FEASIBILITY STUDY

South Basin Groundwater Protection Project
Operable Unit 2

Prepared for:

Orange County Water District

18700 Ward Street

Fountain Valley, California

92708

Prepared by:

Engineering Analytics, Inc.

9820 Willow Creek Road, Suite 395
San Diego, California 92131
(858) 221-0264

Project No. 151099

PROFESSIONAL GEOLOGIST
KENNETH R. PUENTES
No. 7136
STATE OF CALIFORNIA

REGISTERED PROFESSIONAL ENGINEER
LISA G. WAHL
No. CH 005147
Exp. 9/30/24
CHEMICAL
STATE OF CALIFORNIA

January 27, 2023

PROFESSIONAL GEOLOGIST
CHRISTOPHER G.A. ROSS
No. 4594
STATE OF CALIFORNIA

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ACRONYMS AND ABBREVIATIONS

3DMe	3-D Microemulsion™
AOP	Advanced Oxidation Processes
ARAR	Applicable or Relevant and Appropriate Requirements
AS	Air Sparging
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
Bio-LGAC	Biological Liquid-Phase Granular Activated Carbon
bls	below land surface
CalEPA	California Environmental Protection Agency
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cis-1,2-DCE	cis-1,2-Dichloroethene or cis-1,2-Dichloroethylene
CO_2	Carbon Dioxide
COC(s)	Chemical(s) of Concern
COPC(s)	Compound(s) of Potential Concern
COPEC(s)	Compound(s) of Potential Ecological Concern
Cr6	Hexavalent Chromium
CTR	California Toxics Rule
CUPA	Certified Unified Planning Agency
1,1-DCA	1,1-Dichloroethane
1,2-DCA	1,2-Dichloroethane
1,1-DCE	1,1-Dichloroethene or 1,1-Dichloroethylene
DFA	State Water Board Division of Financial Assistance
DNAPL	Dense Non-Aqueous Phase Liquid
DPE	Dual-Phased Extraction
DTSC	California Environmental Protection Agency, Department of Toxic Substances Control
DWR	State of California, Department of Water Resources
EA	Engineering Analytics, Inc.
EISB	Enhanced In-Situ Bioremediation
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ERH	Electrical Resistance Heating

EVO	Emulsified Vegetable Oil
FS	Feasibility Study
FSDE	Feasibility Study Detailed Evaluation
FSISE	Feasibility Study Initial Screening Evaluation
GAC	Granular Activated Carbon
GET	Groundwater Extraction and Treatment
GHG	Greenhouse Gases
gpm	gallons per minute
GRA	General Response Action
GWRS	OCWD Groundwater Replenishment System Advanced Wastewater Purification Facility
H+A	Hargis + Associates, Inc.
HAZWOPER	Hazardous Waste Operations and Emergency Response
HHERA	Human Health and Ecological Risk Assessment
HQ	Hazard Quotient
HR	Hazard Ratio
HRC	Hydrogen Release Compound™
HSU	Hydrostratigraphic Unit
ILCR	Incremental Lifetime Cancer Risk
IRAP	Proposed Interim Remedial Action Plan and Responsiveness Summary
IRM	Interim Remedial Measures
IRWD	Irvine Ranch Water District
ISB	In-Situ Bioremediation
ISCO	In-Situ Chemical Oxidation
ISCR	In-Situ Chemical Reduction
LGAC	Liquid-Phase Granular Activated Carbon
MCL	Maximum Contaminant Level
mg/l	milligrams per liter
MNA	Monitored Natural Attenuation
M&RP	Monitoring and Reporting Program
MUN	Domestic and Municipal Supply
NAPL	Non-Aqueous Phase Liquid
NAVFAC	Naval Facilities Engineering Command, Engineering and Expeditionary Warfare Command
NCP	National Oil and Hazardous Substances Pollution Contingency Plan

NDMA	N-nitrosodimethylamine
NGWA	National Ground Water Association
NL	Notification Level
NOD	Natural Oxidant Demand
NPDES	National Pollutant Discharge Elimination System
NPV	Net Present Value
OCHCA	Orange County Health Care Agency
OCSD	Orange County Sanitation District
OCWD	Orange County Water District
OEHHA	California Environmental Protection Agency, Office of Environmental Health Hazard Assessment
O&M	Operation and Maintenance
OMM	Operations, Maintenance and Monitoring
OSWER	USEPA Office of Solid Waste and Emergency Response
OU2	Operable Unit 2
P&T	Pump and Treat
PCE	Perchloroethylene or Tetrachloroethylene
PDI	Pre-Design Investigation
PFAS	Polyfluoroalkyl Substances
POTW	Public Owned Treatment Works
PRB	Permeable Reactive Barrier
QA/QC	Quality Assurance/Quality Control
RAOs	Remedial Action Objectives
RAP	Remedial Action Program
RI/FS	Remedial Investigation/Feasibility Study
RO	Reverse Osmosis
ROI	Radius of Influence
ROW	Right of Way
RWQCB	Santa Ana Regional Water Quality Control Board
SAG	Stakeholders Advisory Group
SBGPP	South Basin Groundwater Protection Plan
SPDP	Special Purpose Discharge Permit
SRI	Supplemental Remedial Investigation
SVE	Soil Vapor Extraction
SWRCB	State Water Resources Control Board

TAC	Technical Advisory Committee
TB	Toxicity Benchmark
TBC	To-Be-Considered
1,1,1-TCA	1,1,1-Trichloroethane
1,1,2-TCA	1,1,2-Trichloroethane
TCE	Trichloroethylene or Trichloroethene
TFG	The Fehling Group
TMDL	Total Maximum Daily Load
TMV	Toxicity, Mobility, or Volume
UCL	Upper Confidence Limit
ug/l	micrograms per liter
USACE	United States (U.S.) Army Corps of Engineers
USEPA	United States (U.S.) Environmental Protection Agency
USGS	United States (U.S.) Geological Survey
UV	Ultraviolet
VGAC	Vapor-Phase Granulated Activated Carbon
VOC	Volatile Organic Compound
WDR	RWQCB Waste Discharge Requirements
WQO	Water Quality Objectives
ZVI	Zero Valent Iron

EXECUTIVE SUMMARY

Introduction

This Feasibility Study (FS) has been prepared by Engineering Analytics, Inc. (EA) on behalf of the Orange County Water District (OCWD) in support of the South Basin Groundwater Protection Project (SBGPP) Remedial Investigation/Feasibility Study (RI/FS) being conducted by OCWD to address groundwater contamination in Operable Unit 2 (OU2) in the south-central portion of the Orange County Groundwater Basin (the Basin) in Orange County, California (Study Area) (Figure ES-1). OU2 is groundwater contamination in the Shallow Aquifer System off-property of numerous groundwater contamination source sites located within the SBGPP Study Area where groundwater contaminant plumes emanating from individual source sites have migrated and commingled. (Figure ES-2).

The purpose of this FS is to provide detailed evaluation and comparative analysis of remedial alternatives that were developed in the Feasibility Study Initial Screening Evaluation (FSISE) and the Feasibility Study Detailed Evaluation (FSDE) to address groundwater contamination in OU2 (EA, 2021b and 2021e; OCWD, 2021). The FSISE and FSDE were submitted to the Technical Advisory Committee (TAC) for their technical review as part of the reporting requirements listed in the Proposition 1 Grant Agreement (No. D1712505) for the RI/FS between OCWD and the State Water Resources Control Board (State Water Board) Division of Financial Assistance (DFA).

This FS is the culmination of and comprises the FSISE and the FSDE and incorporates all of the related comments and revisions, additional analyses, and information associated with these documents that were requested by the RWQCB, the State Water Board DFA, and the DTSC during the meetings and in the communications referenced in Section 1.0.

Additionally, during the period April 8 through July 6, 2022, comments on the draft OU2 FS were received from the following entities as part of the Stakeholder Advisory Group (SAG) review:

- a letter from the Irvine Ranch Water District dated June 27, 2022;
- a letter from Geosyntec Consultants on behalf of SoCo West, Inc. (SOCO) dated June 30, 2022, with s supplement provided by Geosyntec Consultants on July 5, 2022;
- a letter from Newmeyer Dillion on behalf of DRSS-I, LCC (DRSS) dated July 5, 2022;
- an e-mail from CDM Smith on behalf of Textron dated July 5, 2022;
- an e-mail from Carl Benninger dated July 6, 2022;
- an email from the DTSC dated June 16, 2022, that was transmitted to OCWD on July 11, 2022.

These comments were evaluated and are addressed in the text of this document and as detailed in Appendix V.

OCWD is conducting the SBGPP RI/FS in cooperation with the DTSC and the RWQCB to develop an interim remedy for OU2 groundwater contamination.

Geology and Hydrogeology
From shallow to deep, the three aquifer systems in the Study Area are the Shallow Aquifer System, the Principal Aquifer System, and the Deep Aquifer System. Although identified as separate systems, the aquifer systems are known to be hydraulically connected as groundwater flows between them by way of discontinuities in the aquitards or leakage through the intervening aquitards (OCWD, 2015).

Based on comparison of the elevations of storm channel bottoms in the Study Area with groundwater elevations in the upper portion of the Shallow Aquifer System, it appears that the base of some of the channels in the southern portion of the Study Area are below the water table within the Shallow Aquifer System (Figure ES-3). The base of the channels in the northern portion of the Study Area and the base of some of the channels in the southern portion of the Study Area are above the water table in the Shallow Aquifer System. In cases where the base of the channels is below the water table of the Shallow Aquifer System, there is potential for groundwater to flow from portions of the Shallow Aquifer System into the channels.

Water Supply Wells
Inventories for water supply wells in and adjacent to the Study Area indicate that more than 80 water supply wells have been installed since the latter half of the 1800s with the actual location and current status of many, if not most, of these wells remaining unknown (Figure ES-4). Chemicals of Concern (COCs) have been detected in active and inactive water supply wells within and near the Study Area. Former abandoned and likely improperly destroyed water supply wells in the Study Area may also act as conduits for the transport of groundwater containing COCs from the Shallow Aquifer System downward into the underlying Principal Aquifer System.

Chemicals of Concern
For the purposes of this document, and as described herein, OU2 COCs are defined as compounds that originated from the source sites, which:

- Exceed human health exposure point concentrations (EPCs); and/or
- Exceed toxicity benchmarks for surface water receptors for non-volatile compounds.

COCs originating from the source sites were identified in the Preliminary Remedial Investigation Report (Preliminary RI Report) (Aquilogic, 2015). The SRI identified Compounds of Potential Concern (COPCs) and principal COPCs (Hargis +Associates, Inc. [H + A], 2020). The Human Health and Ecological Risk Assessment (HHERA) identified COPCs and chemicals of potential environmental concern (COPECs) (TFG, 2020).

The revised HHERA was prepared in response to comments from, and subsequent discussions with, the RWQCB and the Office of Environmental Health Hazard Assessment (OEHHA) (TFG, 2020). The HHERA quantified potential risks associated with residential and ecological exposure to contaminants in groundwater. Specifically, the receptors evaluated included a residential child, residential adult, freshwater and saltwater aquatic plants, aquatic invertebrates, and fish. Fifty-eight COPCs exceeding EPCs were identified in the HHERA. Of these only the following were identified as contaminants of concern originating from the source sites and are designated as OU2 groundwater COCs:

- Trichloroethylene (TCE)
- Tetrachloroethylene (PCE)
- 1,1-Dichloroethylene (1,1-DCE)
- 1,4-Dioxane
- Perchlorate
- Hexavalent chromium (Cr6)
- Vinyl chloride
- 1,1-Dichloroethane (1,1-DCA)
- 1,2-Dichloroethane (1,2-DCA)
- cis-1,2-Dichloroethylene (cis-1,2-DCE)
- 1,1,2-Trichloroethane (1,1,2-TCA)

Regarding potential surface water exposures, thirty-eight COPECs exceeding toxicity benchmarks (TBs) were identified in the HHERA. Of these, volatile compounds were removed as OU2 surface water COCs, since these compounds volatilize and are diluted short distances and time periods after entering surface water features. Cr6 was the only remaining non-volatile contaminant of concern originating from the source sites at concentrations exceeding TBs and is therefore the only OU2 groundwater COC related to potential surface water receptors.

Based on the preceding, the term COCs is used in this document to identify the chemicals that will be the subject of OU2 IRMs. The terms COPCs, principal COPCs, and COPECs are used herein only when discussing or referencing their definitions and usage in previous documents[1].

<u>Nature and Extent of OU2 COCs</u>
The Shallow Aquifer System in the Study Area is characterized by various lenses, layers, interbeds, and mixtures of interfingered fine and coarse-grained material. Based on detailed lithologic evaluation and Figures 5-17A through 5-17N in the SRI Report (H+A, 2020), the Shallow Aquifer System, with increasing depth, was subdivided into the following four layers:

- Layer 1: an uppermost fine-grained portion at and below the water table;
- Layer 2: a generally laterally continuous predominantly coarse upper sand zone;
- Layer 3: a mixed zone of sands and fine-grained materials; and
- Layer 4: a laterally continuous and relatively coarse-grained basal sand (Basal Sand).

As discussed with, and to incorporate comments from the RWQCB and the State Water Board DFA, this FS includes additional evaluation and description of the stratigraphic Layers 1 through 4 presented in Section 1.2.1 of the FSISE and the SRI Report cross sections (SRI Figures 5-16

[1] Preliminary RI Report (Aquilogic, 2015), SRI Report (H+A, 2020), HHERA Report (TFG, 2020).

through 5-17N). Revised plan-view figures of COCs in OU2 groundwater were classified into Layers 1 through 4 and are included herein. During the April 7, 2021 meeting, it was agreed that the FS would include figures illustrating color-coded symbols classified by concentration ranges ('color dot maps') for each COC except 1,1-DCA, 1,2-DCA, and 1,1,2-TCA (these chemicals have low prevalence and concentrations in groundwater and concentration range figures do not provide meaningful utility), for each of Layers 1 through 4. Also, as discussed with and requested by the RWQCB and the State Water Board DFA, this FS describes source site-specific hydrostratigraphic units (HSUs) and their correlation with the preceding Layer 1 through 4 designations in areas adjacent to or near conceptually planned OU2 interim remedial measures (IRMs).

<u>Remedy Status and Remedial Action Objectives</u>
One of the U.S. Environmental Protection Agency's (USEPA) primary goals for any corrective action program is to expedite risk reduction through implementation of interim measures to control or minimize ongoing or potential threats to human health or the environment (USEPA, 2012). In many state and federal remedial programs, interim measures are used to address risks to human health or the environment in advance of final remedy selection. The recommended Interim Measure Performance Standard includes:

1. Control, minimize, or eliminate releases(s) or potential release(s) that pose actual or potential threats to human health and the environment and,
2. To the extent practicable, be consistent with remedies that meet the remedy performance standard.

Consistent with USEPA guidance, OCWD intends to implement IRMs that will be consistent with any final remedy, if required. Conceptually, the IRMs would be applied to OU2 groundwater, and long-term groundwater monitoring would be performed as part of these actions. Five-year remedy reviews would be performed to track the progress and effectiveness of the IRMs. The five-year remedy reviews also would evaluate the progress and effectiveness of the source site remedial efforts as they pertain to preventing off-property migration of COCs. Evaluation of the combined effectiveness both of the OU2 IRMs and the source site remedial efforts would provide the basis for determining if changes to source site remedial efforts were warranted and/or if changes to the IRMs were warranted.

Specific recommended remedial action objectives (RAOs) for IRMs contemplated within the OU2 are:

1. Protect groundwater resources from further degradation by preventing lateral and vertical migration of high concentration COCs into zones with lower concentrations of COCs within OU2, to the extent practicable;

2. Protect groundwater resources by preventing the potential for vertical migration of high concentration COCs from the upper/middle portions of the Shallow Aquifer System to the Principal Aquifer System through Legacy Water Supply Wells, to the extent practicable;

3. Protect groundwater resources from further degradation by preventing the spread of COCs exceeding maximum contaminant levels (MCLs) in the leading-edge areas of the plume, to the extent practicable;

4. Implement a reliable interim groundwater remedy(s) that is compatible with ongoing and planned remediation at source sites and associated off-property locations, where applicable;

5. Prevent discharge of COCs exceeding ecological risk-based concentrations from the Shallow Aquifer System to surface water channels; and

6. Prevent human exposure to contaminated groundwater with COC concentrations exceeding MCLs or other applicable or relevant and appropriate requirements (ARARs).

Applicable or Relevant and Appropriate Requirements

Potential federal and State of California ARARs have been identified and evaluated from the universe of regulations, requirements, and guidance for the SBGPP.

General Response Actions, Remedial Technologies, and Process Options

General Response Actions (GRAs) are medium-specific response categories that are likely to satisfy the RAOs as defined by USEPA guidance. GRAs and associated remedial technologies and process options evaluated for OU2 groundwater are presented as follows:

General Response Action	Remedial Technology/ Treated Water Discharge or End Use	Process Option
No Action	None	None
Institutional Controls		Water Well Permit, Notification, Design and Coordination Requirements
		Notifications to Potential Receptors of Risk
Monitoring	Groundwater Monitoring	Remediation Monitoring
Containment	Groundwater Extraction	Groundwater Extraction Wells, Trenches
	Physical Barriers	Slurry Walls, Grout Curtains, Sheet Piling, Sealing Legacy Water Supply Wells
Ex-Situ Groundwater Cleanup	Extracted Groundwater Treatment	Air Stripping
		Liquid-Phase Granular Activated Carbon (LGAC) Adsorption
		Biological Liquid-Phase Granular Activated Carbon (Bio-LGAC) Adsorption
		Advanced Oxidation Process
		Ion Exchange
		Biological Treatment
		Membrane Processes (Reverse Osmosis, Nanofiltration, etc.)
		Evaporation / Condensation
	Treated Water Discharge or End Use Options	Injection
		Storm Drain
		POTW and GWRS
		Non-Potable Reclaimed Water
In-Situ Groundwater Cleanup	In-Situ Groundwater Treatment	Monitored Natural Attenuation
		Active In-Situ Bioremediation
		Chemical Processes
		Thermal Processes
		Physical Processes

POTW = publicly owned treatment works
GWRS = OCWD's Groundwater Replenishment System Advanced Wastewater Purification Facility

For the purposes of this document, source removal and/or source control remedial technologies that have been, are being, or will be implemented at source sites are not included as GRAs, since these efforts are assumed to be implemented by potentially responsible parties under the oversight of state agencies.

<u>Screening of Remedial Technologies and Process Options</u>
Consistent with USEPA guidance, "Effectiveness, implementability, and cost are the criteria used to evaluate and select representative process options."

From the list of technologies potentially applicable for remediating OU2 groundwater, many technologies were excluded from further consideration because they were considered less or not effective, not implementable, or too costly relative to the retained technologies. The main bases for screening the excluded technologies included:

- Inability to treat 1,4-dioxane,
- Potential for incomplete volatile organic compound (VOC) degradation/byproduct generation,
- Incompatibility with off-property access and encumbrance limitations within OU2, and/or
- Relatively high cost for little or no benefit in effectiveness or implementability over other technologies.

Based on the initial screening, the following remedial technologies and process options were retained for development of remedial alternatives:

- No Action
- Institutional Controls
- Monitoring
- Containment with treated water discharge to:
    - POTW and GWRS, or
    - Injection into the Shallow Aquifer System
- Monitored Natural Attenuation
- In-Situ Chemical Oxidation (ISCO) using persulfate
- Sealing Legacy Water Supply Wells, if located

<u>Remedial Alternatives for Further Detailed Evaluation</u>
Excepting the No Action alternative, Institutional Controls, Monitoring, and Sealing Legacy Water Supply Wells process options are not considered stand-alone remedial alternatives, but each of them is recommended as components of any remedial alternative(s) applied as part of OU2 IRMs. Based on the retained process options, the following alternatives were developed in the FSISE to address OU2 IRM RAOs and are further evaluated in detail herein:

- Alternative 1 – No Action
- Alternative 2 – Monitored Natural Attenuation (MNA)
- Alternative 3 – Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS
- Alternative 4 – Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to the Basal Sand

- Alternative 5 – In-Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation
- Alternative 6 – Containment and In-Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with Discharge to POTW and GWRS

Detailed Evaluation of Remedial Alternatives
Section 7 provides detailed evaluation of the remedial alternatives consistent with the following NCP Threshold and Balancing Criteria as well as environmental sustainability:

Threshold Criteria

1. Overall protectiveness of human health and the environment
2. Compliance with ARARs

Balancing Criteria

3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, or volume (TMV) of contaminants through treatment.
5. Short-term effectiveness
6. Implementability
7. Cost

The last two NCP criteria, referred to as "modifying criteria," will be evaluated later and the results will be presented in the Proposed Interim Remedial Action Plan and Responsiveness Summary (IRAP) and the Community Involvement Plan Implementation activities and documents. These criteria are as follows:

8. Regulatory agency acceptance
9. Community acceptance

Groundwater Flow Model
A numerical groundwater flow model was developed to support the evaluation of the six remedial alternatives identified above. The numerical modeling is based on the current conceptual hydrogeologic model of the regional and local groundwater flow system. The groundwater flow model was calibrated to transient conditions representative of the low and high potentiometric cycles observed in area monitoring wells. Calibration targets included groundwater levels, groundwater flow directions (estimated from potentiometric surface maps), and vertical hydraulic gradients. The model calibration incorporated historical groundwater extraction from source site remediation systems and the model simulations incorporated ongoing and planned source site remedial system groundwater extraction. In response to comments received from SoCo West, Inc., (SOCO), the OU2 groundwater flow model grid spacing was refined to incorporate the approved SOCO source area remedy which has yet to be installed. The refined OU2 groundwater flow

model evaluated change in groundwater flow direction and change in groundwater flux at the SOCO property to assess the influence of OU2 groundwater extraction in the vicinity of the SOCO source control remedy.

IRM Compatibility with Source Site Remedial Efforts

The compatibility of the planned IRMs with source site remedial efforts that are ongoing or planned in proximity to the conceptual IRMs was also evaluated. The relative changes in groundwater fluxes and/or directions of flow that may result from implementation of Alternatives 3, 4, 5, and 6 at and near source sites with ongoing or planned remedial actions were evaluated by using the groundwater flow model. Alternative 5 and the ISCO portion of Alternative 6 was evaluated by considering the changes in geochemical conditions at and near source sites with ongoing or planned remedial actions that may result from implementation of these alternatives.

Generally, there were relatively low changes in groundwater fluxes and flow directions in Layers 1 and 2 (the only layers where source site remedial actions are or are planned to be applied) at and near most of the source sites. For the purposes of this evaluation, simulated groundwater flux increases less than a factor of 0.5 and changes in groundwater flow directions less than 20 degrees from ambient (non-IRM pumping conditions) are considered negligible. As further described in Section 7, there are several source sites where the simulated changes in groundwater flux and/or the direction of groundwater flow in Layers 1 and/or 2 resulting from IRM pumping were higher than these screening criteria over limited areas.

For Alternative 5 and the ISCO portion of Alternative 6, it is anticipated that, excepting the Cherry Aerospace source site, changes in geochemical conditions would be limited to the relatively narrow injection width (perpendicular to the direction of groundwater flow) of approximately 24 feet of each ISCO injection alignment, with some changes in geochemical conditions at relatively short distances downgradient of each alignment. It is possible that increases in oxidation potential and/or generation of hexavalent chromium may extend further downgradient of the transects, which could complicate source area remediation at Cherry Aerospace and/or potentially discharge to surface channels in the southern portion of the Study Area. Therefore, Alternative 5 has some potential for impacts to existing remediation systems and/or surface channels in the southern portion of the Study Area. These impacts are less likely for the ISCO portion of Alternative 6.

Comparative Analysis

Table ES-1 summarizes a relative comparison and ranking of the six remedial alternatives regarding the degree to which each one satisfies the two threshold criteria and the five balancing criteria. The six alternatives also are compared and relatively ranked in terms of the green or sustainable practices anticipated during IRM implementation. The sustainability assessment was performed to maintain consistency with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 Code of Federal Regulations [CFR], Part 300), commonly referred to as the National Contingency Plan or NCP. Specifically, the USEPA Office of Solid Waste and Emergency Response (OSWER) *Principles for Greener Cleanups* was used and is referenced herein (USEPA, 2009), which states "OSWER cleanup programs should consider these Principles for Greener Cleanups during any phase of work, including site investigation, evaluation of cleanup options, and optimization of the design, implementation, and operation of new or existing cleanups." The sustainability assessment, like the Threshold and Balancing Criteria, should be used in the remedy selection process, although it may be considered in some instances to be a secondary consideration relative to the Threshold and Balancing Criteria. More detailed sustainability assessment will be conducted during the design phase to integrate green principles into the overall processes. In general, the distinguishing factors that result in ranking certain alternatives more favorably than others are their ability to meet threshold criteria, their implementability, and their cost effectiveness. Excepting Alternative 1 (No Action), Institutional Controls, Monitoring, and Sealing Legacy Water Supply Wells process options would be a component of all applied IRMs, and they would all provide a similar measure of protectiveness to human health and the environment as a component of each alternative.

Threshold Criteria

Comparing the overall Threshold Criteria with each other, Alternatives 3 and 4 rank highest, Alternative 6 ranks moderately high, Alternative 5 has modest ranking, Alternative 2 has a relatively low ranking and Alternative 1 is lowest in rank (Table ES-1).

Alternative 1 (No Action) does not meet the primary threshold criteria of protectiveness of human health and the environment. With excess risk present, this alternative was not retained for consideration as a preferred alternative because of its inability to meet the basic threshold criteria of protectiveness.

Alternative 2 (Monitored Natural Attenuation) also does not meet the primary threshold criteria of protectiveness of human health and the environment with the exception of protection of human exposure to groundwater containing COCs through institutional controls (Table ES-1). In the context of an IRM and since there is no active remediation being implemented there are no chemical-specific ARARs identified for Alternative 2; however, in context of transitioning an IRM to a final remedy, this alternative would not comply with the chemical-specific ARARs associated with the state and federal MCLs for OU2 groundwater COCs in a reasonable timeframe. Alternative 2 does meet the location- and action-specific ARARs.

Alternatives 3 and 4 (Containment with POTW/GWRS and Local Treatment with Reinjection, respectively) meets the primary threshold criteria of protectiveness of human health and the environment and compliance with ARARs (Table ES-1).

Alternative 5 (In-Situ Chemical Oxidation) might meet the threshold criteria of protectiveness of human health and the environment; however, the potential for generation of persistent undesirable byproducts, particularly in close proximity to the surface water channels in the southern portion of the Study Area is of concern (Table ES-1). The potential for generation of persistent undesirable byproducts along with potential for not complying with Basin Plan Water Quality Objectives (WQOs) due to relatively large application of amendments is also of concern when evaluating compliance with ARARs.

Alternative 6 (Containment and In-Situ Chemical Oxidation) is effectively a mix of Alternatives 3 and 5, with a smaller application area for ISCO, thereby reducing, but not eliminating protectiveness of human health and the environment and ARARs (Table ES-1).

Balancing Criteria

Comparing the overall Balancing Criteria with each other, Alternative 3 ranks highest, followed closely by Alternative 4, Alternative 6 ranks moderately high, Alternative 5 has modest ranking, Alternative 2 has a relatively low ranking and Alternative 1 is lowest in rank (Table ES-1).

Alternative 1 (No Action) ranks low in long-term effectiveness, reduction of TMV, and short-term effectiveness, and high in implementability (Table ES-1). It was not ranked in cost.

Alternative 2 (Monitored Natural Attenuation) ranks low in reduction of TMV and short-term effectiveness, relatively low in long-term effectiveness and high in implementability and cost (Table ES-1).

Alternative 3 (Containment with POTW/GWRS) ranks moderately high in cost and high in long-term effectiveness, reduction of TMV, short-term effectiveness and implementability (Table ES-1).

Alternative 4 (Containment with Reinjection) ranks moderately in cost, relatively high in implementability and high in long-term effectiveness, reduction of TMV and short-term effectiveness (Table ES-1).

Alternative 5 (In-Situ Chemical Oxidation) ranks low in cost and moderately in long-term effectiveness, reduction of TMV, short-term effectiveness and implementability (Table ES-1).

