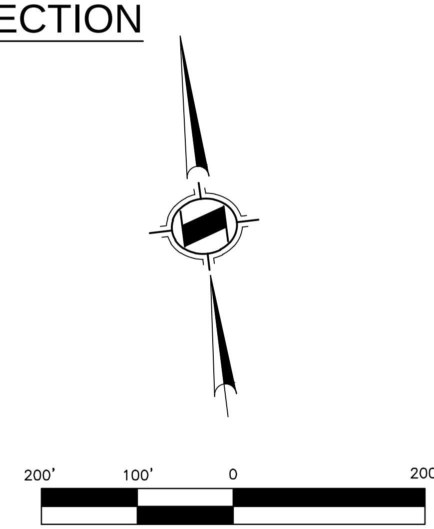
PREPARED BY:	PROJECT TITLE	PROJECT NO.
CWE 1561 E. ORANGETHORPE AVE. SUITE 240 FULLERTON, CA 92831 TEL (714) 526-7500 www.cwecorp.com	JOHN ANSON FORD PARK INFILTRATION CISTERN PROJECT	18292
	SHEET TITLE AVAILABLE AREA WITHOUT PUMPING ARCH EXHIBIT NO. 2B (Conspan 2B)	SHEET 4 OF 4





TYPICAL INFILTRATION CELL SECTION

SCALE: 1"=10'



SCALE: 1"= 200'

PREPARED BY:

CWE
1561 E. ORANGETHORPE AVE.
SUITE 240
FULLERTON, CA 92831
TEL (714) 526-7500
www.cwecorp.com