Alternative 6 (Containment and In-Situ Chemical Oxidation) ranks relatively low in cost and relatively high in long-term effectiveness, reduction of TMV, short-term effectiveness and implementability (Table ES-1).

<u>Green and Sustainable Practices</u>
Comparing the overall Sustainability of each alternative, Alternative 2 ranked highest, followed closely by Alternative 3, Alternative 4 has a modest ranking, Alternative 6 has a relatively low ranking and Alternative 5 has a low ranking (Table ES-1).

<u>Other Considerations</u>
The six remedial alternatives were evaluated relative to one another based on compatibility with source site remediation and proximity to the Armstrong Channel (Table ES-1). Alternatives 1 and 2 are compatible with source site remediation systems; however, neither of these alternatives are compatible with Armstrong Channel. Alternative 5 is slightly more compatible with source site remediation systems when compared to Alternatives 3, 4 and 6; however, this alternative is not compatible with Armstrong Channel. Alternatives 3 and 4 are compatible with source site remediation and compatible with Armstrong Channel, given the flexibility and reversibility of these remedial alternatives. In instances where these alternatives have negligible effects, the containment alignment is relatively close to the source site. At these sites, the options for implementation include not installing extraction wells or balancing extraction rates during implementation to moderate and minimize effects of the respective source sites.

TABLES
EXECUTIVE SUMMARY

Table ES-1. Threshold and Balancing Criteria Evaluation for OU2 Interim Remedial Measures Alternatives, Sustainability Assessment and Other Considerations

			Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
			No Action	Monitored Natural Attenuation	Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS	Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to the Basal Sand	In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation	Containment and In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with discharge to POTW and GWRS
THRESHOLD CRITERIA	Protective of Human Health and Environment	**Overall Ranking**	1	2	5	5	3	4
		Prevent Lateral and Vertical Migration of High Concentration COCs[1]	Low	Low	Moderate to High Removes and treats COCs from groundwater	Moderate to High Removes and treats COCs from groundwater	Moderate Treats COCs in groundwater, may generate undesirable byproducts	Moderate to high Removes and treats COCs from groundwater, may generate undesirable byproducts in limited area
		Prevent Further Degradation of Groundwater Resource	Low	Low	High Contains groundwater COCs in Leading Edge	High Contains groundwater COCs in Leading Edge	High Assuming effective in situ treatment in Leading Edge	High Contains groundwater COCs in Leading Edge
		Prevent COC Exceeding Ecological Receptors Threshold	Low	Low	High Removes and treats COCs from groundwater in southern study area	High Removes and treats COCs from groundwater in southern study area	Low to Moderate Relatively high potential for generation of undesirable byproducts	High Removes and treats COCs from groundwater in southern study area
		Prevent Human Exposure to Groundwater Containing COCs	Low	Moderate to High Through institutional contols	Moderate to High Through institutional contols	Moderate to High Through institutional contols	Moderate to High Through institutional contols	Moderate to High Through institutional contols
	Compliance with ARARs	**Overall Ranking**	0	3	5	5	2	4
		Chemical-Specific	None	In context of IRM, meets ARARs, not likely to be effective at meeting final remedy ARARs in timely manner	Meets	Meets	Potential issues: generation of persistent undesirable byproducts; meeting basin WQOs with frequent application of amendments; and incompatibility with Armstrong Channel	Hybrid of Alternatives 3 and 5
		Location-Specific	None	Meets	Meets	Meets	Meets	Meets
		Action-Specific	None	Meets	Meets	Meets	Potential issue of persistent undesirable byproducts generation	Hybrid of Alternatives 3 and 5

Table ES-1. Threshold and Balancing Criteria Evaluation for OU2 Interim Remedial Measures Alternatives, Sustainability Assessment and Other Considerations

			Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
			No Action	Monitored Natural Attenuation	Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS	Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to the Basal Sand	In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation	Containment and In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with discharge to POTW and GWRS
BALANCING CRITERIA	Long-Term Effectiveness and Permanence	Overall Ranking	1	1	5	5	3	4
		Magnitude of residual waste or treatment residuals	Depends solely on natural attenuation processes, with low/untreated resudual waste likely to migrate beyond current extent	Depends solely on natural attenuation processes, with low/untreated resudual waste likely to migrate beyond current extent	Active treatment effective at reducing residual waste in OU2 coupled with effective source control at individual properties	Active treatment effective at reducing residual waste in OU2 coupled with effective source control at individual properties	Treats COCs in groundwater, may generate undesirable treatment residuals	Hybrid of Alternatives 3 and 5
		Adequacy and reliablity of controls for long-term	No institutional controls or active treatment. Not likely to achieve IRM or final remedy RAOs in reasonable time frame.	No active treatment, has high likelihood of requiring contingency action, not likely to achieve IRM or final remedy RAOs in reasonable time frame. Institutional controls, which are moderately effective, would have to be relied on for longer period.	Proven technology, contingency actions, if needed, tend to be relatively simple to implement. Institutional controls are moderately effective.	Proven technology, reinjection adds complexity to process, contingency actions, if needed, tend to be relatively simple to implement, except for potential to spread unknown untreated emergent compounds within injection zone. Institutional controls are moderately effective.	In-situ distribution of amendments difficult to control, has moderate likelihood of continency actions. Institutional controls are moderately effective.	Hybrid of Alternatives 3 and 5
	Reduction of Toxicity, Mobility, or Volume	Overall Ranking	1	1	5	5	3	4
		Treatment processes	Limited to natural processes	Limited to natural processes	Removal and treatment of COCs in groundwater	Removal and treatment of COCs in groundwater	Treats COCs in groundwater, may generate undesirable byproducts/treatment residuals	Hybrid of Alternatives 3 and 5

Table ES-1. Threshold and Balancing Criteria Evaluation for OU2 Interim Remedial Measures Alternatives, Sustainability Assessment and Other Considerations

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BALANCING CRITERIA	Reduction of Toxicity, Mobility, or Volume	Amount of hazardous substances to be destroyed	Slowest rate of destruction, potential for stalling at intermediate byproducts	Slowest rate of destruction, potential for stalling at intermediate byproducts	Fastest rate of destruction	Fastest rate of destruction	Fastest rate of destruction if amendment delivery successful, potential for undesirable byproduct generation/treatment residuals	Hybrid of Alternatives 3 and 5
		The degree of expected reduction in toxicity, mobility and volume	Slowest rate, potential for stalling at intermediate by products that are mobile and toxic	Slowest rate, potential for stalling at intermediate by products that are mobile and toxic	Reduction in mobility almost immediate through hydraulic control, fastest attainment of reduction in toxicity and volume through extraction and treatment	Reduction in mobility almost immediate through hydraulic control, fastest attainment of reduction in toxicity and volume through extraction and treatment	Reduction in toxicity and volume through in situ treatment if amendment can be delivered to affected portions of groundwater. Potential for generation of negative byproducts that are mobile and toxic	Hybrid of Alternatives 3 and 5
		The degree to which the treatment process is irreversible	Natural processes are irreversible for organic compounds, limited potential for long-term generation of hexavalent chromium if oxidation state of groundwater changes	Natural processes are irreversible for organic compounds, limited potential for long-term generation of hexavalent chromium if oxidation state of groundwater changes	Once COCs are removed from groundwater, the process is irreversible	Once COCs are removed from groundwater, the process is irreversible	Once organic COCs are destroyed, the process is irreversible. There is a modest potential for generation hexavalent chromium due to increased oxidation state in the area of injection	Hybrid of Alternatives 3 and 5

Table ES-1. Threshold and Balancing Criteria Evaluation for OU2 Interim Remedial Measures Alternatives, Sustainability Assessment and Other Considerations

			Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
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BALANCING CRITERIA	Reduction of Toxicity, Mobility, or Volume	The residuals that will remain following treatment	No treatment residuals as there is no active remediation	No treatment residuals as there is no active remediation	Limited: potential for disposal of carbon in off-site treatment process	Limited: potential for disposal of carbon in on-site treatment process	Moderate: potential for negative byproduct formation of hexavalent chromium and change in groundwater chemistry due to in situ reactions	Hybrid of Alternatives 3 and 5
		The degree to which treatment reduces inherent hazards	No incremental reduction over natural processes	No incremental reduction over natural processes	Reduction achieved through containment and extracted groundwater treatment	Reduction achieved through containment and extracted groundwater treatment	Reduction achieved through in-situ treatment	Hybrid of Alternatives 3 and 5
	Short-Term Effectiveness	Overall Ranking	1	1	5	5	3	4
		Risks to community during implementation	Will not attain IRM RAOs	Requires extensive monitoring network, can attain protection of human health through institutional controls, does not attain remaining IRM RAOs	Can attain protection of human health through containment zones along alignments that develop soon after start up	Can attain protection of human health through containment zones along alignments thst develop soon after start up	Can attain protection of human health through in-situ treatment that can develop soon after start up if delivery and amendment application concentration is adequate, potential for generation of persistent undesirable byproducts	Hybrid of Alternatives 3 and 5
		Potential Impacts of workers	None	Managed through health and safety plans	Managed through health and safety and operations, maintenance and monitoring plans	Managed through health and safety and operations, maintenance and monitoring plans	Managed through health and safety and operations, maintenance and monitoring plans	Hybrid of Alternatives 3 and 5

Table ES-1. Threshold and Balancing Criteria Evaluation for OU2 Interim Remedial Measures Alternatives, Sustainability Assessment and Other Considerations

			Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
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BALANCING CRITERIA	Short-Term Effectiveness	Potential Environmental Impacts during implementation	Will not attain IRM RAOs	Can attain protection of human health through institutional controls, does not attain remaining IRM RAOs	May require installation of additional extraction wells to improve performance, low potential for environmental impact	May require installation of additional extraction wells to improve performance, treatment system and/or extraction system may require upgrades/expansion to address unknown untreated emergent compounds, can require expansion of well field into injection zone.	May require additional injections or contingency actions if delivery not effective and/or negative byproduct formation	Hybrid of Alternatives 3 and 5
		Time until protection achieved	Will not attain IRM RAOs.	Can attain protection of human health through institutional controls, does not attain remaining IRM RAOs	Can attain protection of human health through institutional controls, reduce threat of vertical migration through Legacy Water Supply Wells in moderate term by removing and treating high concentration groundwater and attain the remaining RAOs through containment zones along alignments that develop soon after start up	Can attain protection of human health through institutional controls, reduce threat of vertical migration through Legacy Water Supply Wells in moderate term by removing and treating high concentration groundwater and attain the remaining RAOs through containment zones along alignments that develop soon after start up	Can attain protection of human health through institutional controls, reduce threat of vertical migration through Legacy Water Supply Wells in moderate term by treating high concentration groundwater and attain the remaining RAOs through in situ treatment along alignments; however, there is potential generation of undesirable byproducts that could delay, complicate, or not achieve attainment of RAOs	Hybrid of Alternatives 3 and 5

Table ES-1. Threshold and Balancing Criteria Evaluation for OU2 Interim Remedial Measures Alternatives, Sustainability Assessment and Other Considerations

			Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
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BALANCING CRITERIA	Implementability	Overall Ranking	5	5	4	3	3	4
		Technical feasibility	Nothing required	Requires construction of monitor wells with long-term monitoring	Requires construction of monitor/extraction wells/simple filtration systems and LGAC treatment and long-term operation and monitoring	Requires construction of monitor/extraction wells / injection wells / complicated treatment system and long-term operation and monitoring	Requires construction of large number of ISCO injection wells / monitor wells and long-term frequent doing of injection wells with monitoring	Hybrid of Alternatives 3 and 5
		Adminstrative feasibility	No admistrative requirements	Institutional controls can be instituted access in rights of way would require agreements and potentially access fees	Institutional controls can be instituted access in rights of way would require agreements and potentially access fees, obtaining operational permits relatively easy	Institutional controls can be instituted access in rights of way would require agreements and potentially access fees, obtaining operational permits will require additonal effort but is achievable, procurement of treatment system property may be limited by available land	Institutional controls can be instituted access in rights of way would require agreements and potentially access fees, obtaining operational permits will require additonal effort but is achievable, will require relatively comprehensive traffic control plans on relatively frequent basis	Hybrid of Alternatives 3 and 6
		Availability of services and materials	No services or materials required	Services and materials readily available	Services and materials readily available	Services and materials readily available	Services and materials normally available, quantity of amendment may pose some challenges	Services and materials readily available
	Cost	Overall Ranking	0	5	4	3	1	2
		NPV Cost	$0	$24,600,000	$35,800,000	$64,000,000	$348,600,000	$110,300,000

Table ES-1. Threshold and Balancing Criteria Evaluation for OU2 Interim Remedial Measures Alternatives, Sustainability Assessment and Other Considerations

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Sustainability Assessment		**Overall Ranking**	0	5	4	3	1	2
		CO_2 Emissions (metric tons)	0	970	13,000	18,000	170,000	57,000
		Total Energy Used (million BTU)	0	280,000	530,000	670,000	5,000,000	1,800,000
		Total Electricity Used (Mega Watt hours)	0	0	31,000	47,000	0	31,000
OTHER CONSIDERATIONS	**Compatibility with Source Site Remedies**	Allen T. Campbell	Compatible	Compatible	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux	Compatible	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux
		Gallade Chemical	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
		Embee Plating	Compatible	Compatible	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux	Compatible	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux
		Soco West, Former Service Chemical	Compatible	Compatible	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux	Compatible	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux

Table ES-1. Threshold and Balancing Criteria Evaluation for OU2 Interim Remedial Measures Alternatives, Sustainability Assessment and Other Considerations

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OTHER CONSIDERATIONS	Compatibility with Source Site Remedies	Former Diceon Electronics Facility	Compatible	Compatible	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux	Compatible	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux
		Cherry Aerospace	Compatible	Compatible	Compatible	Compatible	Moderate potential for generation of persistent undesirable byproducts upgradient of extraction system.	Potential generation of persistent undesirable byproducts upgradient of extraction system.
		Steelcase Incorporated	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
		Troy Computer	Compatible	Compatible	Adjacent extraction alignment, affects groundwater flow direction, high influence on groundwater flux	Adjacent extraction alignment, affects groundwater flow direction, high influence on groundwater flux	Compatible	Adjacent extraction alignment, affects groundwater flow direction, high influence on groundwater flux
		GE Plastics	Compatible	Compatible	Compatible	Compatible	Low potential generation of persistent undesirable byproducts upgradient of extraction system.	Compatible
		ITT Cannon	Compatible	Compatible	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux	Moderate potential for generation of persistent undesirable byproducts upgradient of extraction system.	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux

Table ES-1. Threshold and Balancing Criteria Evaluation for OU2 Interim Remedial Measures Alternatives, Sustainability Assessment and Other Considerations

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OTHER CONSIDERATIONS	Compatibility with Source Site Remedies	Former Ricoh Electronics Facility	Compatible	Compatible	Adjacent extraction alignment, affects groundwater flow direction and moderate influence on groundwater flux	Adjacent extraction alignment, affects groundwater flow direction and moderate influence on groundwater flux	Compatible	Adjacent extraction alignment, affects groundwater flow direction and moderate influence on groundwater flux
		Baxter Health Care	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
		Bell Industries	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
		Dyer Business Park	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
		BFM Energy	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
		Astech	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
	Compatibility with Armstrong Channel		Incompatible, does not address IRM RAO	Incompatible, does not address IRM RAO	Compatible	Compatible	Low compatibility due to generation of undesirable byproducts	Compatible

[1] It is understood that cross flow from the Shallow Aquifer System into the Principal Aquifer System through Legacy Water Supply Wells is difficult to address for any of the alternatives; however, alternatives that begin to mitigate this risk by extracting/treating COCs from the Shallow Aquifer System are given a moderate to high ranking.

ARAR	Applicable or Relevant and Appropriate Requirements
BTU	British Thermal Units
COCs	Chemical(s) of Concern
GWRS	OCWD Groundwater Replenishment System Advanced Wastewater Purification Facility
IRM	Interim Remedial Measures
ISCO	In-Situ Chemical Oxidation
LGAC	Liquid-phase granular activated carbon
POTW	Public Owned Treatment Works
RAO	Remedial Action Objectives
WQO	Water Quality Objectives from Santa Ana Basin Plan

<u>Criteria Ranking</u>
0 None/Not Applicable
1 Low
2 Low to Moderate
3 Moderate
4 Moderate to High
5 High

FIGURES
EXECUTIVE SUMMARY

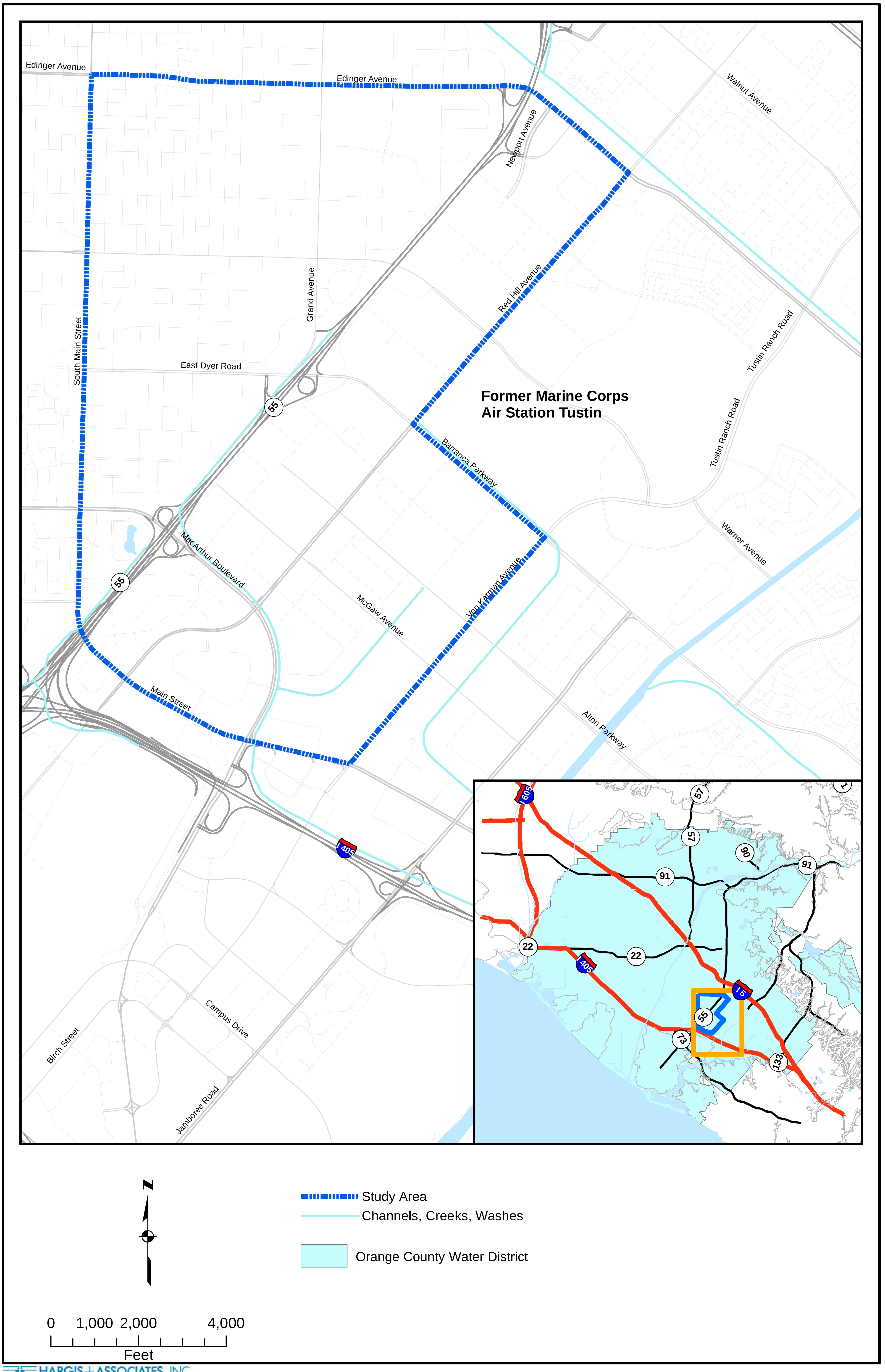

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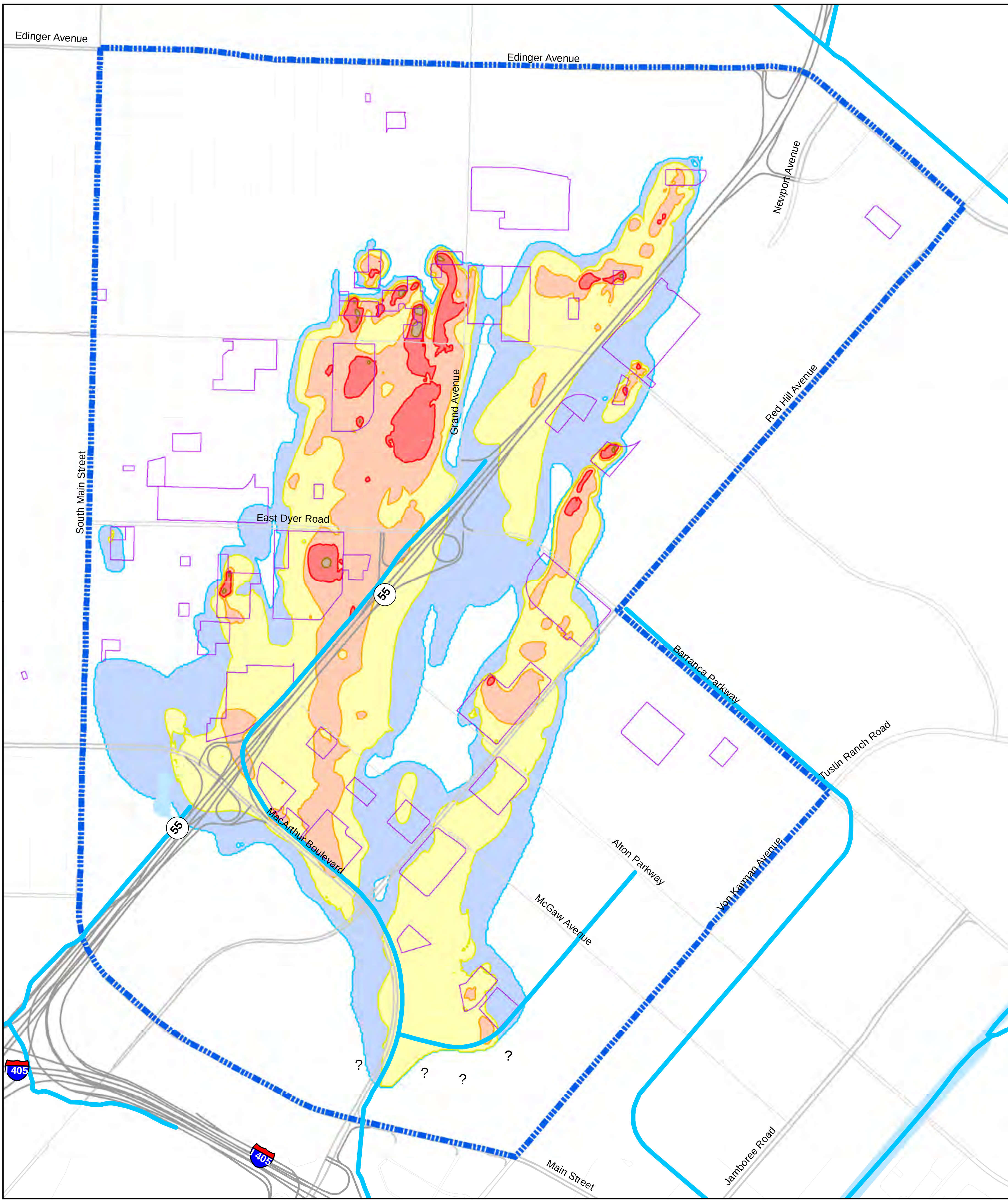
FIGURE ES-1: STUDY AREA LOCATION



NOTES:

Approximate distribution based on maximum concentration of principal chemicals of potential concern (COPCs) (tetrachloroethylene, trichloroethylene, 1,1-dichloroethylene, perchlorate and 1,4-dioxane, micrograms per liter [ug/l]). See appendix for details.

Water level elevation based on upper shallow aquifer system water level measurements in first half of 2012 (see appendix), feet NAVD88 datum. Q1/Q2 2012 water level contours selected as the data set for this period was more extensive than other data sets.

Channels, unspecified
Study Area
Source Sites
Approximate Contour of Water Level Elevation, Upper Portion of Shallow Aquifer System (Q1/Q2 2012)

Approximate extent of principal COPCs
1 ug/l
10 ug/l
100 ug/l
1,000 ug/l
>10,000 ug/l

ug/l = micrograms per liter

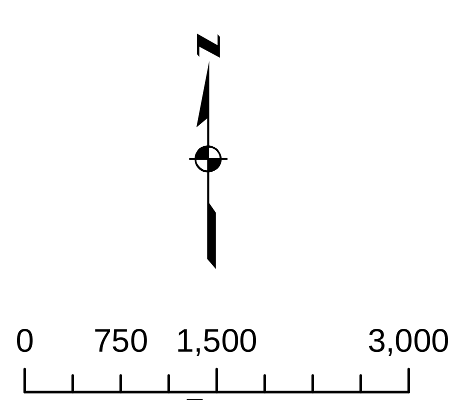


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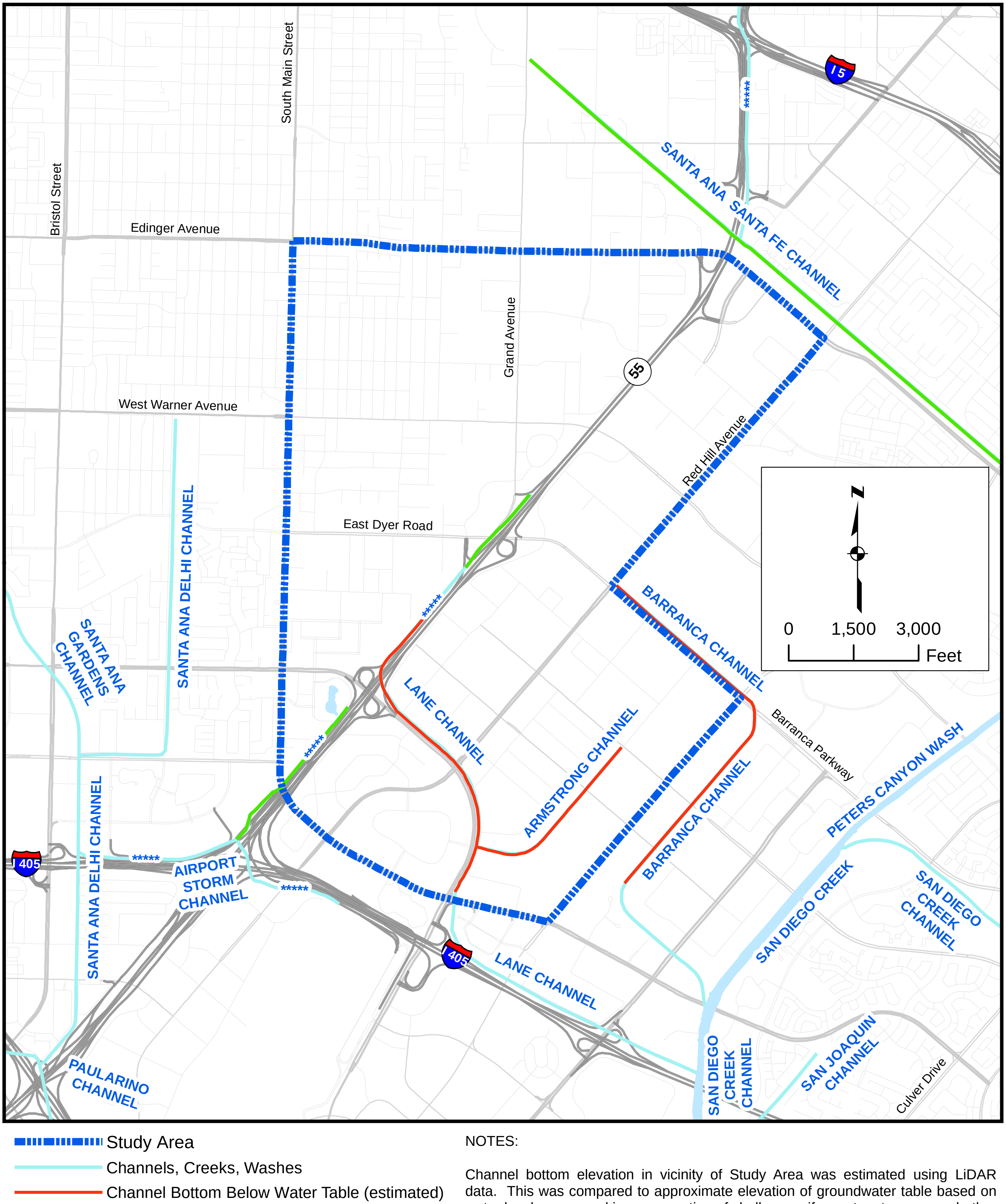
FIGURE ES-2. OVERVIEW OF EXTENT OF PRINCIPAL COMPOUNDS OF POTENTIAL CONCERN IN SHALLOW AQUIFER SYSTEM



NOTES:

Channel bottom elevation in vicinity of Study Area was estimated using LiDAR data. This was compared to approximate elevation of groundwater table based on water levels measured in upper portion of shallow aquifer system to assess whether channel bottom was above or below channel bottom.

Portions of channels that are not indicated to be above or below channel were either too close to assess or not in Study Area.

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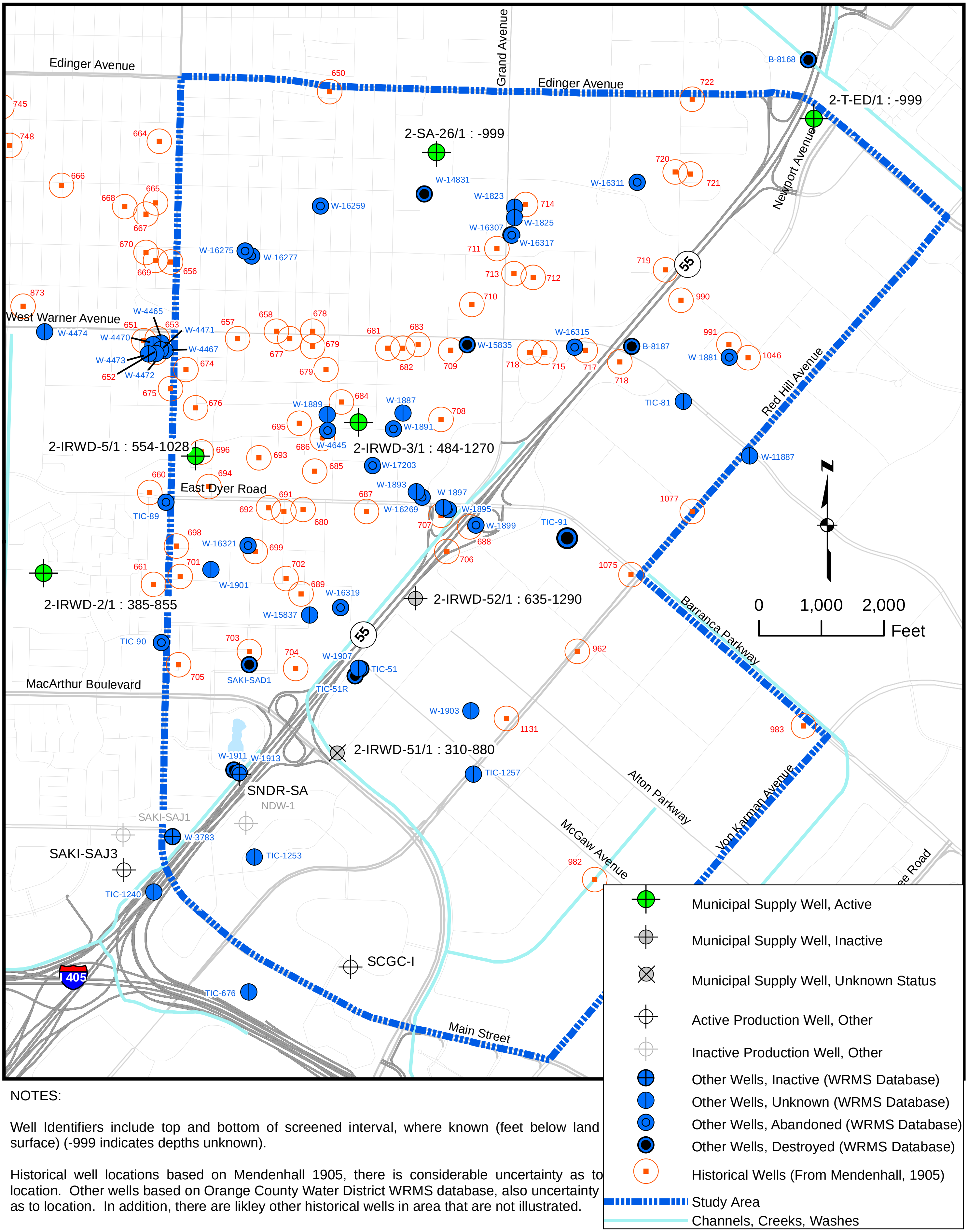
FIGURE ES-3. SURFACE WATER FEATURES WITHIN VICINITY OF STUDY AREA



NOTES:

Well Identifiers include top and bottom of screened interval, where known (feet below land surface) (-999 indicates depths unknown).

Historical well locations based on Mendenhall 1905, there is considerable uncertainty as to location. Other wells based on Orange County Water District WRMS database, also uncertainty as to location. In addition, there are likley other historical wells in area that are not illustrated.

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FIGURE ES-4: LOCATION OF PRODUCTION WELLS IN STUDY AREA VICINITY

1.0 INTRODUCTION

This Feasibility Study (FS) has been prepared by Engineering Analytics, Inc., (EA) on behalf of the Orange County Water District (OCWD) in support of the South Basin Groundwater Protection Project (SBGPP) Remedial Investigation/Feasibility Study (RI/FS) being conducted by OCWD to address groundwater contamination in Operable Unit 2 (OU2) in the south-central portion of the Orange County Groundwater Basin (the Basin) in Orange County, California (Study Area) (Figure 1-1). OU2 is groundwater contamination in the Shallow Aquifer System off-property of numerous groundwater contamination source sites (source sites) located within the SBGPP Study Area where groundwater contaminant plumes emanating from individual source sites have migrated and commingled. There is another Operable Unit designated within the Study Area (Operable Unit 1). Operable Unit 1 is being addressed by responsible parties for the source sites under the oversight of the State of California and pertains to vadose zone and groundwater contamination in the Shallow Aquifer System directly beneath source properties (Aquilogic, 2015).

The purpose of this FS is to provide detailed evaluation and comparative analysis of remedial alternatives that were developed in the Feasibility Study Initial Screening Evaluation (FSISE) and the Feasibility Study Detailed Evaluation (FSDE) to address groundwater contamination in OU2 (EA, 2021b and 2021e; OCWD, 2021). The FSISE and FSDE were submitted to the Technical Advisory Committee (TAC) for their technical review as part of the reporting requirements listed in the Proposition 1 Grant Agreement (No. D1712505) for the RI/FS between OCWD and the State Water Resources Control Board (State Water Board) Division of Financial Assistance (DFA). In a letter dated March 25, 2021, the Regional Water Quality Control Board (RWQCB) transmitted their comments on the FSISE to OCWD (RWQCB, 2021a) (Appendix H). The State Water Board DFA provided their comments on the FSISE in an e-mail to OCWD dated March 29, 2021 (Appendix I). On April 7, 2021, a TAC meeting was convened between representatives of the RWQCB, the State Water Board DFA, OCWD, and EA to discuss the RWQCB and the State Water Board comments on the FSISE (Appendix J). On May 23, 2021, Responses to TAC comments on the FSISE were transmitted to the TAC (EA, 2021d; Appendix K). On May 26, 2021, a TAC meeting was convened between representatives of the RWQCB, the State Water Board DFA, OCWD, and EA to further discuss the RWQCB and the State Water Board DFA comments on the FSISE (Appendix L). On June 17, 2021, the RWQCB transmitted comments on the FSISE to OCWD (Appendix M). On September 20, 2021, OCWD sent the draft FSDE to the TAC (OCWD, 2021). On October 26, 2021, a TAC meeting was convened between representatives of the RWQCB, the State Water Board DFA, DTSC, OCWD, and EA to discuss incorporation of FSISE comments into the FSDE (Appendix N). On November 10 and 15, 2021, OCWD received DTSC comments on the FSDE (Appendix O). On November 24, 2021, OCWD received RWQCB comments on the FSDE (Appendix P). On December 1, 2021, a TAC meeting was convened between representatives of the RWQCB, the State Water Board DFA, DTSC, OCWD, and EA to discuss incorporation of FSISE comments into the FSDE (Appendix Q). On December 15, 2021, a TAC meeting was convened between representatives of the RWQCB, the State Water Board DFA, California Environmental Protection Agency (CalEPA) Department of Toxic Substances Control (DTSC), OCWD, and EA to continue discussion of the December 1, 2021 TAC meeting topics (Appendix R). On December 16, 2021, OCWD transmitted preliminary draft responses to the TAC review comments on the FSDE (Appendix S). On January 10, 2022, a TAC meeting between representatives of the RWQCB, the State Water Board DFA, OCWD, and

EA was convened to discuss the modeling particle tracking portion of the FSDE (Appendix T). On April 7, 2022, OCWD transmitted the draft OU2 FS to the OCWD South Basin Stakeholder Advisory Group (SAG). On May 25, 2022, a Stakeholder Advisory Group (SAG) meeting to discuss the draft OU2 FS was convened, which included participants from the SAG, OCWD, the TAC, and EA.

During the period April 8 through July 6, 2022, SAG comments on the draft OU2 FS were received from the following entities as part of the SAG review (Appendix V):

- A letter from the Irvine Ranch Water District dated June 27, 2022;
- A letter from Geosyntec Consultants on behalf of Soco West, Inc. (SOCO) dated June 30, 2022 with s supplement provided by Geosyntec Consultants on July 5, 2022;
- A letter from Newmeyer Dillion on behalf of DRSS-I, LCC (DRSS) dated July 5, 2022;
- An e-mail from CDM Smith on behalf of Textron dated July 5, 2022;
- An e-mail from Carl Benninger dated July 6, 2022;
- An email from the DTSC dated June 16, 2022, that was transmitted to OCWD on July 11, 2022.

Additionally, on June 28, 2022, OCWD presented a status update on the South Basin project and the alternatives evaluated in the Draft OU2 FS Report to the City of Santa Ana's Delhi Community Association. As part of OCWD's outreach, notifications of the community meeting were sent by mail to all residents and businesses within the South Basin study area.

A Technical Memorandum *Response to Comments on Draft Feasibility Study Report, South Basin Groundwater Protection Project, Operable Unit 2*, prepared by EA, dated November 28, 2022 (Appendix V) evaluated and addressed the above comments, which included updated cost estimates for certain remedial alternatives; evaluation of OU2 groundwater extraction influence on the SOCO source site remedy; and, typographical and minor editorial revisions.

On November 8, 2022, a TAC meeting between representatives of the RWQCB, the State Water Board DFA, DTSC, OCWD, and EA was convened to discuss response to SAG comments on the draft OU2 FS (Appendix U).

This FS is the culmination of and comprises the FSISE and the FSDE and incorporates all of the related comments and revisions, additional analyses, and information associated with these documents that were requested by the RWQCB, the State Water Board DFA, and the DTSC during the meetings and in the communications referenced in the preceding paragraph.

This FS includes the following elements:

- Section 1 provides an introduction, the overall purpose and scope of the Feasibility Study (FS), an outline of the scope of this document, remedy status, and a background summary of the Study Area.
- Section 2 presents remedial action objectives (RAOs) for OU2 groundwater.

- Section 3 presents applicable or relevant and appropriate requirements (ARARs).
- Section 4 provides the evaluated general response actions, remedial technologies and process options.
- Section 5 presents a screening evaluation of remedial technologies and process options.
- Section 6 presents and summarizes remedial alternatives based on the retained remedial technologies and process options.
- Section 7 provides a detailed analysis of remedial alternatives.
- Section 8 presents a comparative analysis of remedial alternatives.
- Section 9 presents references cited.
- Appendix A summarizes the data and methods used to prepare the chemicals of concern (COCs) in OU2 groundwater plan view figures.
- Appendix B describes potential federal and State of California ARARs for the SBGPP.
- Appendix C provides an OU2 remedial alternatives sustainability assessment.
- Appendix D provides detailed cost estimates for OU2 remedial alternatives.
- Appendix E presents details of numerical groundwater flow model development, calibration, and modeling results to support the FS process.
- Appendix F summarizes source site hydrostratigraphic units correlated with Layers 1 through 4 defined herein and groundwater extraction rate estimates, where available
- Appendices G through T provide correspondence, meeting minutes, and evaluations prepared as a result of the 2021 and 2022 TAC meetings.
- Appendix U provides the November 8, 2022 OCWD South Basin Technical Advisory Committee Meeting Minutes (D1712505)
- Appendix V, Response to SAG Comments on Draft Feasibility Study Report, South Basin Groundwater Protection Project, Operable Unit 2

1.1 Remedy Status

One of the U.S. Environmental Protection Agency's (USEPA) primary goals for any corrective action program is to expedite risk reduction through implementation of interim measures to control or minimize ongoing or potential threats to human health or the environment (USEPA, 2012). In many state and federal remedial programs, interim measures are used to address risks to human health or the environment in advance of final remedy selection (USEPA, 2012). The recommended Interim Measure Performance Standard includes:

1. Control, minimize, or eliminate releases(s) or potential release(s) that pose actual or potential threats to human health and the environment and,
2. To the extent practicable, be consistent with remedies that meet the remedy performance standard.

USEPA believes that the recommended performance standard for interim measures to "control, minimize or eliminate" covers the broad range of actions that might be needed at a site-specific level in the short term to address risk to human health and the environment during interim measures (USEPA, 2012). USEPA guidance states that interim measures should, to the extent practicable, be consistent with final remedies (USEPA, 2012). In choosing interim measures, the primary elements of what would be acceptable as a final remedy for the site, including preference for treatment of principal threats, should be considered in the design and application of interim remedial measures (IRMs). A variety of types of interim measures have been implemented (USEPA, 2012). In most cases, these measures, such as source removal, supply of alternate water supplies, plume containment or access controls, have been consistent with any final remedy and are an effective use of remedial resources (USEPA, 2012).

Another USEPA guidance document (USEPA, 1999a) describes when interim actions may be appropriate and states: "Reasons for taking an interim action could include the need to:

- Take quick action to protect human health and the environment from an imminent threat in the short term, while a final remedial solution is being developed; or
- Institute temporary measures to stabilize the site or operable unit and/or prevent further migration of contaminants or further environmental degradation."

The second bullet applies to OU2 IRMs.

In response to the State Water Board DFA comments on the FSISE, it is noted that Interim Remedial Actions do not include numeric cleanup goals as part of RAOs, nor do they provide an estimate for cleanup times (USEPA, 1991 and 1999). Comparing the anticipated relative durations of remedial operations, groundwater extraction and treatment (GET) and in-situ chemical oxidation (ISCO) would be similar and monitored natural attenuation (MNA) would be longer than either GET or ISCO. For Alternatives 2 through 6, it is expected that the IRMs will operate for at least several decades, so 30 years was used as a basis of the comparisons and cost estimates.

Consistent with the preceding USEPA guidance, OCWD intends to implement IRMs that will be consistent with any final remedy, if required. Conceptually, IRMs would be applied to OU2 groundwater and long-term groundwater monitoring would be performed as part of these actions. Five-year remedy reviews would be performed to track the progress and effectiveness of the interim remedy. The five-year remedy reviews also would evaluate the progress and effectiveness of the source site remedial efforts as they pertain to preventing off-property migration of COCs. Evaluation of the combined effectiveness both of the OU2 IRMs and the source site remedial efforts would provide the basis for determining if changes to the IRMs were warranted. A final remedy will likely incorporate restoration of groundwater for the COCs defined herein to the designated beneficial use, to the extent practical, which would be advanced by the selected alternative.

1.2 Background

The Study Area is an approximate five square mile area located in the south-central part of the roughly 300 square mile Basin located in Orange County, California (Figure 1-1). The SBGPP Study Area is located within the southeastern portion of the city of Santa Ana, the western portion of the city of Irvine, and the southwestern portion of the city of Tustin.

The SBGPP Study Area has a decades-long history of industrial operations at numerous individual source sites from which the release of chemicals has resulted in soil and groundwater contamination beneath and downgradient of the industrial sites (Figure 1-2). Plumes of groundwater contamination emanating from chemical releases at individual source sites within the Study Area have migrated away from their source areas and in many cases have commingled to form a broad expanse of groundwater contamination in the Shallow Aquifer System. These commingled plumes extend laterally downgradient in the direction of groundwater flow from north to south, over an area at least 2.5 miles in length and 1.2 miles in width from east to west (Aquilogic, 2015; H+A, 2020).

1.2.1 *Geologic and Hydrogeologic Framework*

The regional geologic and hydrogeologic framework for the Study Area was detailed as part of the Preliminary Remedial Investigation Report (Preliminary RI Report) and was summarized in the Supplemental Remedial Investigation (SRI) Report (Aquilogic, 2015; H+A, 2020). OCWD has divided the groundwater basin into three major aquifer systems based largely on geologic data and vertical potentiometric head differences between wells constructed at different depth intervals within the aquifer systems (Aquilogic, 2015; OCWD, 2015). From shallow to deep, the three aquifer systems are the Shallow Aquifer System, the Principal Aquifer System, and the Deep Aquifer System. Although individually identified, the aquifer systems are known to be hydraulically connected as groundwater flows between them by way of discontinuities in the aquitards or leakage through the intervening aquitards (OCWD, 2015).

First groundwater encountered within the Study Area occurs in the Shallow Aquifer System at depths as shallow as a few feet below land surface (bls). The heterogeneous mixture of sediments that comprise the Shallow Aquifer System within the Study Area extends from near land surface to depths ranging from about 83 feet bls in the south-central portion of the Study Area to about 162 feet bls in the north-central portion of the Study Area (Aquilogic, 2015; Avocet, 2018; H+A, 2020). In OU2, the Shallow Aquifer System is distinguished from the upper portions of the underlying Principal Aquifer System by variable thicknesses of generally finer-grained lower permeability sediments that tend to restrict, but do not preclude, hydraulic communication between the two aquifer systems. The Shallow and Principal Aquifer Systems are components of the Orange and Irvine Groundwater Management Zones which are defined in the Water Quality Control Plan for the Santa Ana River Basin (Basin Plan) (RWQCB, 2016). The Basin Plan designates beneficial uses for the Orange and Irvine Groundwater Management Zones, including the Domestic and Municipal (MUN) beneficial use.

The heterogeneous complex of unconsolidated sediments that comprise the Shallow Aquifer System within the Study Area is generally characterized by various thicknesses of interfingered layers, lenses, interbeds, laminations, and mixtures of clays, silts, sands, and gravels of varying lateral extents. The large- and small-scale spatial variability and juxtaposition of different lithologies reflects the dynamic non-uniform and occasionally punctuated alluvial, fluvial, and channel-fill depositional environments, and sedimentary and cross-cutting erosional processes that characterize the relatively young more-recent infill of the Shallow Aquifer System in this portion of the Basin (Piper and Garrett, 1953; Poland and Piper, 1956; Poland and Sinnott, 1959; Aquilogic, 2015; OCWD, 2015).

The overall thickness of the Shallow Aquifer System within the Study Area decreases from approximately 160 feet in the northern portion of the Study Area to approximately 80 feet in the southern portion of the Study Area (H+A, 2020). The Shallow Aquifer System is distinguished from the upper portions of the underlying Principal Aquifer System by a sequence of predominantly fine-grained aquitard material of variable thickness that in large part appears to be laterally continuous across the Study Area.

Based on detailed lithologic evaluation and Figures 5-17A through 5-17N in the SRI Report (H+A, 2020), the Shallow Aquifer System, with increasing depth, was subdivided into the following four layers:

- Layer 1: an uppermost fine-grained portion at and below the water table;
- Layer 2: a generally laterally continuous predominantly coarse upper sand zone;
- Layer 3: a mixed zone of sands and fine-grained materials; and
- Layer 4: a laterally continuous and relatively coarse-grained basal sand (Basal Sand).

SRI figures referencing the “Upper Portion of the Shallow Aquifer System” always include Layer 1, often include the upper portion of Layer 2, and sometimes include Layer 2 and the upper portion of Layer 3 depending on location within the Study Area; SRI figures referencing the “Lower Portion of the Shallow Aquifer System” correspond with Layer 4 (Basal Sand); and SRI figures referencing the “Middle Portion of the Shallow Aquifer System” often include all or the lower portion of Layer 2 and Layer 3, and sometimes include all or portions of Layer 3 depending on location within the Study Area.

The Basal Sand was encountered at depths ranging from about 67 feet bls in the southern portion of the Study Area, to about 128 feet bls in the northern portion of the Study Area (H+A, 2020). The thickness of the Basal Sand appears to range from about 9 feet in the southern portion of the Study Area, to about 62 feet in the northern portion of the Study Area (H+A, 2020).

1.2.2 *Surface Water*

The predominant surface water features in and around the Study Area are those that have evolved from earlier marshy areas, drainages, and channels that have been re-engineered over the years to form the current network of lined and unlined channels that ultimately drain southerly to San Diego Creek and southwesterly to Upper Newport Bay (Figure 1-3).

Based on comparison of the elevations of the channel bottoms with groundwater elevations in the upper portion of the Shallow Aquifer System, it appears that the base of some of the channels in the southern portion of the Study Area are below the water table within the Shallow Aquifer System. The base of the channels in the northern portion of the Study Area and the base of some of the channels in the southern portion of the Study Area are above the water table in the Shallow Aquifer System. In cases where the base of the channels is below the water table of the Shallow Aquifer System, there is potential for groundwater to flow from portions of the Shallow Aquifer System into the surface channels.

1.2.3 *Impacts to Groundwater in the Principal Aquifer System*

The occurrence, nature, magnitude, and extent of groundwater contamination in the Shallow Aquifer System being addressed as part of OU2 threatens water quality in the underlying Principal Aquifer System that is used extensively for domestic water supply. OCWD is addressing this threat by conducting an RI/FS in support of an interim remedy for OU2 groundwater contamination.

1.2.4 *Data Sources and Results of Prior Investigations*

This FS relies upon data, results and interpretations developed in the Preliminary RI Report (Aquilogic, 2015), and the SRI Report (H+A, 2020), as well as other Study Area investigators and regulatory authorities including, but not limited to, the U.S. Environmental Protection Agency (USEPA); the U.S. Geological Survey (USGS); the California Department of Water Resources (DWR); the CalEPA DTSC; the State Water Resources Control Board (SWRCB); the RWQCB, the Orange County Health Care Agency (OCHCA) acting as the Certified Unified Planning Agency (CUPA) for many of the cities and the county of Orange; OCWD; Irvine Ranch Water District (IRWD); and a host of individual source site investigators that have conducted or are conducting various source site groundwater assessment and remediation activities for responsible and potentially responsible parties at some, but not all, Study Area source sites.

1.2.5 *Water Supply Wells*

For the purposes of this document:

- Water supply wells incorporate the following classifications: Active Municipal Water Supply Wells; Inactive Municipal Water Supply Wells; Unknown Municipal Water Supply Wells; Active Water Supply Wells; Inactive Water Supply Wells; Inactive Other Water Supply Wells; Unknown Other Water Supply Wells; Abandoned Other Water Supply Wells; Destroyed Other Water Supply Wells; Historical Water Supply Wells (Mendenhall, 1905).
- Legacy Water Supply Wells incorporate the following classifications: Historical Water Supply Wells (Mendenhall, 1905); Unknown Other Water Supply Wells (WRMS); and Abandoned Water Supply Wells (WMRS).

Inventories for water supply wells in and adjacent to the Study Area indicate that numerous water supply wells have been installed since the latter half of the 1800s with the actual location and current status of many, if not most, of these wells remaining unknown (H+A, 2020). A 1904 USGS regional well survey (Mendenhall, 1905) included an inventory of more than 80 water supply wells located within and adjacent to the Study Area being used for irrigation, domestic, or stock purposes (Table 1-1). The majority of these water supply wells were located west of the former railroad alignment that is now the SR-55 corridor, south of Warner Avenue, and north of what is now MacArthur Boulevard. Water supply well locations provided as part of the USGS well survey have been digitized to illustrate their approximate locations relative to recognizable features within the Study Area (Figure 1-4). The USGS well inventory indicates that installation dates for this subset of water supply wells ranged from 1870 through 1904; those total depths ranged from 3 to 490 feet bls. The current status of these water supply wells is unknown.

The SRI Report provided an updated inventory of water supply wells located within and adjacent to the Study Area (H+A, 2020) (Table 1-2). The updated inventory indicated that the majority of the 52 additional water supply wells from the OCWD WRMS database are or were located along or west of the SR-55 corridor (Figure 1-4). It is possible that some of these 52 water supply wells were also identified in the 1904 USGS well survey. Well construction information provided for at least 39 of the water supply wells listed in the updated water supply well inventory indicated that these wells extended through the Shallow Aquifer System into the Principal Aquifer System. The status (and count) of the additional 52 water supply wells identified from the WRMS database has been characterized as: destroyed (9 wells); abandoned (18 wells); inactive (1 well); and of unknown status (24 wells).

Trichloroethylene (TCE), tetrachloroethylene (PCE), 1,1-dichloroethylene (1,1-DCE) and/or perchlorate have been detected in two active water supply wells, IRWD-3 and IRWD-5, and two water supply wells that have been properly destroyed and sealed (TIC-51R and TIC-91) (H+A, 2020).

1.2.5.1 Inactive Potable Water Supply Wells

There are two inactive potable water supply wells located within the Study Area along the SR-55 corridor south of Dyer Road (H+A, 2020) (Table 1-2) (Figure 1-4). Available water quality data for these water supply well indicated that low concentrations of TCE and 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113) were detected in groundwater samples collected from IRWD-51 in 1991 (H+A, 2020).

1.2.5.2 Active Water Supply Wells

There are seven[1] active water supply wells located within and adjacent to the Study Area (H+A, 2020) (Table 1-2; Figure 1-4) including:

Well ID	Owner/Operator	Status	Borehole Depth (Feet)	Well Use
IRWD-2	Irvine Ranch Water District	Active	1450	Municipal Supply
IRWD-3	Irvine Ranch Water District	Active	1309	Municipal Supply
IRWD-5	Irvine Ranch Water District	Active	1075	Municipal Supply
SA-26	Santa Ana	Active	1186	Municipal Supply
SAKI-SAJ3	Sakioka & Sons	Active	463	Irrigation
SCGC-I[1]	Southern California Gas Co.	Active	300	Cathodic Protection
SNDR-SA	Lakeside Partners Hutton, LLC	Active	1030	Irrigation
T-ED	Tustin	Active	1492	Municipal Supply

[1] Upon further evaluation by OCWD, this well, which was identified as an Industrial well in the FSISE, was determined to be a cathodic protection well.

Available water quality data for the active water supply wells within the Study Area were compiled from the OCWD WRMS database (H+A, 2020). PCE and perchlorate have been detected in potable water supply well IRWD-3 at above the respective drinking water maximum contaminant levels (MCL) (H+A, 2020). There was also depth specific sampling conducted inside the well casing of IRWD-3 in 2008 and 2009 (H+A, 2020). TCE and PCE were detected at concentrations below the drinking water MCL throughout the entire static water column in July 2008 and were detected in most of the samples collected in May 2009.

1.3 Consistency with the National Contingency Plan

OCWD is conducting the SBGPP RI/FS in cooperation with DTSC and RWQCB to develop an interim remedy or remedies to address chemical contaminants that have impacted groundwater in OU2 (OU2 is groundwater contamination in the Shallow Aquifer System off-property of numerous groundwater contamination source sites located within the SBGPP Study Area where groundwater contaminant plumes emanating from individual source sites have migrated and commingled), and to do so in a manner consistent with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 Code of Federal Regulations [CFR], Part 300), commonly referred to as the National Contingency Plan or NCP.