PROJECT TITLE

JOHN ANSON FORD PARK

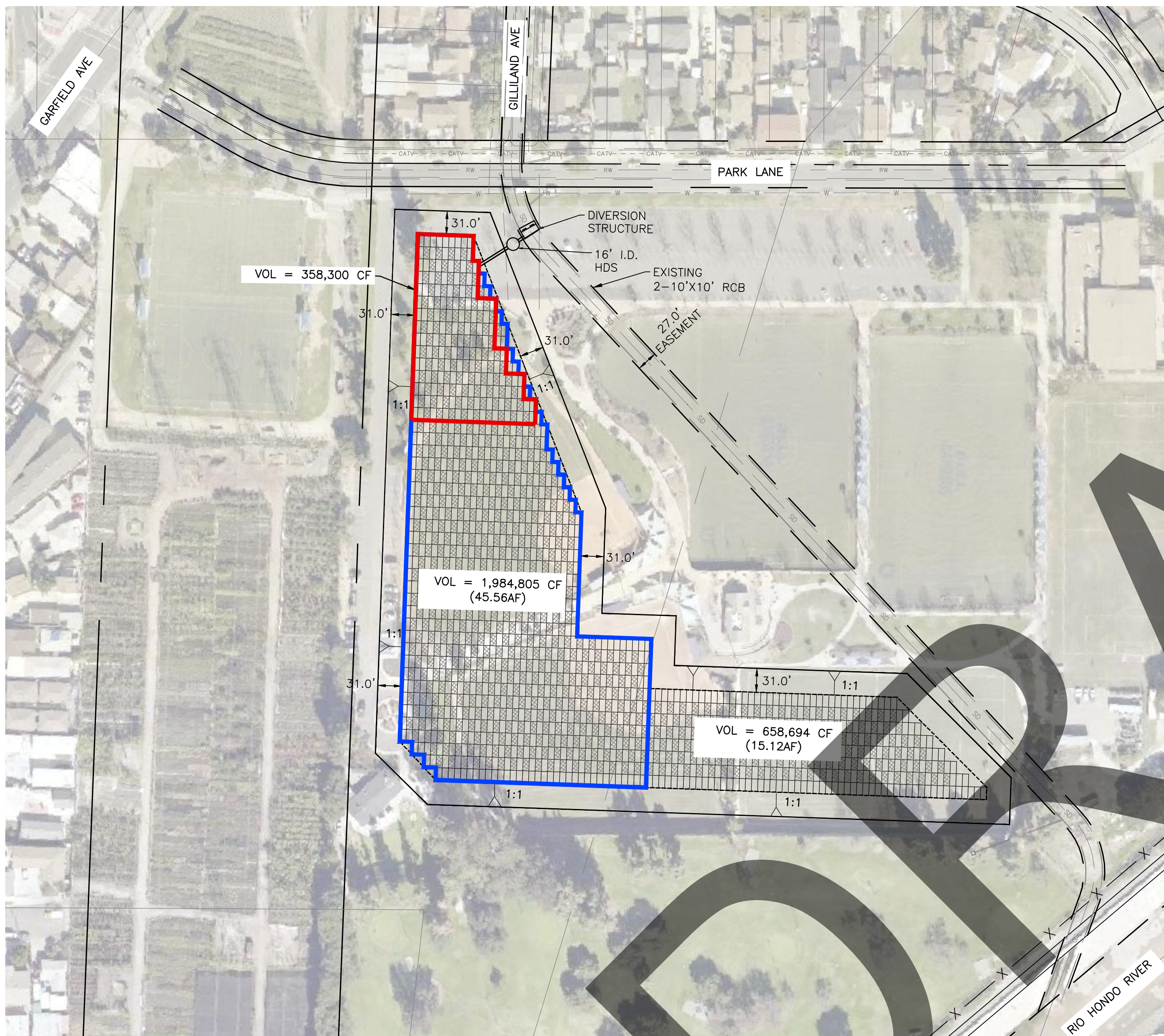
INFILTRATION CISTERN PROJECT

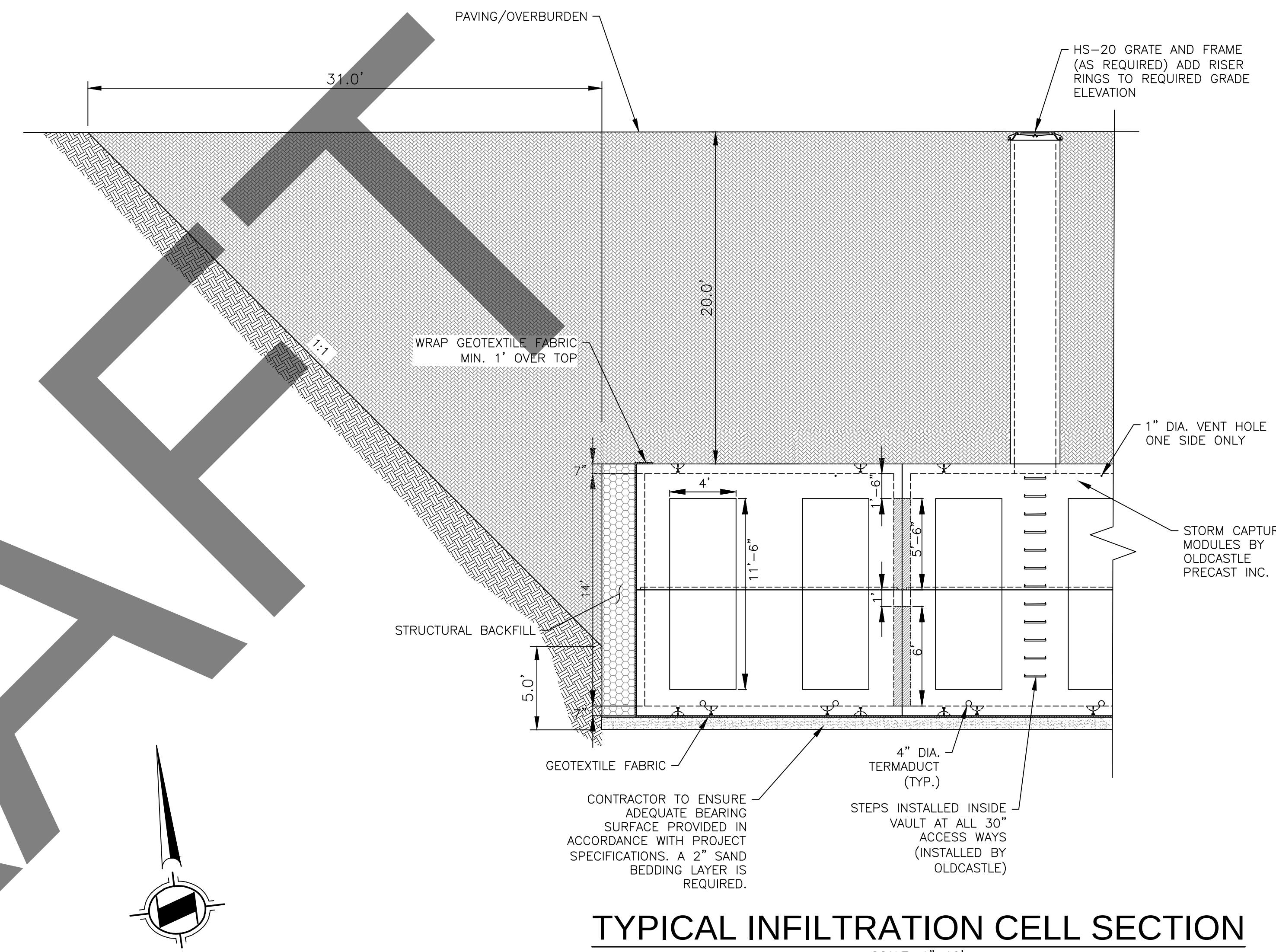
SHEET TITLE

AVAILABLE AREA WITH PUMPING
CLAM SHELL EXHIBIT NO. 1 (Oldcastle 1)

PROJECT NO. 18292

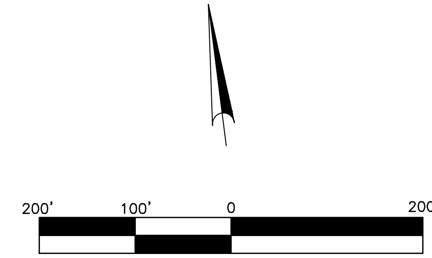
SHEET 1 OF 2





TYPICAL INFILTRATION CELL SECTION

SCALE: 1"=10'



SCALE: 1"= 200'

PREPARED BY:

CWE
1561 E. ORANGETHORPE AVE.
SUITE 240
FULLERTON, CA 92831
TEL (714) 526-7500
www.cwecorp.com