To ensure consistency with the NCP, methods and procedures used as part of this RI/FS process are intended to be in general conformance with relevant guidelines and procedures recommended by federal, state, and local government agencies and regulatory authorities, including USEPA, DTSC, and RWQCB. Where appropriate, guidelines and procedures specified by the American Society for Testing and Materials (ASTM), the American Society of Civil Engineers (ASCE), and the National Ground Water Association (NGWA) have been used.

Other principal elements of the NCP include guidelines and standards for quality assurance/ quality control (QA/QC) for data acquisition, and public participation to ensure stakeholder and community involvement in the decision-making process for implementation of appropriate remedy controls.

1.4 Nature and Extent of Contamination

For the purposes of this FS, the nature and extent of contamination is based on prior analyses presented in the Preliminary RI Report and SRI Report, and further clarified herein (Aquilogic, 2015; H+A, 2020).

The SRI Report (H+A, 2020) identified TCE, PCE, 1,1-DCE, 1,4-dioxane, and perchlorate as principal Compounds of Potential Concern (COPCs). Other organic and inorganic compounds that have been detected in Study Area Shallow Aquifer System groundwater were generally detected less frequently, less broadly distributed, and occur at lower concentrations within the footprints of the principal COPC plumes (H+A, 2020).

The SRI included contaminant distribution (commingled plumes) maps for each of the principal COPCs using the most recent data collected from a variety of groundwater sample locations. The location and general dates of groundwater samples collected have been compiled (Figure 1-5). The plume maps prepared as part of the SRI illustrated the occurrence, magnitude, and extent of the principal COPCs for two depth intervals within the OU2: the upper portion of the Shallow Aquifer System to depths within 60 feet of land surface (Layer 1, in some areas extends into the upper portion of Layer 3) and the middle portion of the Shallow Aquifer System at depths greater than 60 feet to depths near the top of the Basal Sand (all or portions of Layers 2 and 3, depending on area) (Figures 1-6 through 1-15 of the FSISE).

As discussed and agreed upon with the RWQCB and the State Water Board DFA during the April 7, 2021 meeting (EA, 2021c), this FS includes additional evaluation and illustration of the stratigraphic layers 1 through 4 as presented in Section 1.2.1 of the FSISE and in the SRI Report cross sections (SRI Figures 5-16 through 5-17N). Figures 1-6 through 1-25 and 1-27 through 1-39 illustrate revised plan-views of COCs in OU2 groundwater classified into Layers 1 through 4, and Appendix A provides details on the data and methods that were used to prepare these figures. COC figures for 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), and 1,1,2-trichloroethane (1,1,2-TCA) were not prepared for this document, since the frequencies of detection and/or relative concentrations of these COCs were low, and the distributions of these COCs are encompassed by the distributions of COCs illustrated herein. During the April 7, 2021 meeting, it was agreed that the FS would include figures illustrating color-coded symbols classified by concentration ranges ('color dot maps') for each COC, for each of Layers 1 through 4.

1.5 Conceptual Site Model

The conceptual site model was described in the SRI and included a discussion of the nature and extent of contamination, sources of contamination, contaminant fate and transport, and potential exposure and receptor pathways (H+A, 2020).

There are numerous contaminant source areas within the Study Area. Some of the volatile organic compound (VOC) source sites contain dense non-aqueous phase liquid (DNAPL) or residual DNAPL (Aquilogic, 2015) that will continue to act as long-term sources of contamination to off-property groundwater if not contained or removed. Most, if not all, of the source areas are decades old. Given the heterogeneous mix of sediments, with a relatively high proportion of fine-grained sediments, matrix back diffusion from source areas can also serve as a prolonged source of elevated concentrations of COCs from source properties to downgradient off-property locations (Environmental Security Technology Certification Program, 2012; Sale et al., 2013; Stroo et al., 2012; Chapman and Parker, 2005; Seyedabbasi et al., 2012). There is no known or suspected DNAPL in OU2, as OU2 is defined in this document, and identification of DNAPL boundaries are part of the source site remedies.

Remediation of source areas is expected to be conducted by potential responsible parties in tandem with the interim remedy resulting from this RI/FS.

The potential for vapor intrusion of VOCs from source areas and from OU2 groundwater is not part of this RI/FS and to the extent that these pathways pose a risk to human health, they are expected to be addressed by potentially responsible parties and are not further discussed in this document.

Advection of COCs in OU2 groundwater is anticipated to be the predominant transport process, primarily through coarser zones. Legacy Water Supply Wells in the Study Area may also act as conduits for the transport of groundwater containing COCs from the Shallow Aquifer System downward into the underlying Principal Aquifer System. In the southern portion of the Study Area, some portion of COCs in groundwater in the upper portion of the Shallow Aquifer System has migrated to surface water channels that extend below the water table (Harding Lawson Associates, 2000). Groundwater elevation data indicate that, if unabated COCs in OU2 will expand and continue to flow in a southerly direction beyond the Study Area.

Diffusion processes in areas downgradient of source properties are expected to slow COC migration by transferring mass from primary transport zones within the coarse intervals to the surrounding finer grained material. Over time, however, back diffusion from the finer grained intervals back into coarse intervals is expected to prolong conditions that result in elevated COPC concentrations in groundwater.

It is expected that sorption to aquifer solids may retard the migration of TCE/PCE and to a lesser extent 1,1-DCE relative to the rate of groundwater flow. The compound 1,4-dioxane, however, is not expected to experience significant sorption/retardation due to its low sorption potential (Air Force Center for Engineering and the Environment, 2008). In addition, perchlorate and hexavalent chromium (Cr6) sorption are expected to be relatively insignificant.

Given the extent and concentrations of TCE, PCE, 1,1-DCE and 1,4-dioxane detected in groundwater downgradient of source area properties, it is expected that intrinsic biodegradation is not a dominant process affecting these OU2 COCs.

The potential for hydrolysis of the principal COPCs is expected to be low, with the exception of the abiotic transformation of 1,1,1-trichloroethane (1,1,1-TCA) to 1,1-DCE.

Intrinsic oxidation/reduction of VOCs and 1,4-dioxane are not expected to be dominant processes; however, Cr6 can be reduced in areas where reducing conditions naturally occur.

Unrestricted domestic use of groundwater within the Shallow Aquifer System could result in ingestion, dermal, and inhalation exposure to consumers. These pathways and exposures are considered as part of the human health and ecological risk assessment (HHERA) discussed below (H+A, 2020; TFG, 2020). Migration of COCs from the Shallow Aquifer System to the Principal Aquifer System through Legacy Water Supply Wells can also result in a similar exposure pathway. Although not evaluated in the HHERA, it is possible that the detections of COCs in IRWD-3 were a result of this process. IRWD-3 was put on standby status with the detection of COCs. Migration of COCs from the upper portion of the Shallow Aquifer System to surface water channels is another potential exposure pathway that was evaluated as part of the revised HHERA summarized in the following subsection.

1.6 Human Health and Ecological Risk Assessment

A HHERA was conducted to support the RI/FS (H+A, 2020; TFG, 2020). The HHERA incorporated response to comments from, and subsequent discussions with, the RWQCB and the Office of Health Hazard Assessment (OEHHA). The HHERA quantified potential risks associated with residential and ecological exposure to contaminants in groundwater. Specifically, the receptors evaluated included a residential child, residential adult, freshwater and saltwater aquatic plants, aquatic invertebrates, and fish. Evaluation of the potential for vapor intrusion was not part of the HHERA and to the extent that this pathway poses a potential risk to human health, it is expected to be addressed by potentially responsible parties. The HHERA was conducted as a "baseline risk assessment" in that it evaluated potential current risks in the absence of an interim groundwater remedial action to address the commingled plumes downgradient of the source sites.

Risk values in the HHERA were quantified for 126 COPCs and chemicals of potential ecological concern (COPECs). The human health risk values were based on exposure to COPCs associated with inhalation, dermal contact while showering, and ingestion. The ecological risk values were based on exposure of freshwater and saltwater aquatic plants, aquatic invertebrates, and fish to the COPECs in surface water bodies (San Diego Creek and Newport Bay).

1.6.1 *Potential Human Health Risk*

The 58 COPCs identified in the HHERA that exceeded exposure point concentrations (EPCs) follow:

COPC	ILCR $>10^{-6}$	HQ >1	COPC	ILCR $>10^{-6}$	HQ >1
1,1,1,2-Tetrachloroethane	X		Ethanol		X
1,1,2-Trichloroethane (1,1,2-TCA)	X	X	Ethylbenzene	X	
1,1-Dichloroethane (1,1-DCA)	X		Fluoride		X
1,1-Dichloroethene (1,1-DCE)		X	Gasoline Range Organics		X
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	X		Heptachlorodibenzofurans (HpCDF)	X	
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	X		Heptachlorodibenzo-P-dioxins (HpCDD)	X	
1,2,3,6,7,8-Hexachlorodibenzo-P-dioxin (HxCDD)	X		Hexachlorodibenzofurans (HxCDF)	X	
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	X		Hexachlorodibenzo-P-dioxin (HxCDD)	X	
1,2,3,7,8,9-Hexachlorodibenzo-P-dioxin (HxCDD)	X		Hydrogen Sulfide		X
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	X		Manganese		X
1,2,3,7,8-Pentachlorodibenzo-P-dioxin (PeCDD)	X		Mercury		X
1,2,3-Trichloropropane (1,2,3-TCP)	X	X	Naphthalene	X	X
1,2,4-Trimethylbenzene		X	N-Nitrosodiethylamine	X	
1,2-Dibromoethane (EDB)	X		N-Nitrosodimethylamine	X	
1,2-Dichloroethane (1,2-DCA)	X	X	p-Bromofluorobenzene		X
1,4-Dioxane	X	X	Pentachlorodibenzofuran (PCDF)	X	
2,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	X		Pentachlorodibenzo-P-dioxin (PCDD)	X	
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	X		Perchlorate		X
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	X		Perfluorooctanoic acid	X	
Arsenic	X	X	PFOA + PFOS	X	
Benzene	X	X	Tetrachlorodibenzofuran (TCDF)	X	
Bromate	X		Tetrachloroethene (PCE)	X	X
Bromodichloromethane	X		Thallium		X
Carbon tetrachloride	X		Toluene		X
Chloroform	X		Total Petroluem Hydrocarbons - Diesel		X
Chromium (Hexavalent)	X	X	Total Petroleum Hydrocarbons - Volatile Organics		X
cis-1,2-Dichloroethene (cis-1,2-DCE)		X	Total Petroluem Hydrocarbons - Gasoline (TPH-g)		X

COPC	**ILCR $>10^{-6}$**	**HQ >1**	**COPC**	**ILCR $>10^{-6}$**	**HQ >1**
Dichloromethane	X	X	Trichloroethylene (TCE)	X	X
Diesel Range Organics		X	Vinyl Chloride	X	X

Notes:
COPC = Compound of Potential Concern
ILCR = Incremental Lifetime Cancer Risk
HQ = Hazard Quotient
> = Greater Than

Of the COPCs with ILCR values above 10^{-6} and/or HQ values above 1, the COPCs were grouped into the following broad categories:

- OU2 contaminants of concern identified for the source sites as presented in the Preliminary RI Report (Aquilogic, 2015). These chemicals are known to be related to source site operations and consist of the following:
  - TCE
  - PCE
  - 1,1-DCE
  - 1,4-Dioxane
  - Perchlorate
  - Cr6
  - Vinyl chloride
  - 1,1-DCA
  - 1,2-DCA
- Compounds that are generally associated with and/or are breakdown products of source site contaminants of concern and that were detected in more than 1 percent of the samples. These chemicals are likely related to source site operations and consist of the following:
  - cis-1,2-DCE
  - 1,1,2-TCA

The remaining COPCs were not retained as COCs, based on the following criteria:

- Did not appear to be related to sites (for example, dioxins, per- and polyfluoroalkyl substances [PFAS], and fluoride);
- Exposure point concentrations were less than estimated background concentrations presented in the SRI (for example, arsenic, mercury, and thallium);
- Were not persistent (for example fuel related compounds);
- Had two or fewer detections or were detected in a limited number of sampling locations (for example, bromate, hydrogen sulfide, N-nitrosodimethylamine [NDMA], and N-nitrosodiethylamine); and/or

- Can be affected by redox potential due to natural conditions or remediation induced conditions (manganese).

Based on the preceding, the following were designated as OU2 groundwater COCs, and are further evaluated herein:

- TCE
- PCE
- 1,1-DCE
- 1,4-Dioxane
- Perchlorate
- Cr6
- Vinyl chloride
- 1,1-DCA
- 1,2-DCA
- cis-1,2-DCE
- 1,1,2-TCA

In their March 25, 2021 letter to OCWD, the RWQCB requested explanation of why Freon-113, which has been detected in groundwater at concentrations above its maximum contaminant level (MCL) for drinking water in at least one source site within the Study Area, was not listed as a OU2 groundwater COC for further evaluation. As directed by the OEHHA, the 95-percent upper confidence limit (UCL) of the mean concentration in groundwater (95% UCL) for each COPC was the assumed exposure point concentration (EPC) in the Revised HHERA (TFG, 2020). The 95% UCL for Freon-113 is 169.2 micrograms per liter (ug/l), which is below the Freon-113 drinking water MCL of 1,200 ug/l. Therefore, Freon-113 was not listed as an OU2 groundwater COC for further evaluation.

Additionally, the District and the TAC discussed the potential to monitor groundwater for PFAS as part of the Pre-Design Investigation (PDI) and/or potentially as part of the selected IRM (Appendix S). PFAS monitoring would be required for alternatives that rely on Waste Discharge Requirement (WDR) Orders and it is expected that some PFAS monitoring will be conducted as part of PDI and part of groundwater extraction discharge monitoring.

1.6.2 *Potential Ecological Risk*

The ecological risk assessment (ERA) portion of the HHERA identified 80 COPECs with freshwater toxicity benchmarks (TBs) and 49 COPECs with saltwater TBs. Calculation of hazard ratio (HR) values using 95-percent upper confidence limits and TBs resulted in 36 COPECs exceeding the target HR of 1 for freshwater and 19 COPECs exceeding the target HR of 1 for saltwater. The ERA likely overstated the magnitude of potential ecological risk, largely due to the absence of any adjustments to exposure concentrations based on dilution of groundwater with surface water. The ERA assumed that ecological receptors are exposed directly to COPEC concentrations measured in groundwater when in fact COPEC concentrations in groundwater are expected to be reduced significantly through mixing; volatilization for volatile COPECs; and aerobic degradation of vinyl chloride, 1,2-DCA and possibly 1,1-DCE and cis-1,2-DCE. These mechanisms are expected to further decrease COPEC concentrations with downstream flow toward and into Newport Bay. Collection of surface water monitoring data for those COPECs with HR values exceeding 1 would allow for refinement of the ERA results and thus reduce the degree of uncertainty related to the use of groundwater data in the ERA.

Volatile COPECs are assumed to volatilize in surface water over relatively short distances and time periods after entering such systems. Therefore, the potential ecological risks for volatile COPECs in groundwater that could impact surface water receptors were screened from further evaluation. The remaining non-volatile COPECs were grouped into the following categories:

- Groundwater contaminants of concern identified for the source sites as presented in the Preliminary RI Report (Aquilogic, 2015). Cr6 is the only non-volatile COPEC known to be related to site operations.
- The remaining COPECs were not retained as COCs and fell into the following categories:
    - Exposure point concentrations were less than estimated background concentrations presented in the SRI (for example, arsenic, boron, copper, Endosulfan I, mercury, nickel, nitrate, selenium, and silver);
    - Were not persistent (for example fuel related compounds);
    - Had two or fewer detections (hydrogen sulfide);
    - Metals with low mobility (cadmium, cobalt, and lead); and/or
    - Can be affected by redox potential due to natural conditions or remediation induced conditions (iron and manganese).

Based on the preceding, Cr6 is the only designated OU2 groundwater COC for the surface water receptor pathway.

2.0 REMEDIAL ACTION OBJECTIVES

The RAO recommendations for the groundwater IRMs are to protect human health and the environment with respect to the COCs that have migrated from multiple source properties and have commingled in the SBGPP Study Area, forming a large, dissolved contaminant plume. Protection of human health is accomplished by preventing human ingestion of groundwater containing COCs exceeding MCLs/risk-based standards, and protection of the environment is accomplished by decreasing further degradation of the groundwater resource due to plume expansion and maintaining surface water COC concentrations to levels that are protective of potential ecological receptors.

Specific recommended RAOs for IRMs within the SBGPP Study Area are to:

1. Protect groundwater resources from further degradation by preventing lateral and vertical migration of high concentration COCs into zones with lower concentrations of COCs within OU2, to the extent practicable;
2. Protect groundwater resources by preventing the potential for vertical migration of high concentration COCs from the upper/middle portions of the Shallow Aquifer System to the Principal Aquifer System through Legacy Water Supply Wells, to the extent practicable;
3. Protect groundwater resources from further degradation by preventing the spread of COCs exceeding MCLs in the Leading-Edge areas of the plume, to the extent practicable;
4. Implement a reliable interim groundwater remedy(s) that is compatible with ongoing and planned remediation at source sites and associated off-property locations, where applicable;
5. Prevent discharge of COCs exceeding ecological risk-based concentrations from the Shallow Aquifer System to surface water channels; and
6. Prevent human exposure to contaminated groundwater with COC concentrations exceeding MCLs or other ARARs.

Figure 2-1 illustrates source sites with current or currently planned groundwater extraction and treatment systems. Figure 2-2 illustrates source sites with current or planned in-situ remediation programs.

The selected IRMs must achieve the RAOs and must be compatible with ongoing and currently planned remediation at source sites and off-property locations, where applicable. In order to be compatible with remediation at source sites, the IRMs would be implemented to avoid substantially negatively affecting groundwater quality or groundwater velocity/flow/capture conditions or treatment areas at and near source sites with ongoing or planned remedial actions as follows:

- For in-situ technologies, generation of byproducts detrimental to source site remedial efforts will be avoided.

- For groundwater extraction and treatment, significantly increasing groundwater velocities beneath and near the source sites and/or significantly negatively affecting their capture/treatment areas will be avoided.

Based on the ongoing or planned source site remedial efforts, Figures 2-3 through 2-5 illustrate the approximate areas of OU2 targeted for IRMs.

As described in the preceding section, COCs identified at source sites at concentrations exceeding MCLs and/or risk-based standards that are designated as OU2 COCs include:

- TCE
- PCE
- 1,4-Dioxane
- Perchlorate
- Cr6
- Vinyl chloride
- 1,2-DCA
- 1,1-DCE
- cis-1,2-DCE
- 1,1,2-TCA

Cr6 was the only COC identified at source sites at concentrations exceeding ecological risk-based standards that is designated as an OU2 COC.

3.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Potential federal and State of California ARARs have been identified and evaluated from the universe of regulations, requirements, and guidance for the SBGPP. Under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulations, a remedial action must achieve ARARs, unless a waiver is granted. The ARARs can be defined as standards, requirements, criteria or limitations under federal (or if more stringent, state) environmental laws as they relate to onsite remedial actions. In the context of this evaluation of ARARs "onsite" includes the areal extent of contamination and all suitable areas near the contamination necessary for implementation of the response action (40 CFR, Part 300.5). For CERCLA sites, onsite actions must comply with the substantive aspects of ARARs. Since the SBGPP is not a CERCLA site, onsite and offsite actions must comply with applicable local, state, and federal requirements. As defined in the SRI (H+A, 2020) and herein, OU2 is groundwater contamination in the Shallow Aquifer System off-property of numerous groundwater contamination source sites located within the SBGPP Study Area where groundwater contaminant plumes emanating from individual source sites have migrated and commingled. Thus, the term "onsite" in relation to "actions that must comply with applicable local, state, and federal requirements" includes all of OU2.

In some situations, ARARs may not be available or adequately address protection of human health and the environment. Where ARARs do not sufficiently address a situation, to-be-considered (TBC) criteria (e.g., non-promulgated advisories, criteria, guidance, or proposed standards) issued by federal and state agencies can be used to define cleanup and/or performance standards (40 CFR Part 300.400[g][3]). These TBC criteria are not ARARs; they are not enforceable, nor are they legally binding, unless that TBC criterion is adopted as a cleanup or performance standard in the Statement of Basis or applicable permit to construct or operate the Interim Remedy.

The ARARs, in conjunction with the overall protection of human health and the environment criterion, form the threshold criteria to evaluate remedial alternatives when selecting a remedial action. This evaluation includes an initial determination of whether the potential ARARs actually qualify as ARARs, and a comparison for stringency between the federal and state regulations to identify the controlling ARARs. The identification of ARARs is an iterative process. The final determination of ARARs will be made in the Statement of Basis, after public review, as part of the remedial action selection process. Therefore, the ARARs and TBCs identified are considered preliminary.

The ARARs presented in the FSISE have been revised to incorporate comments received from the RWQCB (RWQCB, 2018). The revised ARARs are provided in Appendix B.

4.0 GENERAL RESPONSE ACTIONS, REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

This section describes General Response Actions (GRAs) likely to achieve RAOs and remedial technologies/process options that can be used to implement GRAs. GRAs are selected to satisfy the RAOs for each medium of concern, in this case OU2 groundwater. These actions, initially defined during scoping, are refined during the feasibility study (FS) phase and relate to basic methods of protection such as treatment or containment (USEPA, 1988 and 1989).

In the RI/FS process, the term “technology” refers to general categories of technologies, such as chemical treatment or capping. The term “technology process option” refers to specific alternative processes within each technology family, such as ion exchange or use of a soil clay cap. A list of potentially applicable technologies and technology process options, corresponding to the identified general response actions, is compiled and then reduced by evaluating the process options with respect to technical implementability (USEPA, 1989). That is, existing information on technologies and site characterization data are used to screen out process options that cannot be effectively implemented at a given site.

To simplify the development and evaluation of alternatives, one representative process option should be selected, if possible, for each technology type remaining after the technical implementability screening procedure (USEPA, 1989). Effectiveness, implementability, and cost are the criteria used to evaluate and select representative process options (USEPA, 1989).

4.1 General Response Actions

GRAs are medium-specific response categories that are likely to satisfy the RAOs as defined by USEPA guidance (USEPA, 1988 and 1989). GRAs and associated remedial technologies for OU2 groundwater are summarized below and further described in the following subsections.

- No Action
- Institutional Controls
- Monitoring
- Containment
    - Groundwater Extraction
    - Physical Barriers
- Ex-Situ Treatment Cleanup Actions
    - Extracted Groundwater Treatment
    - Treated Water Discharge or End Use Process Options
- In-Situ Treatment Cleanup Actions
    - Monitored Natural Attenuation
    - Active In-Situ Bioremediation

- Chemical Processes
- Thermal Processes
- Physical Processes

There are commingled groundwater plumes within the SBGPP (Aquilogic, 2015; H+A, 2020). Source removal and/or source control remedial technologies at many, but not necessarily all, source sites have been or are expected to be implemented in accordance with agency approved plans. In addition, some potentially responsible parties have implemented active groundwater remediation at locations off of their respective properties in accordance with agency approved plans. While some of the source sites have implemented, are implementing, or have submitted plans to implement remedial actions to contain or treat groundwater contamination beneath or near their properties, many of these releases have not been confined to each individual source property but have in fact migrated off-property and commingled with contaminant plumes from multiple other individual source sites. It is these commingled plumes that are not subject to previous, ongoing, or planned source site remediation that will be the subject of the proposed OU2 IRMs (Figures 2-3 to 2-5).

For the purposes of this FS, source removal and/or source control remedial technologies applied at individual source sites were not included as GRAs in the FSISE and are not included herein, since these efforts are assumed to be implemented by specific potentially responsible parties under the oversight of state agencies. In addition, containment and/or treatment zones downgradient of source sites, which are being or will be implemented in a timely manner in accordance with agency plans are likewise not included in applicable GRAs in this FS. The detailed analysis of alternatives presented in subsequent sections of this FS does consider existing and planned source removal and/or source control remedial technologies along with source site on- and off-property containment and/or treatment zones.

4.1.1 *No Action*

Under this option, no active groundwater remediation measures including monitoring, institutional controls, or sealing of Legacy Water Supply Wells would be implemented in OU2. This alternative is required by the NCP and CERCLA to provide a baseline for comparison with the risk reduction achieved by other alternatives.

4.1.2 *Institutional Controls*

Institutional controls are non-engineered instruments such as administrative and legal controls that help minimize the potential for human exposure to contamination and/or protect the integrity of the remedy. Institutional controls play an important role in site remedies because they reduce exposure to contamination by limiting land or resource use and guide human behavior. Institutional controls are appropriate during all stages of the cleanup process to accomplish various cleanup-related objectives. To provide overlapping assurances of protection from contamination, institutional controls should be "layered" (i.e., use of multiple institutional controls) or implemented in a series.

4.1.3 *Monitoring*

Groundwater monitoring comprises the periodic measurement of physical and/or chemical parameters to evaluate whether a remedy is performing as expected. Performance monitoring is conducted to evaluate whether the interim remedy is making progress toward achieving short-term protection goals or intermediate performance goals.

4.1.4 *Containment*

Containment uses groundwater extraction or physical barriers to hydraulically contain groundwater contaminants and to recover contaminants from the subsurface. Containment keeps contaminants from reaching drinking water supply wells, wetlands, streams, and other natural resources (USEPA, 2012 and 2020a).

4.1.5 *Ex-Situ Groundwater Cleanup*

Ex-situ groundwater cleanup applies physical, chemical, or biological treatment to extracted groundwater prior to discharge. Potential treated water discharge or end uses for OU2 include:

- Injection;
- Discharge to storm drain;
- Discharge to a publicly owned treatment works (POTW) and the groundwater replenishment system (GWRS); or
- Non-potable reclaimed water discharge.

4.1.6 *In-Situ Groundwater Cleanup*

In-situ treatment occurs when groundwater is treated in place without extraction from the aquifer. In-situ treatment technologies can destroy, immobilize, or remove contaminants.

4.2 Identification of Remedial Technologies and Process Options

Process options for remedial technologies identified for OU2 include:

General Response Action	Remedial Technology/Treated Water Discharge or End Use	Process Option
No Action	None	None
Institutional Controls		Water Well Permit, Notification, Design and Coordination Requirements
		Notifications to Potential Receptors of Risk
Monitoring	Groundwater Monitoring	Remediation Monitoring
Containment	Groundwater Extraction	Groundwater Extraction Wells, Trenches
	Physical Barriers	Slurry Walls, Grout Curtains, Sheet Piling, Sealing Legacy Water Supply Wells
Ex-Situ Groundwater Cleanup	Extracted Groundwater Treatment	Air Stripping
		Liquid-Phase Granular Activated Carbon (LGAC) Adsorption
		Biological Liquid-Phase Granular Activated Carbon (Bio-LGAC) Adsorption
		Advanced Oxidation Process
		Ion Exchange
		Biological Treatment
		Membrane Processes (Reverse Osmosis, Nanofiltration, etc.)
		Evaporation / Condensation
	Treated Water Discharge or End Use Options	Injection
		Storm Drain
		POTW and GWRS
		Non-Potable Reclaimed Water
In-Situ Groundwater Cleanup	In-Situ Groundwater Treatment	Monitored Natural Attenuation
		Active In-Situ Bioremediation
		Chemical Processes
		Thermal Processes
		Physical Processes

POTW = publicly owned treatment works
GWRS = OCWD's Groundwater Replenishment System and Advanced Wastewater Purification Facility

5.0 SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

The following subsections describe the screening criteria that were applied to screen the identified remedial technologies and process options. Consistent with USEPA guidance effectiveness, implementability, and cost are the criteria used to evaluate and select representative process options (USEPA, 1989).

5.1 Effectiveness

Effectiveness is a measure of the ability of an option to: (1) reduce toxicity, mobility, or volume; (2) minimize residual risks; (3) afford long-term protection; (4) minimize short-term impacts; and (5) achieve protectiveness goals and meeting IRM RAOs. Technologies that offer significantly less effectiveness than other proposed technologies are screened from further consideration. Options that do not provide adequate protection of human health and the environment likewise are screened from further consideration.

5.2 Implementability

Implementability is a measure of the technical feasibility and availability of the option and the administrative feasibility of implementing it (e.g., obtaining access to private properties and/or public right-of ways [ROWs]). Options that are technically or administratively infeasible or that would require equipment, specialists, or unavailable access to private properties, or would not be available within a reasonable period were screened from further consideration. One critical implementability component considered in the FSISE and herein is compatibility of process options and treatment technologies with remediation that is ongoing or currently planned at source sites.

5.3 Relative Cost

Relative qualitative costs for implementing the remedial technologies and process options are considered. Technologies that cost more to implement, but that offer no benefit in effectiveness or implementability over other technologies, were screened from further consideration. The TAC requested a sensitivity analysis to assess the variations in specific assumptions associated with design, implementation, operation, discount rate, and the effective life an alternative can have on the costs estimated, and this item was discussed during a December 1, 2021 meeting between representatives of the TAC, OCWD, and EA (Appendices Q, S, and T). It was agreed that a sensitivity analysis would not add substantial value to the FS and that the relative cost estimates and comparisons in this document are not intended to develop or support reserve estimates. The cost estimate(s) for selected Alternative(s) will be refined after pre-design investigation (PDI) data collection and at different phases of the design process.

5.4 Screening of Remedial Technologies and Process Options

Screening of remedial technologies and process options are summarized in Table 5-1 and discussed in the following subsections.

5.4.1 *No Action*

This alternative is required by the NCP (40 CFR Part 300.430) and CERCLA (USEPA, 1988 and 1989) to provide a baseline for comparison with the risk reduction achieved by other alternatives and will not be part of any identified remedial alternative (Table 5-1).

5.4.2 *Institutional Controls*

The properties overlying OU2 groundwater subject to planned IRM(s) are owned by many entities. Therefore, obtaining property deed/land use restrictions preventing the use of groundwater for properties overlying OU2 groundwater is not feasible and will not be part of any identified remedial alternative (Table 5-1). However, an institutional control requiring any party proposing the installation and operation of water supply wells in the Study Area to apply for a well construction permit from the OCHCA is currently in place as a County ordinance. An additional institutional control that is feasible for implementation is notification of OCWD, RWQCB, DTSC and water suppliers in the Study Area by OCHCA of any water supply well construction permit applications. Such notification would allow communication between the agencies and the applicant with the goals of preventing human exposure to COCs and avoiding interference with OU2 IRMs and source site remedial measures. Institutional control measures would be developed and administered as part of OU2 IRMs. Similar institutional controls have been successfully implemented as part of the remedy for groundwater contamination from former Marine Corps Air Station El Toro.

<u>Effectiveness</u>
Effectiveness is considered relatively low (Table 5-1).

<u>Implementability</u>
Implementability is considered relatively high, with the effectiveness limitations noted in Table 5-1.

<u>Cost</u>
Cost is considered relatively low (Table 5-1).

<u>Screening Determination</u>
Institutional controls are retained as a GRA as part of all remedial alternatives, except the No Action Alternative.

5.4.3 *Monitoring*

Some form of groundwater monitoring in accordance with applicable plans, permits, and/or Orders will be required for all retained GRAs and remedial alternatives, except the No Action Alternative.

Long-term groundwater monitoring is a component of containment and in-situ GRAs. Groundwater monitoring also will generate data used to:

- Evaluate contaminant plume migration and provide continuing tracking and interpretation of the distributions of COCs in OU2 groundwater;
- Expand and refine the groundwater monitoring network, if and as required;

- Evaluate and optimize remediation system performance;
- Identify enhancements to or expansion of remediation systems and/or additional areas targeted for groundwater remediation, if necessary; and
- Support additional computer flow modeling evaluations during IRMs application, to the extent implemented.

For the treated groundwater injection discharge option (Section 5.4.6.1), specific groundwater monitoring would be identified in the RWQCB WDR Order Monitoring and Reporting Program (M&RP) that would be obtained for this option.

Long-term monitoring will be performed on a periodic frequency, depending on the objective of the specific monitoring program and the maturity of remedy implementation. The long-term groundwater monitoring network will consist of existing and new wells that will be installed as part of the OU2 IRMs. Groundwater monitoring reports will be prepared and submitted in accordance with the requirements of applicable plans, permits, and/or Orders. The monitoring program will include analysis of COCs. A detailed long-term monitoring program for the selected remedial alternative will be developed as part of the remedial design.

<u>Effectiveness</u>
Effectiveness is considered relatively low (Table 5-1).

<u>Implementability</u>
Implementability is considered relatively high (Table 5-1).

<u>Cost</u>
Cost is considered relatively moderate (Table 5-1).

<u>Screening Determination</u>
Monitoring is retained as a GRA as part of all remedial alternatives, except the No Action Alternative.

5.4.4 ***Containment***

Remedial technologies associated with containment, including groundwater extraction and physical barriers, are described in the following subsections.

5.4.4.1 Groundwater Extraction

Containment uses groundwater extraction or physical barriers to hydraulically contain groundwater contaminants and to recover contaminants from the subsurface. Groundwater extraction and treatment, also commonly referred to as pump and treat, has been widely used in the remediation industry for decades, offering the combined advantages of hydraulic containment of contaminant plumes while also recovering contaminants from the subsurface for ex-situ treatment (Air Force Civil Engineer Center and United States Army Corps of Engineers, 2017). The USEPA (2012 and 2020a) describe that pump and treat (P&T):

> "is a common method for cleaning up groundwater and other aqueous media contaminated with dissolved chemicals, including industrial solvents, metals, and fuel oil. Water is

> extracted and conveyed to an above-ground treatment system that removes the contaminants. P&T systems also are used to 'contain' the contaminant plume. Containment of the plume keeps [the plume] from spreading by pumping contaminated water toward the wells. This pumping helps keep contaminants from reaching drinking water wells, wetlands, streams, and other natural resources."

Groundwater pump and treat is the selected GRA at approximately 20 percent of Superfund sites (USEPA, 2020a) and has been and continues to be applied at hundreds of sites in California (DWR, 2016).

Containment would be applied to OU2 to control or limit the lateral and vertical migration of the existing commingled contaminant plumes. The process option for OU2 groundwater containment is groundwater extraction wells or trenches. Groundwater trenches would extract groundwater from only the upper portion of Layer 1. Groundwater extraction wells would extract groundwater from all or portions of Layers 1 through 3. Groundwater trenches and/or extraction wells placed at selected (optimized) locations could provide hydraulic control of groundwater migrating laterally downgradient in the Shallow Aquifer System or vertically into the Principal Aquifer System.

<u>Effectiveness</u>
Containment using groundwater extraction is an effective and common method of remediating contaminated groundwater and in 2016, approximately 800 sites in California used pump and treat systems as a GRA (DWR, 2016). The DWR stated that, "Most groundwater extraction and treatment remediation systems are located at sites where volatile organic compound (VOC) solvents, such as trichloroethylene (TCE) and PCE, have contaminated groundwater".

A potential challenge associated with containment in OU2 includes the difficulty in reversing the vertical hydraulic gradients in the vicinity of Legacy Water Supply Wells. While extraction of contaminated groundwater from the Shallow Aquifer System would reduce the vertical hydraulic gradient between the Shallow Aquifer System and the Principal Aquifer System in the vicinity of the extraction wells, it would be impractical to extract a sufficient quantity of groundwater from the Shallow Aquifer System to fully overcome the vertical hydraulic gradients between the Shallow Aquifer System and the Principal Aquifer System occurring most of the time.

An additional challenge associated with containment in OU2 is the duration of operating the remedy. The ability to cease operations relies on the effectiveness of source remediation efforts and on multiple pore flushes to remove contaminants from the groundwater where the IRMs are applied. In general, relatively lengthy operations are required due to aquifer matrix and subsurface heterogeneities or low permeability zones where relatively lower groundwater velocities and greater contaminant matrix diffusion can result in relatively less efficient contaminant recovery.
However, groundwater extraction and/or containment have been applied at hundreds of sites in California and at several source sites with some effectiveness in controlling lateral migration; shallow groundwater extraction rates from individual source site extraction wells have ranged from less than 1 to approximately 29 gallons per minute (gpm); and hydraulic capture appears to have been achieved in portions of the Shallow Aquifer System where groundwater extraction has been applied. The effectiveness of pump and treat to achieve containment is considered relatively high (Table 5-1).

Implementability
As demonstrated throughout California and at several source sites, containment is implementable. Although application of containment to OU2 groundwater (extraction wells, piping, treatment systems) will be limited to non-source site private properties and/or public ROWs, its implementability is considered relatively high (Table 5-1).

Cost
Major containment cost categories include design; permitting; extraction wells; pipelines; treatment system construction; treatment system operation and maintenance (O&M); and treated water disposal. Relative cost for containment is considered high (Table 5-1).

Screening Determination
Containment is retained as a remedial technology for developing remedial alternatives.

5.4.4.2 Physical Barriers

Physical barriers are physical structures designed to prevent or minimize movement of groundwater past the structures. These include barriers such as slurry walls, grout curtains, or sheet piling. Installation of these types of barriers are limited to depths of less than 100 feet (Federal Remediation Technologies Roundtable, 2020).

For OU2, sealing of Legacy Water Supply Wells is also a physical barrier that could prevent or minimize movement of groundwater from the Shallow Aquifer System to the Principal Aquifer System.

Effectiveness
Physical barriers applied in OU2 likely would require supplementation with other actions and would not be effective as a stand-alone remedial action. Groundwater mounding behind physical barriers can divert contaminated groundwater laterally around or vertically beneath the barriers to other uncontaminated areas.

If all of the Legacy Water Supply Wells could be located and accessed, sealing them would be effective in mitigating vertical migration of contaminants from the Shallow Aquifer System to deeper aquifers. However, numerous water supply wells have been installed since the latter half of the 1800s with the actual location and current status of most of these water supply wells remaining unknown (H+A, 2020). For this reason, the practical effectiveness of sealing the Legacy Water Supply Wells is considered relatively low (Table 5-1).

Implementability
Physical barriers would be very impractical to design and install over the large OU2 groundwater plume. OU2 is overlain by a highly developed area with industrial and commercial buildings, extensive underground utilities, and highly trafficked streets and consequently the physical construction of the barriers would be extremely difficult at best. Implementing this technology would require extensive and complex permitting, regulatory agency involvement, relocation of numerous subsurface utilities, public participation, and stakeholder negotiations.

Locating all of the Legacy Water Supply Wells to seal them is not possible. Current standard methods for locating these wells are not expected to be successful. Even if all of the wells could reliably be located, many of them would likely be beneath existing structures that would have to be partially or completely demolished to accommodate the well sealing activities.

Implementability is considered relatively low (Table 5-1).

Cost
Relative cost to install physical barriers, or to locate and destroy all of the Legacy Water Supply Wells would be very high (Table 5-1).

Screening Determination
Physical barriers are not retained as a remedial technology for developing remedial alternatives. Based on the preceding, locating and sealing all of the Legacy Water Supply Wells is not feasible and consequently is not practical or retained as a sole remedial alternative. However, sealing Legacy Water Supply Wells when they are discovered or made accessible is retained as a part of all remedial alternatives, except the No Action Alternative.

5.4.5 ***Ex-Situ Groundwater Cleanup***

Ex-situ groundwater cleanup refers to the extraction and aboveground treatment of groundwater before it is discharged to the final end use (e.g., reinjection, non-potable reclaimed water system, storm drain, or POTW and GWRS). Treatment consists of physical, chemical, or biological processes, and can include multiple methods to address different COCs or to meet specific discharge requirements. The purpose of this FS is to primarily address the removal of COCs, however technologies that can be effectively implemented to meet discharge requirements will also be noted for future consideration once end-use pathways are identified. A variety of technologies that have been extensively established in industry are discussed below, with a focus on their applicability to the site conditions and general feasibility as remedial options.

5.4.5.1 Physical Treatment of Extracted Groundwater

The following sections describe remedial technologies evaluated for physical treatment of extracted groundwater.

5.4.5.1.1 Air Stripping

Air stripping is a method of treatment that contacts influent groundwater with air in order to transfer VOCs to vapor phase. Specific technologies include trayed/packed columns, low-profile aeration, bubble diffusion, or aspiration/centrifugal units. Systems are typically combined with vapor-phase granular activated carbon (VGAC) or oxidizer units, which destroy the VOCs that are captured in the air stream (off-gas).

Effectiveness
Well-designed air stripping systems are very effective for the removal of VOCs, however, the effectiveness of these systems depends on contaminant volatility and the air to water ratio. Water-soluble contaminants such as 1,4-dioxane or Cr6, or slightly soluble compounds such as chlorinated alkanes, are not easily removed with this technology. Effectiveness is considered relatively moderate to high (Table 5-1).

Implementability
Air stripping columns can be complex units to operate and require a high level of supervision in comparison to other technologies. Scaling and fouling on the internal trays or packing material are also common issues and can be difficult to remedy without a complete shutdown of the system. Additionally, the air effluent likely would need to be treated with a VGAC system or an oxidizer to meet air quality emission standards. Implementability is considered relatively low (Table 5-1).

Cost
The initial cost of air stripping systems primarily consists of the contactor itself and any instrumentation required to monitor operational effectiveness or increase system automation. These costs can be moderate to high, depending on the size of the system. In addition, operation and maintenance costs are relatively high given the complexity of the unit and potential for scaling that would need to be addressed via a shutdown. Cost is considered relatively moderate to high (Table 5-1).

Screening Determination
Screened from further consideration in the FS due to low implementability compared with other technologies with similar treatment capabilities. However, this technology could be considered in the future during remedial design to meet end use requirements.

5.4.5.1.2 Liquid-Phase Granular Activated Carbon (LGAC) Adsorption

LGAC is known to be highly effective for the removal of TCE and PCE, and moderately effective for the removal of other chlorinated ethenes. In operation, water flows through the carbon bed vessels where contaminants are selectively adsorbed onto the carbon media surface. After the carbon adsorption capacity is reached, the carbon media needs to be replaced and the spent carbon regenerated by a vendor at their facility. Systems typically include multiple vessels to maintain continuous operation and prevent breakthrough.

Effectiveness
LGAC is widely used throughout the industry, and its effectiveness in the removal of TCE, PCE, and other organic compounds is well-established. It is not an effective treatment for 1,4-dioxane, Cr6, or perchlorate. In addition, this technology can be effectively implemented to quench excess hydrogen peroxide after an advanced oxidation process that utilizes ultraviolet (UV)/peroxide treatment. Systems that are currently operating or have operated in the OU2 area have effectively used LGAC as a remedial measure. Effectiveness is considered relatively high (Table 5-1).

Implementability
This technology requires very little supervision during operation. The primary maintenance requirement is the removal and regeneration of the carbon media, which can be accomplished without a full system shutdown if multiple vessels are run in parallel. Transitions between different parallel-run vessels can be automated or conducted manually. Implementability is considered relatively high (Table 5-1).

Cost
Initial costs primarily consist of the initial purchase of the LGAC vessels and media, piping and controls. Operational costs include the removal and regeneration of carbon media, which is

typically conducted through a third-party vendor. Cost is considered relatively moderate (Table 5-1).

Screening Determination
Retained for further evaluation in the FS. This technology is effective for the removal of multiple COCs identified for this OU2 site and is easily implementable for the given site conditions.

5.4.5.1.3 Membrane Processes

Membrane processes are a physical separation technology that allow the selective permeation of compounds through a barrier, resulting in a treated permeate stream and a rejected concentrate/brine stream. Membranes can either be semi-permeable (reverse osmosis [RO]) or very small diameter filtration (nanofiltration). Nanofiltration operates at relatively low pressures compared to RO and is effective in removing divalent ions (such as nitrate and sulfate) but not monovalent ions (such as sodium or chloride). RO removes a wider range of constituents than nanofiltration, including monovalent ions, and is therefore generally more effective than nanofiltration. These systems are often implemented to meet stringent discharge requirements due to the high percentage of removal for ions and dissolved solids. Disposal of the concentrated brine may present disposal challenges.

Effectiveness
Membrane processes are highly effective for the removal of a wide range of ionic species, such as total dissolved solids, perchlorate, Cr6 and many other contaminants, however, are not as effective as other technologies for the removal of 1,4-dioxane or VOCs. Membrane processes are typically implemented to achieve strict concentration requirements for end use options, such as storm drain, reclaimed water, or deep zone injection into an aquifer with higher water quality than the extracted groundwater. Effectiveness is considered relatively high for dissolved solids, perchlorate, Cr6 and many other contaminants, but moderate to low for VOCs and 1,4-dioxane (Table 5-1).

Implementability
Membrane processes are typically implemented with filtration, anti-scalant addition, pH regulation, and clean-in-place systems to combat membrane fouling inherent to membrane treatment. With these supplemental systems integrated into the process design, membrane processes are straightforward to operate and maintain, and can operate almost continuously if multiple units are arranged in parallel. However, the rejected concentrate/brine solution is typically 5 to 15 percent of the influent flow for nanofiltration and 10 to 20 percent of the influent flow for RO and would require discharge to a POTW. Implementability is considered relatively high (Table 5-1).

Cost
Membrane processes, particularly RO systems, can have a high initial cost. However, operational costs are relatively low, since the system can be run with minimal operator attention. Disposal costs for the rejected concentrated brine solution must be considered. Cost is considered relatively high (Table 5-1).

Screening Determination
Screened from further consideration in the FS with the exception of injection of treated groundwater, since membrane processes have low to moderate effectiveness for the treatment of OU2 COCs and since perchlorate and Cr6 have not been identified as significant contaminants in the areas that may be considered for OU2 IRMs. The main documented perchlorate source and associated plume are outside the scope of the OU2 FS and IRMs. Hexavalent chromium is found at several source sites but is not widespread within OU2. Alternative 4 uses reverse osmosis to reduce inorganic constituents to concentrations similar to those existing in the receiving layer (Basal Sand). Ion exchange is not warranted for this type of application.

5.4.5.1.4 Evaporation/Condensation

This technology concentrates dissolved solids and other non-volatile constituents from water by boiling contaminated water and condensing the purified water. However, the boiling points of VOCs and 1,4-dioxane are below or close to that of water and therefore these constituents would be retained in the condensate. In general, systems using this technology are built for relatively low flow applications due to the large amount of energy needed to vaporize water.

Effectiveness
Evaporation/condensation is effective for the removal of non-volatile contaminants and dissolved solids, including perchlorate and Cr6. However, it is not effective for the removal of volatile contaminants or 1,4-dioxane, making this technology unsuitable for the removal treatment of COCs as stated in the RAOs. Effectiveness is considered relatively low (Table 5-1).

Implementability
Systems using evaporation/condensation methods are very energy intensive, since the untreated water needs to be heated to boiling. The heating method (e.g., direct-fired, electric) can generate operational or maintenance challenges. In addition, dissolved solids deposited in the evaporation chamber can build up and decrease the heat transfer efficiency of the system or damage the equipment. Evaporation/condensation units do have a relatively small footprint and are best suited for low flow rate applications. Implementability is considered relatively moderate (Table 5-1).

Cost
Evaporation/condensation units are expensive relative to their operating capacity, and the heating method can present high installation and operating costs for utilities. Cost is considered relatively high (Table 5-1).

Screening Determination
Screened from further evaluation in the FS, due to low effectiveness and high cost compared to other technologies.

5.4.5.1.5 Ion Exchange

Ion exchange is a chemical process in which dissolved ionic contaminants are exchanged with innocuous ions with similar charge on the surface of a cation or anion ion exchange resin. Ion exchange resins are physical media that aid in ion exchange and therefore have been grouped into physical treatment of groundwater. The process stream should be prefiltered prior to ion exchange to prevent particulate fouling of the resin matrix. Ion exchange resins typically used for groundwater treatment employ a strong base anion exchange resin which selectively removes dissolved anions (including perchlorate or Cr6 as chromate) which have a higher affinity for the resin than the lower affinity, exchangeable anion which is released from the resin into the effluent water.

Ion exchange resins are contained in a fixed or moving bed down-flow or up-flow contactor system. The resin must be regenerated when the resin becomes fully loaded with ions removed from the groundwater and breakthrough occurs. Regeneration is accomplished using a strong acid, strong base, or high concentration brine solution (depending on the resin type and contaminants) to replace the contaminant ions on the resin and multiple bed volumes of regenerant are typically used to restore the exchange capacity.

Effectiveness
Ion exchange processes are highly effective for the removal of many organic and inorganic ions, including perchlorate and Cr6, however ion exchange is not effective for the removal of VOCs or 1,4-dioxane. Effectiveness is considered relatively high for perchlorate and Cr6 but ineffective for VOCs and 1,4-dioxane (Table 5-1).

Implementability
Ion exchange beds have a relatively small footprint and can be operated continuously if multiple reactors are run in parallel. These systems require minimal operational supervision, and maintenance is infrequent. However, the regeneration solution can present operational and/or disposal challenges. Implementability is considered relatively high (Table 5-1).

Cost
Cost is primarily driven by the type of resin used, which may need to be specialized if other constituents in the process stream compete with ion exchange sites, and the disposal of the regeneration solution. Cost is considered relatively moderate to high (Table 5-1).

Screening Determination
Screened from further consideration in the FS, since perchlorate, Cr6, and organic ions have not been identified as significant contaminants in the areas that may be considered for OU2 IRMs. However, this technology could be considered in the future during remedial design to meet end use requirements.

5.4.5.2 Chemical Treatment of Extracted Groundwater

The following section describes remedial technologies evaluated for chemical treatment of extracted groundwater.

5.4.5.2.1 Advanced Oxidation Process (AOP)

AOP refers to a class of technologies that utilize various methods to create hydroxyl radicals in a treatment system, which react with and destroy a variety of organic compounds. Common methods include UV radiation, hydrogen peroxide, ozone, or a combination of multiple methods. For this site, ozone is not an acceptable treatment process option since it has the potential to create bromate as a harmful byproduct. AOP is commonly used in both groundwater and wastewater treatment for both contaminant destruction and water disinfection.

Effectiveness

AOP is known to be highly effective for the removal of 1,4-dioxane, NDMA, and unsaturated VOCs, however, the effectiveness for destruction of chlorinated alkanes (e.g., 1,1-DCA) is much lower. Effectiveness for systems utilizing UV radiation depends on the turbidity of the influent water for UV transmittance and requires pre-filtration to maximize operation. This technology is used extensively throughout industry and is a reliable method for the removal of many organic COCs identified earlier in this document. Effectiveness is considered relatively high (Table 5-1).

Implementability

The large variety of AOP methods available allows any system to be tailored to site specific needs. Reactors typically have a small footprint and are low maintenance. In general, AOPs are not stand alone, and may require downstream quenching or filtration to capture oxidation byproducts or excess peroxide/ozone. Implementability is considered relatively high (Table 5-1).

Cost

AOPs have a high capital cost, require the replacement of feedstock as the system operates, and lamp replacement is typically required every 3 to 5 years. Many AOP systems have developed advanced, energy-efficient lamps to reduce electrical costs, however the energy costs for this technology will be relatively higher than other technologies. Other operational costs are relatively low, since the system is simple to run and can do so with minimal supervision. Cost is considered relatively high (Table 5-1).

Screening Determination

Retained for further evaluation in the FS, since it effectively treats 1,4-dioxane and other VOCs such as TCE and PCE.

5.4.5.3 Biological Treatment of Extracted Groundwater

The following sections describe remedial technologies evaluated for biological treatment of extracted groundwater.

5.4.5.3.1 Biological Liquid-Phase Granular Activated Carbon (Bio-LGAC) Adsorption

Bio-LGAC systems are very similar to standard LGAC systems, but they also allow for a limited build-up of a biological film on the carbon media that can remove a wider range of COCs. The Bio-LGAC process involves the simultaneous adsorption and aerobic biodegradation of many organic contaminants and has been most frequently used in the advanced treatment for potable water and industrial wastewater treatment. This treatment technology also includes nutrient injections and other process controls that are necessary to maintain the health of the biomass and the effectiveness of the system.

Effectiveness

Similar to LGAC, this technology is effective for the treatment of VOCs and perchlorate and can be tailored to specific contaminants through the selection of biological species. Organisms can be sensitive to process conditions, and an inability to effectively manage the reaction environment can result in a decrease in effectiveness or total lack of treatment. Effectiveness is considered relatively high (Table 5-1).

Implementability
Bio-LGAC systems have a relatively small footprint and are relatively easy to install. The primary issue of Bio-LGAC is the build-up of biomass during operation, which requires backwashing to remove and the subsequent disposal of biomass. In addition, off-gas produced as a byproduct may require additional treatment through VGAC or an oxidizer, and filters may need to be installed downstream of the process to capture biomass that escapes the Bio-LGAC vessel. In addition, greater operational supervision is required for Bio-LGAC systems than LGAC systems since the biological organisms can be sensitive to minor changes in process conditions. Implementability is considered relatively moderate (Table 5-1).

Cost
Costs primarily depend on the initial purchase of the LGAC vessels, media, and starting biomass. Operational costs may include periodic purchase of additives used to maintain the health of the biomass. Cost is considered relatively moderate to high (Table 5-1).

Screening Determination
Screened from further consideration in the FS, since the marginally improved removal efficiency does not justify the increased operational complexity over a standard LGAC system.

5.4.5.3.2 Biological Treatment

Biological treatment of extracted groundwater typically takes place in an above-ground reactor that contains high surface area media, such as sand. Microbes that are effective in the degradation of specific COCs live in the reactor and are maintained with nutrient injections and process control. Systems can be operated aerobically or anaerobically, depending on the application.

Effectiveness
Systems using biological treatment can be customized to target specific COCs present at the treatment site and are highly effective for the removal of VOCs and perchlorate. Maintaining process conditions that allow the microbes to thrive is the primary determining factor for effectiveness, and mismanaged systems can have very low removal rates. Effectiveness is considered relatively high (Table 5-1).

Implementability
Biological treatment systems possess inherent operational complexity, since microbes are highly sensitive to process conditions. In addition, off-gas treatment and periodic biomass removal may be required. Implementability is considered relatively moderate (Table 5-1).

Cost
Since the design of biological treatment systems depends heavily upon the specific microbes present in the reactor, costs can vary widely. Simpler systems tend to be less expensive, but still require a high degree of process monitoring and control that can drive up costs quickly. Cost is considered relatively moderate to high (Table 5-1).

Screening Determination
Screened from further consideration in the FS, due to high operational complexity relative to other available technologies.

5.4.6 *Treated Water Discharge or End Use Process Options*

As described further below, treated water discharge, end use, or disposal options include:

- Injection
- Storm drain disposal
- POTW and GWRS
- Non-potable reclaimed water use

5.4.6.1 Injection

Treated groundwater would be discharged to the subsurface using injection wells. The injection wells could be screened in the interval from which groundwater is extracted; in the Shallow Aquifer System beneath the extracted interval (screened in the Basal Sand); or in the deeper aquifer systems.

Effectiveness
As described above, individual source site extraction wells reportedly have achieved sustainable groundwater extraction rates ranging from less than 1 to approximately 29 gpm. This suggests that injection of treated water may be a feasible discharge option. Since the receiving aquifer(s) would have sufficient capacity to accept treated water, this option would allow uninterrupted discharge and would not have the potential limitations described herein for non-potable reclaimed water end use and/or storm drain discharge. Effectiveness in disposing of the treated groundwater is considered relatively high (Table 5-1).

Implementability
The Principal Aquifer System is currently used for the production of drinking water. For reinjection into aquifers that currently are used for the production of drinking water, the extracted water would have to be treated to relatively strict discharge standards that are often more stringent than drinking water standards. State Water Resources Control Board Resolution 68-16 prohibits degradation of groundwater used for potable uses. Under the state's anti-degradation policy, water that meets drinking water standards might require additional treatment prior to injection since the receiving aquifer may have better water quality than water that is treated only to drinking water standards. Injection into the Principal Aquifer System could require treatment technologies that generate a waste brine stream high in total dissolved solids, which cannot be reused and would be discharged to a POTW. For these reasons, injection into the Principal Aquifer System is not further considered herein.