PROJECT TITLE

JOHN ANSON FORD PARK

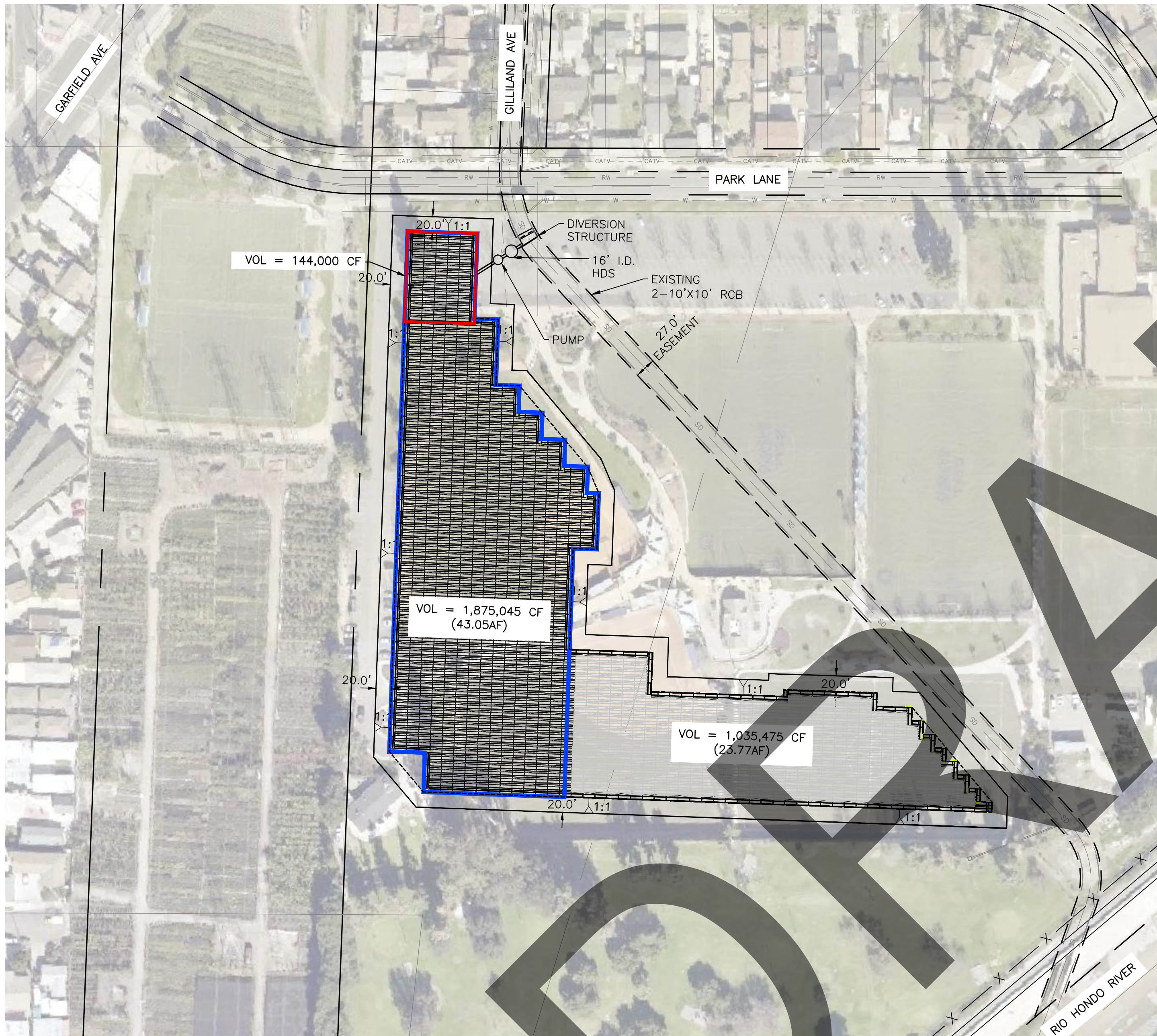
INFILTRATION CISTERN PROJECT

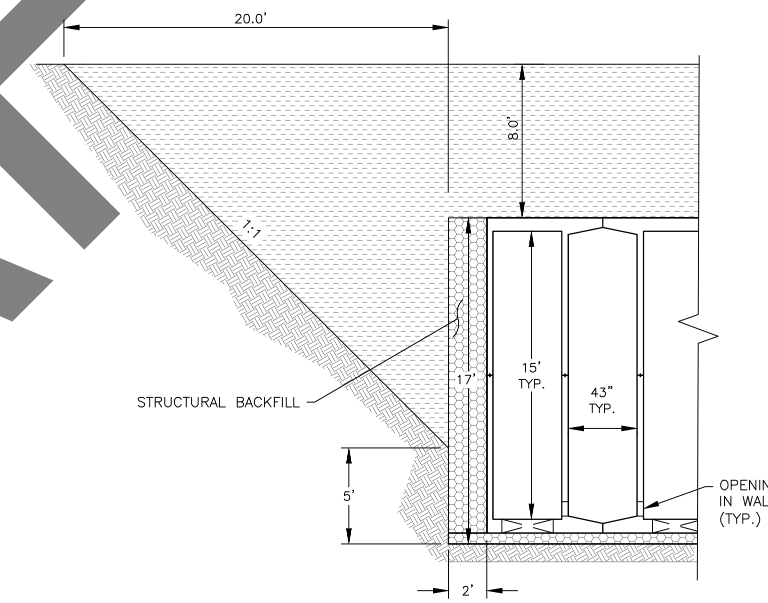
SHEET TITLE

AVAILABLE AREA WITHOUT PUMPING
CLAM SHELL EXHIBIT NO. 2 (Oldcastle 2)

PROJECT NO. 18292

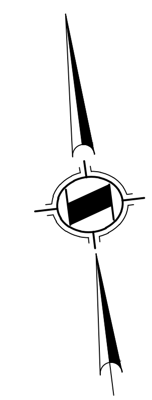
SHEET 2 OF 2

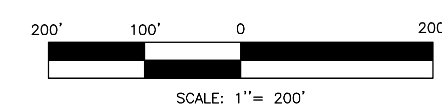




TYPICAL INFILTRATION CELL SECTION

SCALE: 1"=10'





PREPARED BY:

CWE
1561 E. ORANGETHORPE AVE.
SUITE 240
FULLERTON, CA 92831
TEL (714) 526-7500
www.cwecorp.com