Injection of treated groundwater into the zone from which it is extracted would require consideration of potential interference with source site remedial efforts and existing plumes within the Shallow Groundwater System which would require significant access and permitting effort. Injection into the same vertical interval (Layers 1 through 3) where extraction would be applied is not recommended based on:

1. The predominantly fine-grained nature of Layer 1 and to a lesser extent Layer 3 and the anticipated low injection rates and relatively more frequent well development activities resulting therefrom;

2. The potential to displace relatively high COC concentrations in Layers 1 through 3 and negatively affect surrounding shallow groundwater quality; and
3. The potential for increasing lateral and vertical groundwater velocities that could intercept nearby Legacy Water Supply Wells and accelerate vertical migration of COCs from the Shallow Aquifer System into the Principal Aquifer System.

Thus, injection into the Basal Sand (Layer 4) portion of Shallow Aquifer System is the only injection scenario that is considered in this document. This would require acquisition of a RWQCB WDR Order, which would specify the discharge conditions that typically require injected water quality to meet drinking water MCLs or notification levels (NLs), and/or meet the water quality existing in the Basal Sand.

Implementation would be difficult based on the extensive permitting and agency approvals that would be required. Multiple injection wells would have to be installed and conveyance piping would be required from the treatment system to each injection well. Injection well performance typically is more sensitive to changes in groundwater levels and water quality compared with extraction wells and they typically require relatively more frequent and robust maintenance and redevelopment.

Implementability is considered relatively low (Table 5-1).

<u>Cost</u>
Based on the preceding administrative, permitting, access, treatment requirements, agency, and public participation requirements, the relative cost is considered high (Table 5-1).

<u>Screening Determination</u>
Injection into the Basal Sand is retained in the FS as a discharge option for remedial alternatives.

5.4.6.2 Storm Drain

Water would require treatment to meet National Pollutant Discharge Elimination System (NPDES) discharge standards and would be discharged to nearby storm drains or storm channels. The current general discharge permit for discharges to surface waters from groundwater remediation in the San Diego Creek/Newport Bay Watershed (impaired water bodies) is Order No. R8-2007-0045. Based on discussions with RWQCB, this general permit would be required if selenium concentrations exceed 5 to 6 ug/l, and relevant total maximum daily load (TMDL) requirements would apply. Alternatively, there is an expired general discharge permit for groundwater cleanup discharges to surface water in the Santa Ana River Basin that may be renewed, but would only be applicable if selenium concentrations are below 5 ug/l.

Both general permits have narrative and numerical discharge objectives, and numeric criteria for priority toxic pollutants contained in the California Toxics Rule (CTR) criteria are applicable. In order to meet CTR criteria, this disposal option would require treatment technologies that generate a waste brine stream high in total dissolved solids, which would be discharged to a POTW.

<u>Effectiveness</u>
The discharge capacity to storm drains or storm channels may be completely utilized during and after precipitation events, which would require temporary termination or cycling of groundwater

containment extraction wells. These short-term cycling events are not anticipated to reduce effectiveness of remedy. Effectiveness is considered relatively moderate (Table 5-1).

<u>Implementability</u>
Discharge to storm drains would require NPDES permitting and compliance with very stringent CTR criteria. In order to achieve these discharge objectives, treatment likely would be complex and would need to include membrane process with a concentrated brine discharged to the POTW. Implementability is considered relatively low (Table 5-1).

<u>Cost</u>
Capital costs could vary depending upon the distances to and capacity of existing storm drains and channels in the area. If existing storm drain capacity is too low, the capacity may have to be expanded, or the treated water would have to be conveyed longer distances to a location where storm drain capacity is adequate. A replenishment assessment fee for all extracted groundwater would be applicable to fund replenishment of the groundwater. Given the relatively high degree of groundwater treatment, cost is considered relatively moderate to high (Table 5-1).

<u>Screening Determination</u>
Storm drain discharge is not retained in the FS as a discharge option for remedial alternatives.

5.4.6.3 POTW and GWRS

Treated water would be discharged to a municipal sewer under a Special Purpose Discharge Permit (SPDP) and conveyed to the Orange County Sanitation District (OCSD) POTW Reclamation Plant No. 1 in Fountain Valley. Most of the Plant No. 1 effluent is further treated at the GWRS, a joint collaboration of OCWD and OCSD, which produces high-quality water to recharge the groundwater basin, protects the groundwater basin from seawater intrusion, and reduces the amount of wastewater discharged to the ocean. This discharge option supports the groundwater resource by returning the treated groundwater to the basin; however, there are costs associated with operation of the GWRS.

Discharge to the OCSD POTW must comply with all maximum allowable local non-domestic discharge limits described in Ordinance No. OCSD-53 Table 1 and prohibitions in Sections 201 (A) and (B). Currently Table 1 does not contain VOC discharge limits and the 1,4-dioxane discharge limit is 1.0 milligram per liter (mg/l). Pretreatment prior to discharge is likely to be required if 1,4-dioxane concentration exceeds 10 to 25 percent of the discharge limit. Local discharge limits are periodically reevaluated by OCSD, and the next evaluation and possible revision to discharge limits is expected in 2022.

<u>Effectiveness</u>
The discharge capacity to the POTW may be diminished during and after precipitation events, which would require temporary termination or cycling of groundwater containment extraction wells. These short-term cycling events are not anticipated to reduce effectiveness of remedy. POTW/GWRS is an effective extracted and treated water discharge option that is sustainable and preserves the groundwater resource and effectiveness is considered relatively high (Table 5-1).

Implementability
POTW discharge standards are the least stringent of all the discharge and end use options. The local POTW agency has communicated a desire to accept this water for its operations and implementability is considered relatively high (Table 5-1).

Cost
Sewer discharge costs under OCSD's SPDP include administrative permit fees, discharge flow-based fees, supplemental capital facilities capacity charges, and surcharge fees for suspended solids and biological oxygen demand. Additionally, the incremental cost to treat the discharged water using the GWRS could also be incurred.

Discharge to the POTW would likely have the lowest relative costs for treatment and the relative overall cost of this discharge option is therefore relatively moderate compared to the other discharge or end use options (Table 5-1).

Screening Determination
POTW/GWRS is retained in the FS as a discharge option for remedial alternatives.

5.4.6.4 Non-Potable Reclaimed Water

Treated water could be distributed to an existing non-potable reclaimed water pipeline network in the area for reuse as irrigation or industrial water.

Effectiveness
Since treated water production could exceed demand for non-potable reclaimed water at different times of the day and/or year, implementation of this end use option would be highly difficult. Non-potable reclaimed water demand is seasonal. Highest demand is in the summer season, and the lowest demand is in the winter season. This cyclical demand could result in reduced containment effectiveness during periods where groundwater extraction rates and related groundwater capture zone(s) could be diminished over prolonged periods of time. Effectiveness is considered relatively low (Table 5-1).

Implementability
There are no existing non-potable reclaimed water pipeline networks in the OU2 area that could be used for reuse. In addition, permitting for production and distribution of non-potable reclaimed water would present challenges as Waste Discharge Requirements/Water Reclamation Requirements permits are generally specific to municipal water reclamation plants and specific distributors. Implementability of this option is relatively low (Table 5-1).

Cost
This option is practically infeasible based on implementability criteria. The relative cost would be high (Table 5-1).

Screening Determination
Reclaimed water is not retained in the FS as a discharge option for remedial alternatives.

5.4.7 ***In-Situ Groundwater Cleanup***

In-situ groundwater cleanup typically is used to remediate groundwater by reducing the toxicity, mobility, and volume of the targeted contaminants. In-situ treatment technologies and process options also can be used as part of a containment remedy.

In-situ process options include natural attenuation and biological, chemical, thermal, and physical treatment (Table 5-1). These response actions would include treatment of COCs in OU2 groundwater to meet the RAOs.

In-situ treatment technologies are focused on reducing the toxicity, mobility, and volume of OU2 groundwater. These treatment technologies produce relatively less waste than ex-situ treatment methods such as pump and treat systems. Except for natural attenuation, all in-situ treatment processes utilized as part of an OU2 groundwater remedy would be employed as a barrier to intercept and destroy the contaminant plume(s) and prevent their further lateral migration downgradient of high concentration areas and/or near the leading edge of the plumes.

5.4.7.1 Monitored Natural Attenuation (MNA)

MNA includes physical processes such as dispersion, diffusion, dilution, adsorption, and passive volatilization; chemical processes such as chemical oxidation, reduction, neutralization, and precipitation; abiotic degradation; and reactions resulting from biological processes to reduce contaminant concentrations to an acceptable level without active intervention. MNA has been accepted as a treatment technology for lower concentrations of many contaminants, and several guidance documents have been produced by regulatory agencies (USEPA 1998, 1999b, 2010, and 2015). Certain "lines of evidence" need to be met for MNA to be considered (USEPA 1998, 1999b).

Examples of lines of evidence typically used to evaluate MNA effectiveness include:

- Historical contaminant mass reduction - monitoring data vs. time (temporal data):
    - Concentration vs. time graphs for individual wells
    - A collection of plume maps over time
    - Statistical trend analysis, such as Mann-Kendall
    - Mass loss along a flow line
    - Modeling results indicating mass reduction
- Hydrogeologic or geochemical data:
    - Documentation that daughter product formation accounts for parent compound concentration decreases
    - Demonstrating that geochemical conditions support the desired attenuation process, such as anaerobic degradation
    - Demonstrating that electron acceptors are being depleted and electron acceptors are sufficient
- Field or microcosm studies, if the first two lines of evidence are not sufficient

If these requirements are, or appear to be met, a long-term monitoring plan is developed to ensure MNA remains protective; guidance documents also have been developed for monitoring (USEPA 2004, 2011). It is clear that intrinsic biodegradation (natural attenuation) was and is not sufficient to prevent migration of COCs from source sites to off-property downgradient areas. Based on the statistical analysis of COC concentration trends downgradient of source site remediation areas presented in the SRI, it is also clear that these processes are not sufficient where existing conditions represent expanding COPC plumes, steady state or stable conditions.

<u>Effectiveness</u>
If applied at appropriate locations, with an adequate monitoring network and analytical schedule, MNA is effective, especially for large, relatively low concentration plumes where other technologies cannot be applied or would be prohibitively costly. For OU2 groundwater, MNA effectiveness is expected to be limited by the presence of Legacy Water Supply Wells within the Study Area, with the actual location and current status of most of these wells remaining unknown. These wells in the Study Area likely act as conduits for the transport of groundwater containing COCs from the Shallow Aquifer System downward into the underlying Principal Aquifer System. Additionally, the concentrations and distributions of COCs beneath and downgradient of source sites not subject to source site remedial efforts in several areas of OU2 groundwater where MNA could potentially be implemented suggest that MNA applied as a sole remedial action would not be effective. MNA effectiveness and the ability to cease monitoring relies on COC concentration reductions in areas where subsurface heterogeneities and low permeability zones result in prolonged matrix back diffusion. For these reasons, MNA effectiveness is considered relatively low (Table 5-1).

<u>Implementability</u>
Because MNA requires only monitoring, it is relatively easy to implement, requiring relatively less infrastructure compared with other process options, which is ideal for a highly developed area like OU2. MNA monitor wells would be installed on privately owned, non-source site properties and/or public ROWs. As a stand-alone process option, MNA would require a substantial number of monitor wells and a very large monitoring network compared with other process options, which could complicate implementability. Implementability is considered relatively high (Table 5-1).

<u>Cost</u>
Since MNA requires only monitoring, which all other remedies also require, along with analysis of some additional parameters and evaluation of data, it is relatively less costly than other process options. However, as a stand-alone process option, MNA would require a substantial number of monitor wells and a very large monitoring network compared with other process options, Therefore, cost is considered relatively moderate (Table 5-1).

<u>Screening Determination</u>
MNA is retained in the FS as a process option for remedial alternatives.

5.4.7.2 Active In-Situ Bioremediation (ISB)

ISB technologies typically apply nutrients, sometimes bioaugmented with microorganisms, to the subsurface to stimulate biodegradation of contaminants by generating environments suitable for the sustenance and propagation of microorganisms. Microbial degradation can be either anaerobic or aerobic. Bioremediation effectiveness is affected by pH, temperature, redox conditions, site hydrology, and the conditions required for biodegradation of each targeted contaminant. Most chemicals degrade more rapidly and completely under aerobic conditions. However, some contaminants (e.g., PCE) require anaerobic conditions to biodegrade. Nutrients would be applied to OU2 groundwater using multiple injection wells placed along linear alignments constructed perpendicular to the direction of groundwater flow. The injection well alignments would be designed to intercept and treat contaminants along the groundwater flow path through the alignments.

Effectiveness
Bioremediation applied at South Basin source sites with solvents and/or 1,4-dioxane has had limited effectiveness. Degradation of parent compounds (PCE and TCE) has been observed at some sites (Arcadis, 2019; Stantec, 2020a and 2020b). However, generation of persistent, undesirable (cis-1,2-DCE) and more toxic (vinyl chloride) daughter products have been observed (Arcadis, 2019). ISB of 1,4-dioxane has been documented in pilot studies after the addition of oxygen and an appropriate bacterial culture to induce metabolic biodegradation of 1,4-dioxane (Chiang et al., 2016). The addition of oxygen and an appropriate substrate (e.g., butane, propane, ethane) can induce cometabolic biodegradation of 1,4-dioxane. Zhang et al. (2016) demonstrated that chlorinated VOCs inhibit biodegradation of 1,4-dioxane. Thus, it has been recommended that chlorinated VOCs be removed before using biological treatment for 1,4-dioxane (USEPA, 2020a). In addition to the above, potential challenges associated with ISB in OU2 include an inability to reduce COC concentrations before they cross flow from the Shallow Aquifer System into the Principal Aquifer System through Legacy Water Supply Wells. It is generally impractical to deploy targeted in-situ treatment in the immediate vicinity of Legacy Water Supply Wells due to the unknown location of these wells. The ability to cease application of ISB and achieve RAOs relies on the effectiveness of source remediation efforts, reliance of pore flushing between ISB transects, and reliance on effective distribution of amendments into the subsurface. In general, prolonged operations are required due to incomplete and insufficient delivery of amendments in heterogeneous systems or low permeability zones and back diffusion processes (EPA, 2013) within the application area and throughout the IRM area between transects. Effectiveness is considered relatively low (Table 51).

Implementability
The process option for ISB would include injection wells and biological treatment, perhaps enhanced with bioaugmentation (enhanced in-situ bioremediation [EISB]). Given the relatively large areas potentially targeted for remediation in OU2, application of ISB for "plume-wide" remediation throughout OU2 is infeasible and not considered herein. ISB injection wells placed at regular, closely spaced intervals along linear alignments constructed perpendicular to the direction of groundwater flow could provide treatment of COCs migrating laterally in the Shallow Aquifer System. Construction of injection wells for ISB would be confined to limited areas at non-source site private properties and/or public ROWs as demonstrated at the remediation performed downgradient of the ITT source site (Arcadis, 2019). Further, ISB typically requires multiple application events at a relatively moderate frequency related to other process options (likely less often than ISCO and more often than in-situ chemical reduction [ISCR]) and may be relatively more burdensome and disruptive to affected property owners or public ROW users. Implementability is considered relatively moderate (Table 5-1).

Cost
The cost to install injection wells, procure nutrients and bioaugmentation agents, and perform ISB injections on a per-event basis is relatively low. However, the combination of likely multiple application events, particularly if undesirable byproducts are generated and persist at a relatively moderate frequency would add to the overall cost, which is considered relatively moderate to high (Table 5-1).

Screening Determination
ISB is not retained in the FS as a process option for remedial alternatives for OU2 groundwater subject to IRMs, since OU2 groundwater contains a mix of chlorinated solvents and 1,4-dioxane.

5.4.7.3 Chemical Processes

Chemical process options for in-situ treatment include ISCO, ISCR, and chemical fixation.

ISCO involves emplacement of a strong oxidizing agent (amendment) such as hydrogen peroxide, sodium persulfate, or sodium permanganate, to the subsurface. These oxidizing agents cause the rapid chemical degradation of some COCs. ISCR involves emplacement of a reducing agent (amendment) such as zero valent iron (ZVI), calcium polysulfide, or sodium dithionite to the subsurface. For in-situ chemical processes to effectively destroy contaminants, the oxidant/reductant must come into direct contact with the contaminant molecules. Another consideration for ISCO is natural oxidant demand (NOD), which refers to the consumption of an oxidant by non-target constituents due to reactions related to the organic and inorganic components in the matrix (soil or groundwater). As a result, the selection of an oxidant is greatly dependent on the site conditions such as the aquifer NOD, permeability, size and concentration of the target COC, and the persistence of the oxidant in a particular environment.

Given the relatively large areas potentially targeted for remediation in OU2, application of ISCO and/or ISCR for "plume-wide" remediation throughout OU2 is infeasible and not considered herein. Oxidizing and/or reducing agents can be emplaced using dedicated injection wells; injected directly into aquifer materials through direct-push boreholes using specialized injection tooling; or by pneumatic emplacement into open boreholes. However, based on the potential for surfacing of amended water and on the anticipated multiple applications that any in-situ technology is likely to require, the last two methods of emplacement are not considered for OU2 groundwater. ISCO and/or ISCR injection wells placed at regular, closely spaced intervals along linear alignments constructed perpendicular to the direction of groundwater flow could provide treatment of COCs migrating laterally in the Shallow Aquifer System. ISCO applied to OU2 groundwater likely would require more frequent applications based on the short ISCO amendment longevity relative to ISCR or ISB amendments.

Chemical treatment also can be applied as a permeable reactive barrier (PRB). This technology is designed to intercept and treat contaminants where they are placed along linear alignments constructed perpendicular to the direction of groundwater flow. PRBs are constructed in trenches containing reactive media applied to treat specific COCs. The barrier allows water to pass through while the media removes the contaminants by precipitation, degradation, adsorption, or ion exchange. PRB performance can be affected by the presence of fractured rock, heterogeneous lithologic conditions, deep aquifers, high aquifer hydraulic conductivity, and barrier plugging.

PRB applications using oxidizing or reducing amendments in a configuration required for effective treatment are not feasible at OU2 due to accessibility constraints on the private property and public ROWs where this remedy will be installed; therefore, PRBs are not further considered.

A significant OU2 groundwater COC is 1,4-dioxane, which is not effectively treated using most ISCO amendments and all ZVI amendments. Therefore, ISCR will not be further evaluated in this document.

ISCO has been applied at several source sites using potassium permanganate (Ricoh Electronics Facility); persulfate (Bell Industries and Baxter Health Care); persulfate activated with chelated iron (Baxter Health Care); and hydrogen peroxide and ozone (Universal Circuits).

ISCO pilot testing at Ricoh using potassium permanganate in 2009 resulted in short-term COC concentration declines, followed by rebounding concentrations within approximately 6 months of application (Wayne Perry Inc., [WPI], 2018). Further, baseline and groundwater monitoring data collected during groundwater remediation pilot testing at the Ricoh source site indicated that elevated concentrations of metals were produced as a result of ISCO groundwater remediation using permanganate (WPI, 2010). Chromium groundwater concentrations in monitor well RMW-1 increased from a baseline (pre-injection) concentration of 34 ug/l to a maximum post-injection concentration of 10,400 ug/l and baseline (pre-injection) chromium groundwater concentrations in monitor well RMW-6S increased from 21 ug/l to a maximum post-injection concentration of 588 ug/l. Ricoh reportedly is now planning to apply EISB using lactate (WPI, 2019).

ISCO pilot studies were performed in 2011 and 2015 at Baxter Healthcare using persulfate to treat 1,4-dioxane and 1,1-DCE. In 2017 the studies were expanded to source area treatment using persulfate activated with chelated iron. Data collected during and after the 2017 source area treatment indicate that COC treatment effectiveness was limited and 1,4-dioxane was not effectively treated (BBJ Group, 2019).

ISCO pilot testing at Universal Circuits using hydrogen peroxide and ozone was performed in 2007. Some destruction of 1,1-DCE was observed, but there was no mention of 1,4-dioxane, which occurs at significant concentrations.

ISCO pilot testing using persulfate performed at the Bell Industries site in 2016 reportedly was successful. An ISCO pilot study using sodium persulfate was implemented in the bakery area south of the site. Based on the results of the study, ISCO treatment was deemed effective for both 1,1-DCE and 1,4-dioxane. However, based on the limited radius of influence of the chemical injections, the short duration of the chemical reaction, and the cost of the material, large-scale implementation was deemed cost prohibitive (Atlas, 2019).

Based on the preceding, the only in-situ process option further considered to target chlorinated VOCs and 1,4-dioxane is ISCO with the use of activated persulfate.

Effectiveness

As described in the preceding section, ISCO pilot testing performed at the Bell Industries site in 2016 appears to have successfully treated COCs, including 1,4-dioxane. However, experience within OU2 and at many other sites throughout Southern California indicate that, relative to ISCR, ISCO application typically requires more frequent applications, which is reflected in the implementability and cost criteria. In addition to the above, potential challenges associated with ISCO in OU2 include an inability to reduce COC concentrations before they cross flow from the Shallow Aquifer System into the Principal Aquifer System through Legacy Water Supply Wells. It is generally impractical to deploy targeted in-situ treatment in the immediate vicinity of Legacy Water Supply Wells due to unknown location of these wells. The ability to cease application of ISCO relies on the effectiveness of source remediation efforts, reliance of pore flushing between ISCO transects, and reliance on effective distribution of amendments into the subsurface. In general, prolonged operations are required due to unpredictable delivery of amendments in heterogeneous or low permeability zones and back diffusion processes within the application area and throughout the IRM area between transects. Effectiveness is considered relatively moderate (Table 5-1).

Implementability
The process option for ISCO would include injection wells and chemical treatment. ISCO injection wells placed at regular, closely spaced intervals along linear alignments constructed perpendicular to the direction of groundwater flow could provide treatment of COCs migrating laterally in the Shallow Aquifer System. Construction of injection wells for ISCO in groundwater would be confined to limited areas at non-source site private properties and/or public ROWs. Further, ISCO typically requires multiple application events at a relatively high frequency related to other process options and may be relatively more burdensome and disruptive to affected property owners or public ROW users. Implementability is considered relatively moderate (Table 5-1).

Cost
The cost to install injection wells, procure oxidant and perform ISCO injections on a per-event basis is relatively low. However, the combination of likely multiple application events at a relatively high frequency will add to the overall cost, which is considered relatively high (Table 5-1). In fact, although ISCO using persulfate was successfully used to treat COCs, including 1,4-dioxane, in groundwater at the Bell Industries source site, it was reported that full-scale application of ISCO would be too costly and application of GET is now proposed (Atlas, 2019).

Screening Determination
ISCO using activated persulfate is retained in the FS as a process option for remedial alternatives.

5.4.7.4 Thermal Processes

Thermal processes heat groundwater to volatilize certain COCs. Thermal processes for in-situ treatment of contaminants in groundwater typically include electrical resistance heating (ERH), thermal conduction heating, steam injection, and hot air injection.

Effectiveness
Effectiveness of thermal processes is considered relatively high but is infeasible in OU2 based on implementability limitations (Table 5-1).

Implementability
Given the relatively large areas potentially targeted for remediation in OU2, application of thermal technologies for "plume-wide" remediation throughout OU2 is practically infeasible. Any thermal remedy would require design, permitting, construction, and operation and maintenance of soil vapor extraction (SVE) systems to contain, capture, and treat VOC off-gassing from the groundwater. The feasibility of obtaining sufficient access to private properties and/or public ROWs to install and maintain the thermal process infrastructure (electrodes, probes, conveyance piping, electrical lines, SVE wells and piping, SVE treatment system[s]) is very low and would negatively encumber these properties. Implementability is considered relatively low (Table 5-1).

Cost
Energy requirements would be prohibitively high. Thermal process infrastructure (electrodes, probes, conveyance piping, electrical lines, SVE wells and piping, SVE treatment system[s]) costs would be high. The cost is considered relatively very high (Table 5-1).

Screening Determination
Thermal processes are not retained in the FS as a process option for remedial alternatives.

5.4.7.5 Physical Processes

Physical process options for in-situ treatment of contaminated groundwater include air sparging (AS) with SVE, or the use of fracturing to emplace amendments into groundwater. AS removes VOCs and some semi volatile organic compounds from groundwater by volatilization, and SVE then removes the vapor-phase contaminants using vacuum blowers and vapor extraction wells. The extracted vapor is collected at the surface and is treated or discharged to the atmosphere, or both. Fracturing can be applied using either hydraulic or pneumatic methods and can create pathways in the aquifer that increase the permeability of soils. However, RWQCB Order No. R8-2018-0092, General Waste Discharge Requirements for In-Situ Groundwater Remediation at Sites Within the Santa Ana Region states:

> The discharge of wastes in geological formations in a manner that increases the mobility and/or extent of the contaminant plume through fracturing of the geologic formation is prohibited. Additionally, fracturing of aquitards that separate two distinct water-bearing zones is prohibited under any condition.

Therefore, fracturing as a physical process will not be considered further in the FS for OU2 IRMs.

Effectiveness
AS would not effectively treat 1,4-dioxane. Further, AS is not technically feasible, since the volume of groundwater subject to OU2 IRMs is relatively large and many of the properties overlying it are inaccessible. Effectiveness is considered relatively low (Table 5-1).

Implementability
Given the relatively large areas potentially targeted for OU2 IRMs, application of AS for "plume-wide" remediation throughout OU2 is practically infeasible. Any AS remedy would require design, permitting, construction, and operation and maintenance of SVE systems to contain, capture, and treat VOC off-gassing from the groundwater. The feasibility of obtaining sufficient

access to private properties and/or public ROWs to install and maintain the AS process infrastructure (AS wells, conveyance piping, electrical lines, SVE wells and piping, SVE treatment system[s]) is very low and would negatively encumber these properties. Implementability is considered relatively low (Table 5-1).

Cost
Energy requirements would be prohibitively high. AS infrastructure (AS wells, conveyance piping, electrical lines, SVE wells and piping, SVE treatment system[s]) costs would be high. The cost is considered relatively very high (Table 5-1).

Screening Determination
Physical processes are not retained in the FS as a process option for remedial alternatives.

5.5 Retained Remedial Technologies and Process Options

The results of the technology screening are summarized Table 5-1. From the list of technologies potentially applicable for remediating OU2 groundwater, many technologies were excluded from further consideration because they were considered less effective, not implementable, or too costly relative to the retained technologies. The main bases for screening the excluded technologies included:

- Inability to treat 1,4-dioxane;
- Potential for incomplete VOC degradation/byproduct generation;
- Incompatibility with OU2 access configuration and access and encumbrance limitations; and/or;
- Relatively high cost for little or no benefit in effectiveness or implementability over other technologies.

Based on the preceding section the following remedial technologies and process options are retained for development of remedial alternatives:

- No Action
- Institutional Controls
- Monitoring
- Containment with treated water discharge to:
  - POTW and GWRS, or
  - Injection into the Basal Sand of the Shallow Aquifer System
- Monitored Natural Attenuation
- ISCO using persulfate
- Sealing Legacy Water Supply Wells, if located

The Institutional Controls, Monitoring, and Sealing Legacy Water Supply Wells process options are not considered stand-alone remedial alternatives. However, each of these process options will be a part of any remedial alternative(s) implemented as IRMs for OU2.

6.0 DEVELOPMENT OF REMEDIAL ALTERNATIVES

The retained technologies and representative process options are combined in this section to formulate remedial alternatives.

6.1 Alternative Development Approach

USEPA guidance requires that a No Action Alternative be considered and compared to the Action alternatives (USEPA, 1988). The No Action Alternative does not include active remediation, institutional controls or monitoring at OU2. Excepting the No Action Alternative, remedial alternatives were assembled, some as sole remedies, and some by combining the remedial technologies and process options related to the containment and treatment GRAs. Each of the active alternatives also incorporates groundwater monitoring, institutional controls and sealing Legacy Water Wells, if located and accessible.

6.2 Remedial Alternatives

Institutional Controls, Monitoring, and Sealing Legacy Water Supply Wells process options are not considered stand-alone remedial alternatives, but each of these process options will be a part of any remedial alternative(s) applied as part of an OU2 IRM, excepting the No Action Alternative. Based on the retained process options, the following alternatives were developed to address OU2 IRM RAOs:

- Alternative 1 – No Action
- Alternative 2 – Monitored Natural Attenuation
- Alternative 3 – Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS
- Alternative 4 – Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to the Basal Sand
- Alternative 5 – In-Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation
- Alternative 6 – Containment and In-Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with discharge to POTW and GWRS

6.2.1 *Alternative 1 – No Action*

USEPA guidance requires that a No Action Alternative be considered and compared to the action alternatives (USEPA, 1988 and 1989). The No Action Alternative is therefore included as a baseline alternative and does not include active remediation, institutional controls, sealing Legacy Water Supply Wells, or monitoring at OU2. No cost is associated with this alternative. There are existing and planned/approved source site remedial actions, existing regulatory and statutory controls over groundwater extraction and use, existing or planned non-CERCLA response actions (i.e., cleanup under state orders or cessation of pumping by operators at water supply wells affected by VOCs), and natural attenuation. However, the lateral and vertical remediation or containment of the OU2 groundwater plumes downgradient of the source sites are not objectives of these source site remedial actions.

6.2.2 *Alternative 2 – Monitored Natural Attenuation*

Alternative 2 remedial actions would include comprehensive collection of groundwater samples from a substantial MNA monitoring network; laboratory and field analyses of relevant MNA analytes and parameters; and detailed evaluation of MNA data throughout OU2. As a stand-alone remedial alternative, a substantial number of additional monitor wells would be required. Collected data would be evaluated in accordance with guidance criteria to determine if MNA is an effective treatment option (USEPA, 1998 and 1999b). If determined to be an effective remedial alternative, a long-term monitoring plan would be developed and data collected pursuant to this monitoring plan would be periodically reevaluated to determine if MNA is performing as expected (USEPA, 2011).

6.2.3 *Alternative 3 – Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS*

Alternative 3 remedial actions would include installation of groundwater extraction wells screened in all or portions of Layers 1 through 3 within the Shallow Aquifer System and construction of an aboveground treatment system(s). As conceptually illustrated on Figure 2-3, this alternative would be applied at select and accessible locations within higher concentration and leading-edge areas of the plumes. Groundwater would be extracted in higher concentration areas to decrease lateral and vertical migration of high concentration COCs into zones with lower concentrations within OU2; decrease the threat of COC migration from the Shallow Aquifer System to the Principal Aquifer System through Legacy Water Supply Wells that cannot be located or properly destroyed; and begin to treat and reduce the concentration of COCs in groundwater. Groundwater would be extracted from leading-edge areas to control the spread of OU2 COCs and minimize discharge of COCs exceeding ecological risk-based concentration from the Shallow Aquifer System to surface water channels. Extracted groundwater would initially be treated using filtration to reduce sediment load and LGAC to reduce VOC concentrations, then discharged to the sewer and would ultimately be treated by the POTW and GWRS.

Groundwater monitoring would be conducted to evaluate performance of the containment system, maintain compliance with permits, plans, or orders, and to evaluate remediation progress. The groundwater monitoring program would be developed as part of the final IRM design. Access controls would be implemented around the treatment system(s) to communicate potential risks and exclude unauthorized access to the treatment building. O&M would consist of extraction well maintenance and redevelopment, and treatment system operations, monitoring and maintenance that would include filter and LGAC change out and disposal, equipment maintenance and repair, and process monitoring.

6.2.4 *Alternative 4 – Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to the Basal Sand*

Alternative 4 remedial actions would include installation of groundwater extraction wells screened in all or portions of Layers 1 through 3 within the Shallow Aquifer System; installation of injection wells screened in Layer 4 (Basal Sand) within the Shallow Aquifer System; and construction of an aboveground treatment system(s). As conceptually illustrated on Figure 2-3, this alternative would be applied at the same locations with effectively the same performance as Alternative 3. Extracted groundwater would initially be treated using UV light and hydrogen peroxide technology to reduce 1,4-dioxane to required treatment levels. Groundwater would then be passed through LGAC to treat the remaining COCs. Additional treatment to reduce total dissolved solids may also be performed. Treated water would then be injected into the Basal Sand.

Groundwater monitoring would be conducted to evaluate water quality, maintain compliance with permits, plans, or Orders, and to evaluate remediation progress. The groundwater monitoring program would be developed as part of the WDR Order M&RP that would be required for this alternative. The groundwater monitoring program would be developed as part of the final IRM design. Access controls would be implemented around the treatment system(s) to communicate potential risks and exclude unauthorized access to the treatment building. O&M would consist of extraction and injection well maintenance and redevelopment, and treatment system operations, monitoring and maintenance that would include chemical supply, LGAC change out and disposal/recycling, equipment maintenance and repair, and process monitoring. The groundwater monitoring program would be developed as part of this alternative.

6.2.5 *Alternative 5 – In-Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation*

Alternative 5 remedial actions would include installation of injection wells screened in all or portions of Layers 1 through 3 within the Shallow Aquifer System and periodic application of ISCO using persulfate. Dissolution of sodium persulfate results in the formation of the persulfate anion ($S_2O_8^{2-}$) and two sodium ions (Na^+). The persulfate anion ($S_2O_8^{2-}$) is a strong oxidant, which itself can degrade many environmental contaminants or it can be catalyzed with various reactants to form the more powerful sulfate radical.

Persulfate activation is required to convert the persulfate into the highly reactive persulfate anion radical, a very strong oxidant capable of destroying a wide range of contaminants. Selection of the persulfate activation method, however, depends on many factors, including the target contaminants, lithology, hydrogeology, and other specific site conditions, which can be conducted during the Pre-Design Investigation if an alternative using ISCO is part of the IRMs. The persulfate activator that will be included in the detailed evaluation is high pH (alkaline) activation, which is known to generate super oxide radicals, providing a source of reductive species capable of destroying, among other compounds, chlorinated ethenes. Alkalinity can also increase desorption of contaminants from soil surfaces or enhance dissolution of non-aqueous phase liquids (NAPLs) for better contact with the persulfate. The target pH for effective activation is in the range of 10.5 to 12. Sodium hydroxide (NaOH) often is used to adjust alkalinity for injection applications.

The mechanism for sodium persulfate oxidation of contaminants is direct oxidation and free radical formation. Direct oxidation utilizes the oxidation capacity of the persulfate ion itself, converting to the sulfate ion (SO_4^{2-}) upon reaction. This method is capable of oxidizing VOCs and other compounds. In these reactions, several byproducts, including carbon dioxide, sulfate, chloride, and hydrogen ions, are generated and released to the groundwater. These reaction byproducts are not expected to pose water quality problems, since most of the byproducts are either innocuous or will readily react with aquifer material and subsequently stabilize.

As conceptually illustrated on Figure 2-4, this alternative would be applied at select and accessible locations within higher concentration and leading-edge areas of the plumes. ISCO would be applied in transects within relatively high COC concentration area to decrease lateral and vertical migration of high concentration COCs into zones with lower concentrations within OU2; decrease the threat of COC migration from the Shallow Aquifer System to the Principal Aquifer System through Legacy Water Supply Wells that cannot be located or properly destroyed; and begin to treat and reduce the concentration of COCs in OU2 groundwater. ISCO would be applied in leading-edge areas to control the spread of OU2 COCs and minimize discharge of COCs exceeding ecological risk-based concentration from the Shallow Aquifer System to surface water channels. The repeated application and consequent reactive persistence of persulfate in the subsurface may result in diffusive transport of the oxidant into low permeability zones. This can be beneficial in reducing the effects of contaminant rebound that can occur when reverse matrix diffusion of contaminants occurs from low permeability strata (Parker, 2002). Persulfate density is greater than water and density-driven transport may generate greater lateral and vertical distribution of oxidants into the aquifer that could further enhance the contact between oxidants and contaminants. Persulfate persistence in the subsurface is directly proportional to its injected concentration and inversely proportional to the natural oxidant demand of the aquifer material and/or contaminants. Injection of persulfate at relatively higher concentrations would allow increased reactive persistence in the subsurface relative to injection of relatively lower concentrations.

Groundwater monitoring would be conducted to evaluate water quality, maintain compliance with permits, plans, or Orders, and to evaluate remediation progress. The groundwater monitoring program would be developed as part of the WDR Order M&RP that would be required for this alternative. O&M would include persulfate and potentially other chemical procurement, injection well maintenance, and periodic application of persulfate using the injection wells.

6.2.6 *Alternative 6 – Containment and In-Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with discharge to POTW and GWRS*

Alternative 6 remedial actions would include: installation of groundwater extraction wells screened in all or portions of Layers 1 through 3 within the Shallow Aquifer System; construction of an aboveground treatment system(s); installation of injection wells screened in all or portions of Layers 1 through 3 within the Shallow Aquifer System and periodic application of ISCO using persulfate. As conceptually illustrated on Figure 2-5, the ISCO portion of this alternative would be applied in OU2 at select and accessible high concentration areas within OU2, and the GET portion of this alternative would be applied at select and accessible locations within the remaining high concentration and leading-edge areas of the plume. ISCO and groundwater extraction would be applied to relatively high COC concentration areas to decrease lateral and vertical migration of high concentration COCs into zones with lower concentrations within OU2; decrease the threat of COC migration from the Shallow Aquifer System to the Principal Aquifer System through Legacy Water Supply Wells that cannot be located or properly destroyed; and begin to treat and reduce the concentration of COCs in OU2 groundwater. Groundwater would be extracted from leading-edge areas to control the spread of OU2 COCs and minimize discharge of COCs exceeding ecological risk-based concentration from the Shallow Aquifer System to surface water channels. The groundwater end-use would be determined based on the evaluations performed for Alternatives 3 and 4. The ISCO process would be similar to Alternative 5, although somewhat limited in scope.

Groundwater monitoring would be conducted to evaluate water quality, maintain compliance with permits, plans, or Orders, and to evaluate remediation progress as generally outlined for groundwater extraction and treatment/ISCO processes outlined in Alternatives 3 and 5, respectively.

7.0 DETAILED EVALUATION OF REMEDIAL ALTERNATIVES

This section presents an individual analysis of each of the six remedial alternatives presented previously in Section 6. Each of the alternatives is evaluated against seven of the nine NCP criteria. The last two NCP criteria, referred to as "modifying criteria," will be evaluated after the FS is complete.

7.1 NCP Criteria and Sustainability Assessment

The seven NCP evaluation criteria for which the six alternatives will be evaluated in this document are presented in this section. In addition, sustainability assessment has also been evaluated for each of the remedial alternatives (Section 7.1.3). The sustainability assessment was performed to maintain consistency with the NCP. Specifically, the USEPA Office of Solid Waste and Emergency Response (OSWER) *Principles for Greener Cleanups* was used and is referenced herein (USEPA, 2009), which states "OSWER cleanup programs should consider these Principles for Greener Cleanups during any phase of work, including site investigation, evaluation of cleanup options, and optimization of the design, implementation, and operation of new or existing cleanups." The sustainability assessment, like the Threshold and Balancing Criteria, should be used in the remedy selection process, although it may be considered in some instances to be a secondary consideration relative to the Threshold and Balancing Criteria. More detailed sustainability assessment will be conducted during the design phase to integrate green principles into the overall processes. The last two NCP criteria incorporate regulatory agency and community acceptance and will be conducted later (Section 7.1.4).

7.1.1 ***Threshold Criteria***

The first two NCP criteria are threshold criteria and the alternative must comply with them to be eligible for consideration as a remedy.

Overall Protection of Human Health and the Environment
This criterion assesses whether each alternative provides and maintains adequate protection of human health and the environment. Alternatives are assessed to determine whether they can adequately protect human health and the environment from unacceptable short- and long-term risks posed by OU2 COCs. This criterion is also used to evaluate how risks would be eliminated, reduced, or controlled through treatment, engineering controls, and/or institutional controls.

Compliance with ARARs
This criterion is used to determine if each alternative would comply with ARARs under federal environmental laws and state environmental or facility siting laws, or whether invoking waivers to specific ARARs is justified. Other information identified as TBC criteria, such as advisories, criteria, or guidance, is considered where appropriate during the ARARs analysis. Potential action-, location-, and chemical-specific ARARs for the alternatives presented in this FS are identified in Appendix B.

7.1.2 ***Balancing Criteria***

The balancing criteria are used to evaluate the relative advantages and disadvantages of each remedial alternative.

Long-Term Effectiveness and Permanence
This criterion addresses the ability of an alternative to maintain reliable protection of human health and the environment over time once clean-up objectives have been achieved. The primary components of this criterion are the magnitude of residual risk remaining in OU2 groundwater after remedial objectives have been met and the extent and effectiveness of controls that might be required to manage the risk posed by treatment residuals and untreated wastes.

Reduction of Toxicity, Mobility, or Volume through Treatment
This criterion addresses the degree to which alternatives employ treatment or recycling technologies that permanently and significantly reduce the toxicity, mobility, or volume (TMV) of hazardous materials in OU2 groundwater. The NCP expresses EPA's preference for remedies where treatment is used to reduce the principal threats at a site through destruction of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media.

Short-Term Effectiveness
This criterion considers the effect of each alternative on the protection of the community, workers and the environment during the construction and implementation process. The short-term effectiveness evaluation addresses protection during implementation of the IRM prior to meeting the RAOs of the final remedy.

Implementability
This criterion evaluates the technical feasibility and administrative feasibility (i.e., the ease or difficulty) of implementing each alternative and the availability of required services and materials during its implementation.

Cost
This criterion evaluates the cost of implementing each alternative. The cost of an alternative encompasses engineering, construction, and O&M costs incurred over the life of the project. This includes both short-term capital costs and long-term O&M costs.

The cost estimates include capital and annual O&M costs, as well as net present value (NPV). The NPV allows costs for remedial alternatives to be compared by discounting all costs to the year that the alternative is implemented. For estimating NPV, a 30-year period of operation has been assumed. The remedial alternatives may extend beyond 30 years. For all alternatives, the NPV was calculated using the discount rate of 2.5 percent, which was provided by OCWD. The 2.5 percent discount rate is based on OCWD's financial personnel input and is the typical current discount rate used by OCWD for assessing longer-term projects (Appendix S).

7.1.3 ***Sustainability Assessment***

In addition to the seven NCP criteria, each alternative is also evaluated using the concept of sustainability by estimating its consumption and reuse of raw materials (including treated groundwater and wastewater), energy consumption, and greenhouse gas (GHG) emissions associated with different treatment technologies (Appendix C). The sustainability assessment was performed to maintain consistency with the NCP. Specifically, the USEPA OSWER *Principles for Greener Cleanups* was used and is referenced herein (USEPA, 2009), which states "OSWER cleanup programs should consider these Principles for Greener Cleanups during any phase of work, including site investigation, evaluation of cleanup options, and optimization of the design, implementation, and operation of new or existing cleanups." This assessment evaluates the degree to which the remedial alternative can be viewed as "green" from the perspective of improving environmental conditions. However, the use of energy, materials, and resources for the cleanup activities creates its own environmental footprint. The assessment and optimization of the cleanup to minimize its environmental impact is referred to as "green cleanup assessment." The OSWER policy cites the following five elements of a green cleanup assessment that are assessed for each alternative (USEPA, 2009):

- Total Energy Use and Renewable Energy Use
- Air Pollutants and Greenhouse Gas Emissions
- Water Use and Impacts to Water Resources
- Material Management and Waste Reduction
- Land Management and Ecosystems Protection

The Land Management and Ecosystem element focuses on minimizing areas requiring activity or use limitations (e.g., destroy or remove contaminant sources); minimizing unnecessary soil and habitat disturbance or destruction; using native species to support habitat; and minimizing noise and lighting disturbance. Since these items either are addressed by or are not applicable to the individual remedial alternatives presented herein, this element was not evaluated. The Water Use for the alternatives evaluated herein are similar and low. The Impacts to Water Resources regarding water quality are summarized in the evaluation of the effectiveness of each remedial alternative. The Impacts to Water Resources regarding water quantity have not been assessed; however, Alternatives 1 and 2 use no and little water, respectively; Alternatives 3, 4, and 6 extract groundwater, but return the majority of it to the groundwater resource through recharge; and, Alternative 5 also effectively returns utilized water to the groundwater resource through injection.

The SiteWise™ Tool for Green and Sustainable Remediation was used to evaluate and semi-quantitatively rank the sustainability of each of the remedial alternatives (Naval Facilities Engineering Command, Engineering and Expeditionary Warfare Command [NAVFAC], 2018) (Appendix C). SiteWise is designed to calculate the environmental footprint of remedial alternatives generally used by the industry. The tool is a series of Excel sheets and provides a detailed baseline assessment of several quantifiable sustainability metrics including: GHGs; energy usage; electricity usage from renewable and non-renewable sources; criteria air pollutants that include sulfur oxides (SOx), oxides of nitrogen (NOx), and particulate matter (PM); water usage; resource consumption; and accident risk. SiteWise was jointly developed by Battelle, U.S. Navy, and U.S. Army Corps of Engineers (USACE).

For the purposes of this document, the SiteWise evaluation was limited to selected well construction and treatment system construction activities (piping installation, treatment system construction) and O&M activities (i.e., groundwater monitoring and treatment system O&M)

The assessment is carried out using a building block approach where each remedial alternative is first broken down into modules that can represent generic components of an alternative or mimic the remedial phases in most remedial actions, including remedial action constructions, and long-term remedial action operation / long-term monitoring. Once broken down into various modules, the footprint of each module is calculated individually. The different footprints are then combined to estimate the overall footprint of the remedial alternative. SiteWise can be applied at the remedy selection, design, or implementation stage (NAVFAC, 2018).

Since the remedial action alternatives use similar technologies, the sustainability assessment focused on the relative comparison of the environmental impacts between the alternatives. The sustainability assessment will be revisited at the Remedial Design (RD) phase and sustainable remediation principles will be integrated into the design and operation of the selected remedial alternative once the IRMs are selected. The environmental footprint assessment of each alternative is preliminary during the FS and development of remedial alternatives. One objective during the RD phase is to reduce to the maximum extent practicable, the environmental footprint of the selected remedy with the goal of protecting human health and the environment. Detailed engineering studies will be conducted to optimize the components of the selected alternatives (for example, not just to reduce the initial cost of pipeline installation, but to account for energy usage (pumping power costs) associated with different pipeline materials (e.g., use smaller versus larger pipe sizes, use of smoother pipeline materials to reduce pressure losses, etc.). The design will include consideration of extensive use of lower energy consuming equipment, as well as solar panels to produce onsite power to offset facility power requirements from the local power supplier. In addition, consideration will be given to procurement of electrical power from greener source suppliers. Emerging technologies and changes in the economic environment at the time of RD will also be considered in order to minimize the environmental footprint of the selected remedy.

7.1.4 ***Modifying Criteria***

The last two NCP criteria, Regulatory Agency Acceptance and Community Acceptance, referred to as "modifying criteria," will be evaluated and the results will be presented in the Proposed Interim Remedial Action Plan and Responsiveness Summary (IRAP) and the Community Involvement Plan Implementation activities and documents.

<u>Regulatory Agency Acceptance</u>
Considers whether the state regulatory agencies agree with the analyses and recommendations, as described in the RI, FS, IRAP, and the Community Involvement Plan implementation activities and documents. Regulatory agencies, including the RWQCB, DTSC, and State Water Board DFA, are members of the TAC that provided technical input and review during the development of the RI and FS. Following agency acceptance of the Supplemental RI report in February 2021, TAC meetings continued to be held to discuss agency comments on the ARARs presented in the FS (Appendix B), screening of remedial technologies, and identification and evaluation of remedial alternatives described in the FS. TAC meeting minutes, agency comments, and responses to comments on the development of the FS are presented in Section 1.0 and Appendices H through U. Further agency engagement and input is planned during the future development of the proposed IRAP.

<u>Community Acceptance</u>
Considers whether the local community agrees with the analyses and preferred alternative. Following solicitation, review, and preparation of responses to comments on the

Supplemental RI report in 2020-21, engagement with the community continued during the FS development through the SAG and community outreach meetings, as well as review of the Draft OU2 FS Report. The SAG members include local city officials, water agencies, business and community groups, environmental interests, and current or former property owners (including their legal representatives and environmental consultants). Section 1.0 describes opportunities offered to the community to learn about the FS and to review and comment on the Draft OU2 FS Report. Responses to stakeholder comments on the Draft OU2 FS Report are provided in Appendix V. Further community engagement and input is planned during the future development of the proposed IRAP. This engagement will include at least one public meeting, review of the proposed IRAP, and Responsiveness Summary regarding comments received, all of which will be documented.

7.2 Detailed Evaluation of Remedial Alternatives

The following six remedial alternatives for OU2 IRMs are included in the detailed analysis presented in this section:

- Alternative 1 – No Action
- Alternative 2 – Monitored Natural Attenuation
- Alternative 3 – Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS
- Alternative 4 – Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to the Basal Sand
- Alternative 5 – In-Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation
- Alternative 6 – Containment and In-Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with Discharge to POTW and GWRS

Table 8-1 summarizes the general response actions and process options included in each of the six remedial alternatives described herein.

The results of the individual evaluations presented in this section will provide the basis for comparative analysis in Section 8.0. The remedial alternatives will be compared to one another with respect to their ability to meet the NCP criteria and to achieve the IRM RAOs for OU2 groundwater. This comparison of alternatives will provide the required information for selecting the remedial alternative for achieving these objectives.

7.2.1 *Scope of Alternatives and Common Elements*

Descriptions of the six remedial alternatives were presented in Section 6.0. Additional details regarding Alternatives 2 to 6 are presented in Section 7.2.3. This information was used to develop the feasibility study cost estimates presented in the respective sections.

Since restrictions on groundwater use/exposure will be required until each remedy achieves the final remedy RAOs, the Institutional Controls, Monitoring, and Sealing Legacy Water Supply Wells process options will be a part of any OU2 IRMs. Costs for Institutional Controls and Sealing Legacy Water Supply Wells are common to Alternatives 2 to 6. Since each of these costs are expected to be similar for each of these alternatives, an assumed placeholder cost of $50,000 per year for these activities was incorporated into the overall estimate for Alternatives 2 to 6. The level of effort for groundwater monitoring varies for the different remedial alternatives; therefore, the estimated costs based on scope of groundwater monitoring and reporting have been included in the estimated total costs for each of the remedial alternatives. The costs of CERCLA statutory 5-year remedy reviews were assumed to be the same for Alternatives 2 to 6 at $100,000 per event, starting 5 years after construction of the respective alternative is complete.

Alternatives 2 to 6 will require a PDI to support more specific design aspects of the respective alternative. For the purposes of this document, PDI for Alternatives 2 to 6 includes installation of associated groundwater monitor wells. Additional PDI tasks would likely include sampling and hydraulic testing for Alternatives 2 to 6 and possibly some bench testing (for Alternatives 4 to 6). The cost estimate for PDI for Alternatives 2 and 3 consists of monitor well installation and a rough order of magnitude cost ($1,000,000 placeholder) for sampling, hydraulic testing, and document preparation. The cost estimate for PDI for Alternatives 4 to 6 also consists of monitor well installation and a rough order of magnitude cost ($1,500,000 placeholder) for sampling, hydraulic testing, bench testing, and document preparation.

Feasibility study cost estimates incorporate unit rates that were developed from multiple sources including: rough budgetary estimates from suppliers; professional experience/judgement with similar projects; published cost estimates for similar processes; and/or web-based research. The detailed cost estimates and source of estimate are contained in Appendix D. To the extent practical, the cost estimates attempt to incorporate coordination, permitting, security, utility clearance, traffic control, materials, equipment, and staff to implement the identified activities. It is important to recognize that the cost estimates prepared for the FS are meant to provide a comparative analysis between alternatives and provide a rough order of magnitude estimate of cost, and as such, should not be used for budgetary purposes.

7.2.2 *Incorporation of RWQCB Data Gap Analysis*

The RWQCB provided an evaluation of groundwater monitoring data gaps (RWQCB data gaps) as part of their review of the SRI in their *Summary of Data Gaps for the Supplemental Remedial Investigation Report – Orange County South Basin Groundwater Protection Project, Operable unit 2 (Grant Agreement No. D1712505)* (RWQCB, 2019) (Appendix G). The RWQCB and the SWRCB have indicated that the SRI is complete and final (EA, 2021; OCWD, 2020) and therefore there are no data gaps related to the RI. However, and as indicated in the response to comments for the SRI (EA, 2021a), the COC distribution maps presented in the SRI and provided herein are further evaluated in relation to the ongoing or planned source site remedial efforts. This evaluation is used to identify potential data gaps associated with the Preliminary Design Investigation (PDI) or initial capital cost construction phases of IRMs for Alternatives 2 through 6. There is overlap between the RWQCB data gaps and the IRM data gaps described herein. Thus, the following sections describe areas where the RWQCB data gaps overlap with the IRM data gaps and the

RWQCB data gaps could be addressed in whole or part by implementation of Alternatives 2 through 6.

The level of effort to select specific locations and depths of data gap monitor wells can be high and is reserved for the selected alternative during the Remedial Design phase of work. The level of effort to develop and present detailed data gap evaluation in this document for each alternative would not add commensurate value or influence comparison and selection of an alternative. All of the alternatives presented herein include a substantial number of monitor wells as summarized in Table 7-1. For groundwater extraction alternatives, extraction well monitoring data will also be collected, which substantially increases the monitoring data for these alternatives. The RWQCB data gaps that are not addressed in this document will be reviewed prior to conducting the PDI to assess relevancy to the selected alternative. The information developed during the PDI will inform and close data gaps for the selected alternative, and there may be data gaps that become more apparent during implementation of the remedy which will be evaluated during 5-year remedy reviews.

The following summarizes RWQCB data gaps that could be addressed in whole or part by implementation of the MNA alternative (Alternative 2) and the alternatives that incorporate an active remedial technology (Alternatives 3 to 6). For ease of reference, the numbers in parentheses in the following bullet items are from RWQCB (2019).

For Alternative 2, additional groundwater assessment/monitor well installation and monitoring would be performed by OCWD as part of the IRM PDI or initial capital construction phases at the following sites:

<u>Bell Industries Off-Site (2)</u>

- Further delineation is needed vertically and laterally near MW-24 and -24C stepping out laterally to the west, and downgradient to the southwest (Area 2, Figure 7-1).
- Further delineation is needed vertically and laterally south of Bell Industries and adjacent to the 55 Freeway near CPT-15, -114, -17, and -111. Since 2012, no data has been collected, therefore, the extent of the comingled COC plume may have migrated beyond the contour boundary and may be impacting sites south of the 55 Freeway (Area 2, Figure 7-1).

<u>Holchem and Circuit One (5)</u>

- The area bounded to the west by Holchem/Embee Plating, to the south by E Warner Avenue, to the east by Circuit One, and to the north by Barlen Enterprises (Area 1, Figure 7-1).

<u>Area Bounded by S. Grand Avenue, E. Warner Avenue and the 55 Freeway (7)</u>

- Since 2012, no data has been collected in the area near CPT-115, 116B, and 117, therefore, this area needs further delineation vertically and laterally. The upgradient contributions have not been fully defined for target COCs, especially for TCE, 1,1-DCE and 1,4-dioxane. Therefore, the depicted plume boundaries may have merged and/or migrated vertically and laterally since its initial assessment (Area 2, Figure 7-1).

Cherry Aerospace Off-Site (8)

- CPT data has been collected in 2012 and 2015; however, no data has been collected since. Further delineation is needed both vertically and laterally for the following location: West of Cherry Aerospace and north of SAM-4 (Area 4, Figure 7-1).

ITT Cannon (9)

- Further delineation is needed vertically and laterally between SAM-5 and SAM-6, and-near CPT-123, 124, and 190. Nearby monitoring wells MW-45B (44.3-59.3 ft bgs) and MW-17A/B (5-25 and 30-35 ft bgs) do not fully capture the shallow contamination from approximately 0-60 ft bgs and to a lesser extent do not capture the leading edge of the COCs plume from approximately 60 ft bgs-Basal Sand as depicted in the figures (Area 4, Figure 7-1).

West of intersection of Redhill Avenue and Alton Parkway (13)

- Area vertically and laterally West of Redhill Avenue and South of Alton Parkway (Area 5, Figure 7-1).

South of the intersection of Redhill Avenue and Gillette Avenue (14)

- The eastern edge of the plume between Gillette Avenue and Armstrong Avenue (near SAM-10 and north of Baxter Healthcare) has not been delineated for all COCs. The Former Standard Screw Products Site (1712 Langley Avenue, Irvine, CA 92714) will provide some groundwater monitoring data; however, further delineation is necessary and this area remains a data gap (Area 6, Figure 7-1).
- In addition, no data exists from 0-36.5 ft bgs in the vicinity of SAM-10A (36.5-46.5 ft bgs) and step-out borings have not delineated potential downgradient impacts. CPT-170 (18-22 and 27-31 ft bgs) had detectable concentrations of all COCs within this shallow zone (Area 8, Figure 7-1).