PROJECT TITLE

JOHN ANSON FORD PARK

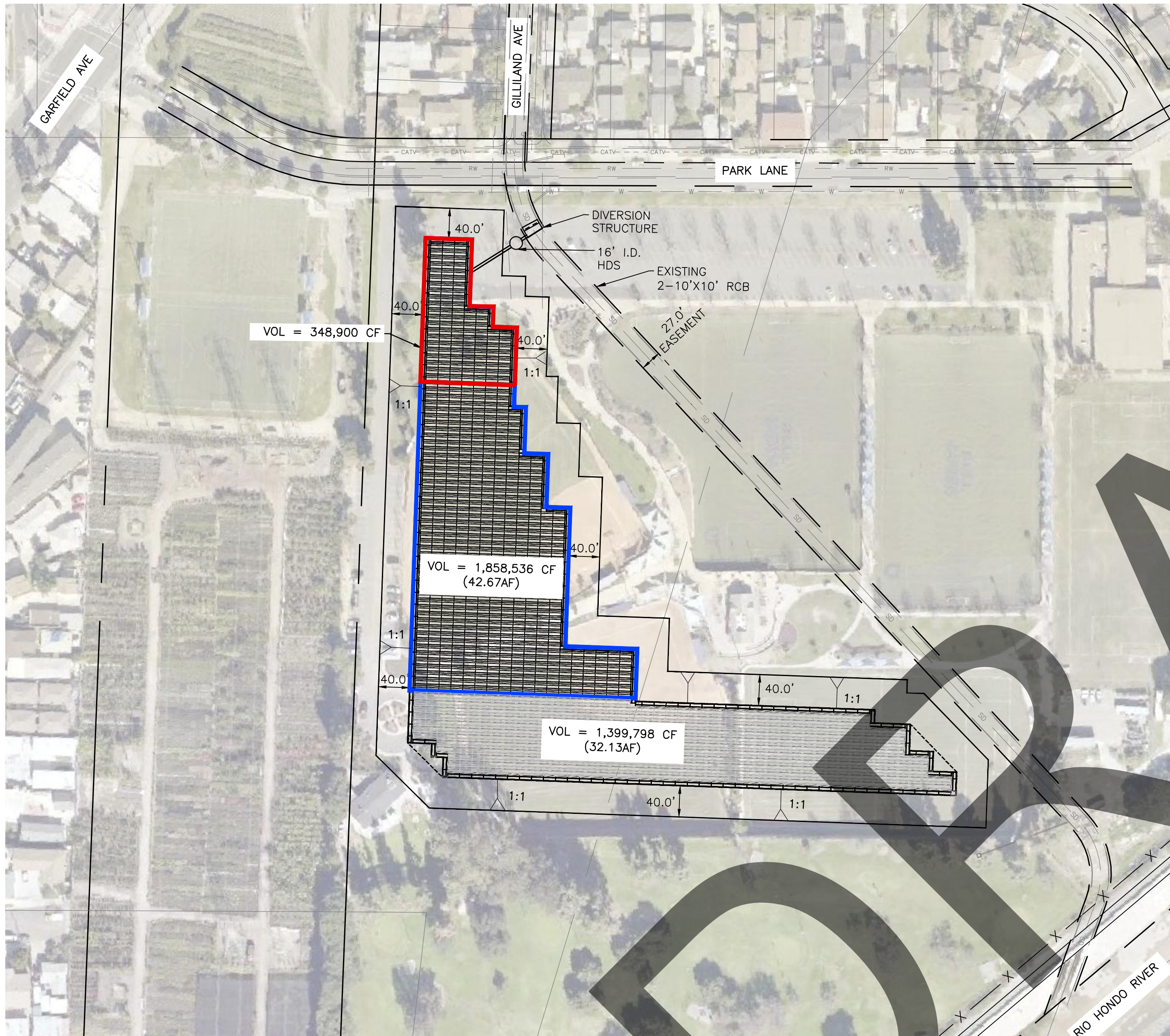
INFILTRATION CISTERN PROJECT

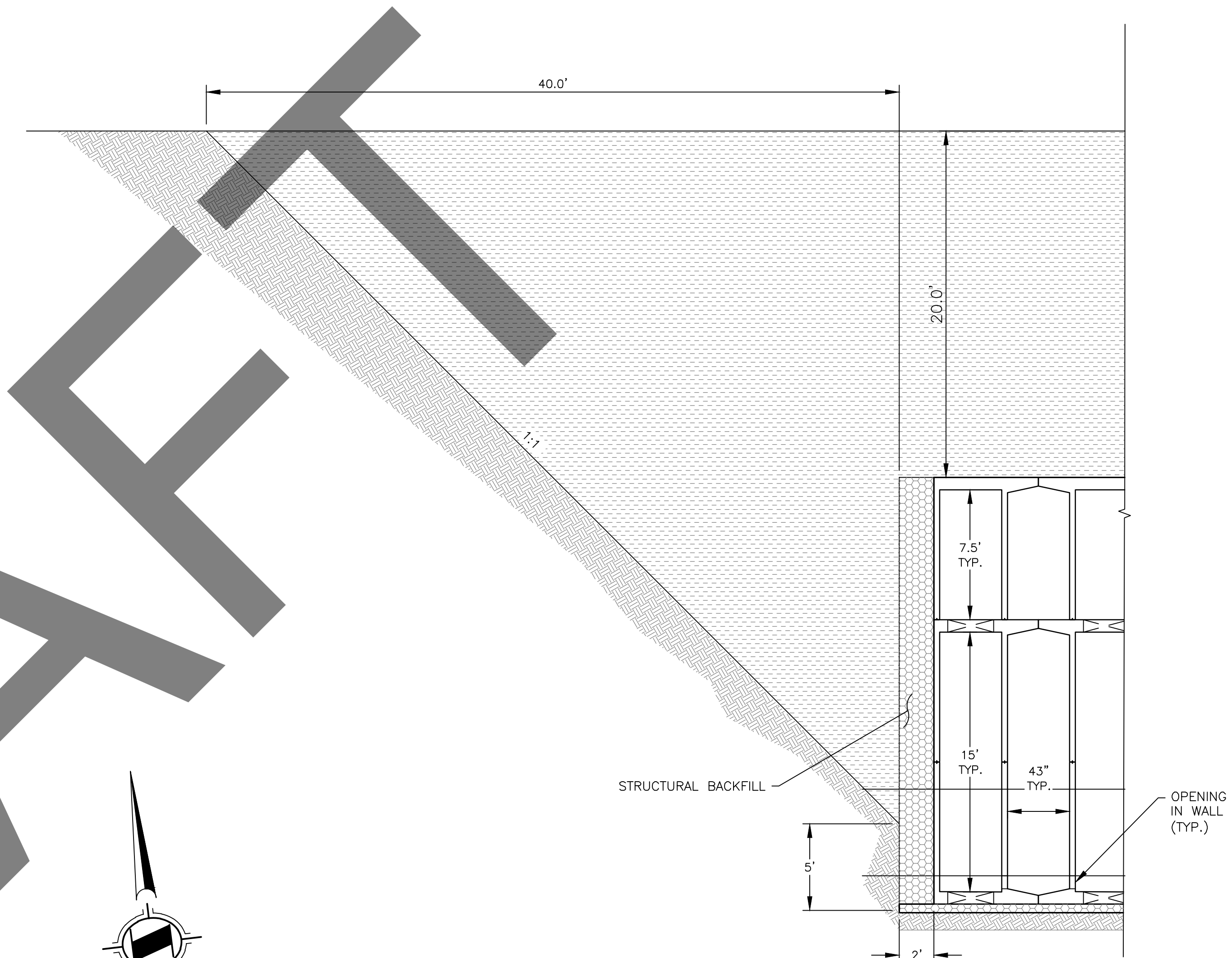
SHEET TITLE

AVAILABLE AREA WITH PUMPING
STORMTRAP EXHIBIT NO. 1 (Stormtrap 1)

PROJECT NO. 18292

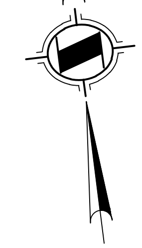
SHEET 1 OF 2





TYPICAL INFILTRATION CELL SECTION

SCALE: 1"=10'



SCALE: 1"= 200'

PREPARED BY:
CWE
1561 E. ORANGETHORPE AVE.
SUITE 240
FULLERTON, CA 92831
TEL (714) 526-7500
www.cwecorp.com

PROJECT TITLE

JOHN ANSON FORD PARK

INFILTRATION CISTERN PROJECT

SHEET TITLE

AVAILABLE AREA WITHOUT PUMPING
STORMTRAP EXHIBIT NO. 2 (Stormtrap 2)

PROJECT NO. 18292

SHEET 2 OF 2