South of the 55 Freeway and MacArthur Blvd (15)

- The southern edge of the plume has not been fully delineated vertically and laterally and presents a data gap. Since 2012, no data has been collected south of the intersection of MacArthur and the 55 Freeway, therefore, the extent of the commingled COC plume may have migrated beyond the contour boundary since the time the groundwater grab samples were obtained. Data gaps exist at the leading edge of the plume near CPT-147, 148, 160, 159, and 157 (Area 7, Figure 7-1).

Baxter Healthcare and Edwards Lifesciences Off-Site (16)

- Further delineation of the leading edge of the plume is needed vertically and laterally located to the west of MacArthur Blvd, bounded by Redhill Avenue and Main Street, and in the general vicinity of CPT-174 (Area 6, Figure 7-1).
- Further delineation of the plume is needed vertically and laterally to the east of MacArthur Blvd, bounded by Redhill Avenue and Main Street, and in the general vicinity of CPT-156, 175, 176, and 184. The leading edge of the plume has not been delineated for all COCs. In addition, SAM-9A (37.5-42.5 ft bgs) does not address shallow contamination from 0-37.5 ft bgs. The sites at the southern edge of the project Study Area include Olen Properties (2031 Main Street, Irvine, CA 92714) and Deft Chemical Coating, Inc. (17451 Von

Karman Avenue, Irvine, CA 92714) which have groundwater monitoring data that may further define the downgradient extent of the contaminants (Area 8, Figure 7-1).

For Alternatives 3, 4, 5, and 6 additional groundwater assessment/monitor well installation and monitoring would be performed by OCWD as part of the IRM PDI or initial capital construction phases at or near the following sites:

<u>Steelcase Off-Site (4)</u>

- South of Steelcase Incorporated and Pullman Street (Area 3, Figure 7-2/3/4/5).

<u>Area Bounded by S. Grand Avenue, E. Warner Avenue and the 55 Freeway (7)</u>

- Since 2012, no data has been collected in the area near CPT-115, 116B, and 117, therefore, this area needs further delineation vertically and laterally. The upgradient contributions have not been fully defined for target COCs, especially for TCE, 1,1-DCE and 1,4-dioxane. Therefore, the depicted plume boundaries may have merged and/or migrated vertically and laterally since its initial assessment (Area 1, Figures 7-2 through 7-5).

<u>Cherry Aerospace (8)</u>

- CPT data has been collected in 2012 and 2015; however, no data has been collected since. Further delineation is needed both vertically and laterally for the following location: west of Cherry Aerospace and north of SAM-4 (Area 1, Figures 7-2 through 7-5).

<u>Intersection of 55 Freeway and East Dyer Road (11)</u>

- Further delineation is needed vertically and laterally in the vicinity of SAM6, CPT-168, CPT-171, and west of 7-MW-5.
    - Approximatively 0-60 ft bgs:
        - The eastern extent of the TCE and PCE plumes near CPT-171 have not been defined.
        - The leading edge of the 1,1-DCE and 1,4-dioxane plume near CPT-168 has not been delineated. There is the potential for the 1,1-DCE and 1,4-dioxane plumes emanating from the general areas, of Holchem, Universal Circuits/Bell Industries and Steelcase to have comingled since the collection of water quality samples in 2012.
    - Approximately 60 ft bgs-Basal Sand:
        - The leading edge of the 1,1-DCE and 1,4-dioxane plume near CPT-168 has not been delineated. There is the potential for the 1,1-DCE and 1,4-dioxane plumes emanating from the general areas of Holchem, Universal Circuits/Bell industries, and Steelcase to have comingled since the collection of water quality samples in 2012 (Area 4, Figures 7-2 through 7-5).

<u>West of intersection of Redhill Ave and Alton Parkway (13)</u>

- Further delineation is needed vertically and laterally for all COCs in between CPT-141 and CPT-186 (Area 5, Figures 7-2 through 7-5).

South of the intersection of Redhill Avenue and Gillette Avenue (14)

- The eastern edge of the plume between Gillette Avenue and Armstrong Avenue (near SAM-10 and north of Baxter Healthcare) has not been delineated for all COCs. The Former Standard Screw Products Site (1712 Langley Avenue, Irvine, CA 92714) will provide some groundwater monitoring data; however, further delineation is necessary and this area remains a data gap (Area 6, Figures 7-2 through 7-5).

South of the 55 Freeway and MacArthur Blvd (15)

- The southern edge of the plume has not been fully delineated vertically and laterally and presents a data gap. Since 2012, no data has been collected south of the intersection of MacArthur and the 55 Freeway, therefore, the extent of the comingled COC plume may have migrated beyond the contour boundary since the time the groundwater grab samples were obtained. Data gaps exist at the leading edge of the plume near CPT-147, 148, 160, 159, and 157 (Area 7, Figures 7-2 through 7-5).
- In addition, SAM-8A is screened from 33-43 ft bgs and does not address shallow contamination from 0-33 ft bgs.

Baxter Healthcare and Edwards Lifesciences Off-Site (16)

- Further delineation of the plume is needed vertically and laterally to the east of MacArthur Blvd, bounded by Redhill Avenue and Main Street, and in the general vicinity of CPT-156, 175, 176, and 184. The leading edge of the plume has not been delineated for all COCs. In addition, SAM-9A (37.5-42.5 ft bgs) does not address shallow contamination from 0-37.5 ft bgs. The sites at the southern edge of the project Study Area include Olen Properties (2031 Main Street, Irvine, CA 92714) and Deft Chemical Coating, Inc. (17451 Von Karman Avenue, Irvine, CA 92714) which have groundwater monitoring data that may further define the downgradient extent of the contaminants (Area 8, Figures 7-2 through 7-5).

7.2.3 ***Remedial Alternatives***

The following sections describe the remedial alternatives developed within this document. Except Alternative 1 (No Action), Institutional Controls, Monitoring, and Sealing Legacy Water Supply Wells process options would be a component of all applied IRMs, and they would all provide a similar measure of protectiveness to human health and the environment as a component of each alternative.

7.2.3.1 Alternative 1 – No Action

The No Action Alternative is the baseline to which all other alternatives are compared. There is no monitoring. It does not comply with ARARs nor is it protective of human health and the environment. As a result, there is no need to evaluate the No Action Alternative to the modifying criteria. In addition, No Action is not an active remedy and does not include 5-year reviews because there is no action; therefore, there is no cost associated with this alternative. This alternative is required by the NCP for detailed analysis as a baseline for comparison of the risks and costs of the other alternatives.

Overall Protection of Human Health and the Environment
The No Action Alternative does not include any Institutional Controls to prevent exposure to the contaminated site groundwater, and there is no way to monitor migration of the OU2 contaminant plumes. Thus, this alternative would not be sufficiently protective of human health or the environment because this alternative would not meet the basic threshold criteria of protecting human health and the environment, and there is documented excess risk associated with the site groundwater.

Compliance with ARARs
In the context of an IRM and since no action is taken, there are no chemical-specific ARARs identified for Alternative 1. Likewise, there are no location-specific or action-specific ARARs associated with this alternative. This alternative would not satisfy the USEPA preference for treatment in accordance with 40 CFR Part 264.

Long-Term Effectiveness and Permanence
The No Action Alternative would allow continued migration of COCs in groundwater with some potential reduction from natural attenuation processes; however, its effectiveness cannot be determined without groundwater monitoring. Without the implementation of Institutional Controls, the potential risk of using contaminated groundwater for drinking or other purposes would remain.

Reduction of Toxicity, Mobility, or Volume
In the No Action Alternative there would be no active treatment process for the contaminated groundwater. Therefore, TMV would not occur through treatment and any TMV reduction would be related to potential natural attenuation processes. The extent or the rate of reduction would not be known without a groundwater monitoring program. This alternative would not satisfy the statutory preference for treatment as a principal element of a remedial action.

Short-Term Effectiveness
Since no remedial action is performed, there is no additional short-term exposure to Site workers, residents, or the environment.

Implementability
The No Action Alternative can be easily implemented.

Cost
The present value cost of Alternative 1 is $0.

Sustainability Assessment
Since no remedial action is performed, a sustainability assessment is irrelevant.

7.2.3.2 Alternative 2 – Monitored Natural Attenuation

Alternative 2 would include installation of monitor wells within the IRM areas, followed by long-term MNA monitoring. MNA monitoring would be used to track the rate at which natural destructive and nondestructive processes are reducing OU2 groundwater COCs. Figure 7-1 illustrates conceptual MNA groundwater monitoring areas This alternative would include the capital costs of installing an MNA monitoring network, and the O&M costs associated with sampling, reporting, signage installation, and 5-year reviews, which would be performed until RAOs for the final remedy are achieved.

Natural attenuation includes a number of physical, biological, and chemical processes that reduce the mass, toxicity, mobility, and concentration of contaminants without human intervention. These naturally occurring processes of biodegradation, volatilization, dispersion, and dilution can reduce contaminant concentration to acceptable levels, given enough time. MNA is a process option that evaluates and tracks the rate at which these natural processes are occurring. As stated in the EPA documents on MNA, destructive processes (biodegradation, abiotic degradation) are preferred over passive physical processes such as dilution (EPA 1998, 1999b).

MNA is often used as a follow up or combined remedy with other treatment technologies. MNA is seldom used as a stand-alone remedy for individual plumes, especially with the combination and concentrations of COCs in OU2 groundwater. The following detailed evaluation assumes MNA as a stand-alone remedy and does not preclude the use of MNA as a follow up remedy to other treatment technologies in this evaluation.

As stated in Section 5.4.7.1, MNA has not and cannot prevent continued migration of COCs in OU2. The first line of evidence (historical mass reduction) has not been met. The SRI included statistical Mann-Kendall trend analysis (H+A, 2020; Figures 5-19a through 5-19d). The results showed that in the groundwater between land surface and 100 feet in depth, the trends for COCs at concentrations above screening levels were overwhelmingly increasing.

The second line of evidence (hydrogeologic or geochemical data) also has not been met. As stated in the EPA MNA documents, destructive degradation mechanisms are preferred over passive, physical mechanisms. Biodegradation of chlorinated COCs has occurred at or downgradient of source sites where chlorinated COCs were co-released with other chemicals (e.g., methylene chloride, toluene, xylene) that can serve and appear to have served as electron donors for reductive dechlorination (e.g., Holchem) or where active ISB was performed (e.g., ITT). However, at both of these examples, significant concentrations of more mobile and/or more toxic daughter biodegradation products (cis-DCE and vinyl chloride) can or have been produced and still remain at concentrations ten to one thousand times above screening levels (Figures 1-28 through 1-31). Cis-DCE and vinyl chloride have been detected in greater than 25 percent and 10 percent of all samples, respectively (SRI, Table 5-4). At the other sites with chlorinated COCs where no ISB has been performed or there were no significant co-releases of potential electron donors, the geochemistry is not suitable for the anaerobic processes that completely biodegrade chlorinated COCs to occur. The only significant degradation reaction that has occurred is the complete abiotic degradation of 1,1,1-TCA to 1,1-DCE resulting in a mass loss of approximately 27 percent. However, the screening level for 1,1-DCE is approximately 35 times lower than that of 1,1,1-TCA.

The geochemistry is also not suitable for the degradation of perchlorate or transformation of chromium to a non-toxic form. Perchlorate has been detected at concentrations exceeding the drinking water MCL for the most part in an area outside the IRM areas (Figures 1-22 to 1-25). Hexavalent chromium was detected at concentrations exceeding the current drinking water MCL for total chromium and the former California drinking water MCL in relatively isolated areas within the Study Area (Figures 1-36 to 1-39). In general, the hexavalent chromium detected in the middle of the northern portion of the Study Area appears to be related to releases at one or more facilities and the detection in the southern portion of the Study Area appears to be related to ISCO applications as part of source site remediation.

1,4-dioxane has been detected in greater than 60 percent of all samples collected from the Study Area (H+A, 2020; Table 5-4). The literature indicates that biodegradation of 1,4-dioxane has been observed to occur under aerobic conditions at many other sites (unrelated to the Study Area), but not all (Adamson et al., 2015; Zhang et al., 2016; Adamson et al., 2021). Although slightly aerobic conditions exist in the shallow aquifer, the length of the 1,4-dioxane plumes (greater than several thousand feet) indicates the 1,4-dioxane plumes are not being controlled by natural biodegradation or any other destructive process (Figures 1-18 through 1-21).

Laboratory microcosm studies (third line of evidence) or field studies (other than active ISB) do not appear to have been performed at source sites.

Overall Protection of Human Health and the Environment

Alternative 2 would not effectively prevent migration of nor prevent further degradation of COCs in OU2 groundwater and would not prevent COCs exceeding ecological receptor thresholds from potentially discharging into surface waters, excepting that which would be accomplished through natural attenuation processes. However, an institutional control requiring any party proposing the installation and operation of water supply wells in the Study Area to apply for a well construction permit from the OCHCA is currently in place as a County ordinance. An additional institutional control that can feasibly be implemented is notification of OCWD, RWQCB, DTSC, and water suppliers in the Study Area by OCHCA of any water supply well construction permit applications. Such notification would allow communication between the agencies and the applicant with the goals of preventing human exposure to COCs and avoiding interference with OU2 IRMs and source site remedial measures. Maintaining a prohibition on the use of groundwater for potable purposes within OU2, without appropriate notification and planning will provide protection to human health by minimizing the risk of exposure to OU2 COCs in groundwater.

Compliance with ARARs

In the context of an IRM and since there is no active remediation being implemented, there are no chemical-specific ARARs identified for Alternative 2; however, in context of transitioning IRM to final remedy, this alternative would not comply with the chemical-specific ARARs associated with the state and federal MCLs for OU2 groundwater COCs in a reasonable timeframe. Alternative 2 would comply with potential action-specific ARARs because the remedy is limited to installation of monitor wells and associated monitoring in the potential areas where this alternative could be applied. Alternative 2 complies with location-specific ARARs. This alternative would not satisfy the USEPA preference for treatment in accordance with 40 CFR Part 264.

Long-Term Effectiveness and Permanence

Institutional Controls would be effective in preventing or reducing human exposure to contaminated groundwater through restrictions on potable uses and requiring controls and/or permits on water supply well installation activities. However, this alternative is not considered an effective long-term process option for OU2, since natural attenuation processes would not be likely to achieve IRM RAOs within a reasonable timeframe due to the natural conditions of the subsurface showing limited evidence of COC degradation.

Reduction of Toxicity, Mobility, or Volume
Alternative 2 would not accelerate the reduction in the TMV of OU2 groundwater COCs in relation to active treatment alternatives. The TMV of OU2 COCs would diminish solely as a result of natural attenuation processes, which have been shown to be slow as a result of the site geochemistry (i.e., low pH, high ORP, lack of electron donor).

Short-Term Effectiveness
Although the short-term effectiveness of Institutional Controls would be satisfactory to prevent human exposure to OU2 groundwater COCs, there would be minimal reduction of OU2 COC migration. All construction activities would take place within developed areas and with minimal expected impacts to the environment. Alternative 2 has a small potential for short-term exposure of Site workers to COCs during installation and monitoring of groundwater monitor wells. However, the potential for short-term exposure is reduced by using appropriate work procedures and controls. During remedy construction, noise and dust abatement along with appropriate traffic control would be required to protect the community during the remedy implementation. Standard and/or Hazardous Waste Operations and Emergency Response (HAZWOPER) OSHA requirements would be protective of workers during the construction and monitoring activities.

Implementability
Because MNA requires only construction of monitor wells and monitoring, it is relatively easy to implement, requiring relatively less infrastructure compared with other process options, which is ideal for a highly developed area like OU2. MNA monitor wells would be installed on privately owned, non-source site properties and/or public ROWs. As a stand-alone process option, MNA would require a substantial number of monitor wells and a very large monitoring network compared with other process options, which could complicate implementability.

Alternative 2 would be applied without any disruption to the previous, ongoing, or planned source site remedial efforts.

Cost
The following outlines the major scope elements associated with capital and operations, maintenance and monitoring (OMM) costs for Alternative 2 which have been used to estimate the feasibility level cost estimates. Capital costs for this alternative include installation of monitor wells. Appendix D provides the detailed assumptions and cost estimates for this alternative.

Installation and Testing of Monitor Wells: Monitor wells would be required as a component of Alternative 2 to monitor the effectiveness of this remedy. Figure 7-1 illustrates conceptual monitoring areas associated with Alternative 2 and Table 7-1 provides an estimate of the number of monitor wells that would be required to implement this alternative. The distributions of COCs in each monitoring area (Figures 1-6 through 1-39) were evaluated to estimate the number of monitor wells that conceptually would be required in each of Layers 1 through 4 to adequately monitor MNA processes and remediation progress.

Monitoring and Reporting: The MNA monitoring analytical schedule would include collection of groundwater samples from all MNA monitor wells for analysis of the compounds/constituents/parameters specified in Table 7-2.

Cost Estimate: Detailed cost estimates and the assumptions used to generate them for all remedial alternatives are provided in Appendix D. The total NPV costs associated with Alternative 2 are $24,600,000 over an assumed 30-year project lifetime and are summarized as follows:

Cost Analysis for Alternative 2 – Monitored Natural Attenuation

Total Project Lifetime	30 Years
Capital (Year 1)	$5,200,000
OMM Costs, Years 2 to 30	$26,400,000
Total Capital and OMM NPV (2.5% discount rate)	$24,600,000

Sustainability Assessment
The SiteWise Tool for Green and Sustainable Remediation was used to evaluate and semi-quantitatively rank the sustainability of each of the remedial alternatives (NAVFAC, 2018) (Appendix C). The overview of carbon dioxide (CO_2) emissions, and total energy and electricity used for the construction (PDI and construction) and OMM components are summarized in the following table:

Metric	**Construction**	**OMM**	**Total**
CO_2 Emissions (metric tons)	880	91	970
Total Energy Used (million British Thermal Units)	280,000	1200	280,000
Total Electricity Used (Mega Watt Hours)	0	0	0

7.2.3.3 Alternative 3 – Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS

Alternative 3 comprises installation of groundwater extraction wells and conveyance piping, filtration to reduce sediment load, discharge to the sewer, and treatment by the POTW (OCSD Plant 1) and GWRS. The POTW treatment includes preliminary, primary, and secondary treatment (including screening, clarification, activated sludge process, trickling filters, clarifiers, biological treatment to break down organic matter, and settling tanks). Extracted groundwater would be treated using filtration to reduce sediment load and LGAC to reduce VOC concentrations. Treated water would then be discharged to the sewer and conveyed to the POTW and GWRS. All secondary effluent from the POTW flows to the GWRS where it is treated using a three-step advanced process: microfiltration, reverse osmosis, and ultraviolet light with hydrogen peroxide, producing high quality purified water that meets or exceeds state and federal drinking water standards. GWRS product water goes to the Talbert seawater intrusion barrier (protecting groundwater), mid-basin injection wells, or groundwater recharge basins.

Figure 7-2 illustrates the conceptual groundwater containment alignments where groundwater extraction wells would be installed and operated. COCs present in the targeted layers would be extracted, contained, and treated during treatment by the POTW and GWRS. Groundwater would be hydraulically contained by pumping extraction wells.

This alternative would include the capital costs of installing groundwater extraction and monitor wells and filtration treatment systems at each alignment, and the O&M costs associated with sampling, reporting, signage installation, and 5-year reviews, which would be performed to maintain compliance with IRMs RAOs and until final remedy RAOs are achieved.

Access controls would be implemented at the filtration systems to warn of dangers and prohibit unauthorized access to the respective area. O&M would comprise monitoring discharge to the sewer at each alignment and maintenance that would include change out of LGAC and filter bags, equipment maintenance and repair, and process monitoring. Groundwater monitoring would be performed to track and evaluate groundwater COC concentrations in OU2.

<u>Overall Protection of Human Health and the Environment</u>
Institutional Controls, Monitoring, and Sealing Legacy Water Supply Wells process options would be a component of this alternative, and they would all provide a similar measure of protectiveness to human health and the environment as a component of this alternative. Alternative 3 is protective of human health and the environment, since it would reduce the mass of COCs that would migrate beyond areas in OU2 where it would be applied, thereby reducing potential human health exposures. In addition, maintaining a prohibition on the use of groundwater for potable purposes within OU2, with appropriate notification and planning will provide protection to human health by minimizing the risk of exposure to OU2 COCs in groundwater. COCs in extracted groundwater would be treated at the POTW and the GWRS to destroy and/or reduce concentrations by the POTW and the GWRS. Alternative 3 would achieve OU2 COC capture through extraction along the alignments where it would be applied. Extraction in areas of relatively high COC concentrations/mass and at the leading edges of OU2 plumes would maintain containment and prevent further COC migration in these areas, with the exception of cross flow from the Shallow Aquifer System into the Principal Aquifer System through Legacy Water Supply Wells; however, this alternative does begin to mitigate this risk by extracting and treating COCs from the Shallow Aquifer System. Multiple groundwater extraction wells would allow the extraction rates to be varied throughout the containment areas in response to changing groundwater flow conditions.

This alternative would permanently remove contamination from the extracted groundwater and would achieve overall protection of human health and the environment.

<u>Compliance with ARARs</u>
In the context of an IRM this alternative would meet chemical-specific ARARs as water treated at the POTW and GWRS meets applicable discharge requirements. In the context of transitioning the IRM to final remedy, this alternative also would meet chemical-specific ARARs associated with the state and federal MCLs for OU2 groundwater COCs by removing these COCs from OU2 groundwater. Alternative 3 would comply with potential action-specific ARARs because extracted groundwater would meet POTW pre-treatment requirements prior to discharge. Alternative 3 would meet location-specific ARARs. Treatment of extracted groundwater at the POTW and GWRS would occur prior to discharge in accordance with requirements for these systems. This alternative would satisfy the USEPA preference for treatment in accordance with 40 CFR Part 264.

<u>Long-Term Effectiveness and Permanence</u>
Alternative 3 would achieve capture of the OU2 COCs where it is applied and therefore meet the IRM RAOs. The groundwater extraction and treatment in this alternative would permanently remove COCs from the groundwater. Alternative 3 provides long-term effectiveness and

permanence, provided that the system is operated, maintained, and monitored until the final remedy RAOs are met.

<u>Reduction of Toxicity, Mobility, or Volume</u>
The treatment provided under Alternative 3 would reduce the toxicity, mobility, and volume of contaminants from the extracted groundwater. The treatment provided under Alternative 3 would remove contaminants from the extracted groundwater and the treatment processes would reduce the volume and toxicity of compounds present in the extracted groundwater. The treated effluent concentrations would be below those required by the POTW and the GWRS.

<u>Short-Term Effectiveness</u>
Short-term effectiveness of Institutional Controls would be satisfactory to prevent human exposure to OU2 groundwater COCs and operation of Alternative 3 would minimize OU2 COC migration. All construction activities would take place within developed areas and with minimal expected impacts to the environment. Alternative 3 has a small potential for short-term exposure of Site workers to COCs during installation and operation/monitoring of the system components. However, the potential for short-term exposure is reduced by using appropriate work procedures and controls. During remedy construction, noise and dust abatement along with appropriate traffic control would be required to protect the community during the remedy implementation. Standard and/or HAZWOPER OSHA requirements would be protective of workers during the construction.

<u>Implementability</u>
As demonstrated throughout California and at several source sites, containment is implementable. Although application of containment to OU2 groundwater (extraction wells and collection piping) would be limited to non-source site private properties and/or public ROWs, its implementability is considered moderate to high. The resources and materials needed to construct, implement, and maintain this alternative are readily available.

<u>Cost</u>
The following sections summarize the major scope elements associated with capital and OMM costs. Capital costs for this alternative include installation and testing of monitor wells (PDI), and design and construction of the remedy. Appendix D provides the detailed assumptions and cost estimates for this alternative.

PDI Monitor Well Installation and Testing: Monitor wells would be required as a component of Alternative 3 to monitor the effectiveness of this remedy and to ensure that remedy implementation does not significantly affect any nearby source site remedy(s). Figure 7-2 illustrates eight monitoring areas associated with Alternative 3: six of the areas encompass the eight extraction well alignments described above, and two of the areas are to further evaluate groundwater quality upgradient of alignments G-6 and G-7 illustrated on Figure 7-2. The distributions of COCs in each monitoring area were evaluated (Figures 1-6 through 1-35) to estimate the number of monitor wells that conceptually may be required in each of Layers 1 through 4.

Construction of Extraction Wells: Figure 7-2 illustrates eight conceptual alignments (identified as G-1 through G-8) where extraction wells would be installed as part of Alternative 3. The groundwater flow model was used to simulate groundwater extraction and particle tracking was used to estimate the total groundwater extraction rate that would be required to contain groundwater (Appendix E) throughout each alignment as follows:

Alignment Number	Layers Conceptually Targeted for Alternative 3 OU2 IRMs	Estimated Groundwater Flux Across Alignment (gpm)
G-1	Layers 1 and 2	29
G-2	Layers 1 through 3	29
G-3	Layers 1 through 3	69
G-4	Layer 1	1
G-5	Layers 1 and 2	22
G-6	Layers 1 and 2	103
G-7	Layers 1 through 3	83
G-8	Layers 1 through 3	8

The estimated number of extraction wells is based on the lithology of each Layer and on the approximate average sustainable extraction rates achieved at some of the source sites in OU2 (Appendix F). Based on source site extraction rate data, extraction wells in the northern portion of the Study Area generally have lower capacities, and extraction wells in the southern portion of the Study Area (i.e., ITT Cannon source site) have higher capacities, both of which generally align with the model-simulated extraction rate totals. General assumptions regarding the estimated groundwater extraction rates follow:

- If extraction occurs in Layer 1, extraction wells are completed in Layer 1 and separate extraction wells are placed in deeper Layers, where required.
- If extraction occurs in Layer 2 and Layer 3, the extraction well would be screened across Layer 2 and the upper portion of Layer 3.
- The extraction rate for Layer 1 wells is 1 gpm.
- The extraction rate for Layer 2 wells from alignment G-5 to the north is 2 gpm.
- The extraction rate for Layer 2 wells south of alignment G-5 is 8 gpm.
- The extraction rate for Layer 2/3 wells from alignment G-5 to the north is 4 gpm.
- The extraction rate for Layer 2/3 wells south of alignment G-5 is 10 gpm.

The number of extraction wells along each alignment was estimated by dividing the groundwater flux along each of the alignments in each layer by the assumed extraction rate per well for each layer within each alignment:

	Alignment Identifier								
	G-1	G-2	G-3	G-4	G-5	G-6	G-7	G-8	Subtotal
Number Extraction Wells Layer 1			2	1					3
Number Extraction Wells Layer 2	15				11	13			39

	Alignment Identifier								
	G-1	G-2	G-3	G-4	G-5	G-6	G-7	G-8	Subtotal
Number Extraction Wells Layer 2/3		7	17				8	1	33
								TOTAL	**75**

Extraction well capital costs were estimated as the product of the number of extraction wells along each alignment in each layer and the unit rate cost for extraction wells (Appendix D).

Construction of Treatment System: Treatment systems would be required for Alternative 3 to provide particulate filtration of extracted groundwater prior to discharge to the sewer. It is assumed that a total of 9 systems would be required: one for each of seven conceptual groundwater containment alignments (G-1 through G-5 and G-7 and G-8) and 2 for the G-6 alignment (one on each side of State Route 55 [SR 55]). Each system would be located within the respective alignment and would consist of a fenced concrete pad area for cartridge or bag-filter housings, LGAC vessels, instrumentation and control, power drop/panel/distribution for each extraction well within the respective alignment, discharge flowmeter, and tie-in to local sewer lateral. Total system costs are estimated as the product of the number of treatment systems and the total cost per system (Appendix D).

Construction of Collection Piping: The collection piping cost estimate is based on the total length of the eight conceptual groundwater containment alignments, totaling 10,000 feet, with the filtration system assumed to be located within each respective alignment. The disposal piping length is assumed to be 900 feet based on an assumed distance of no more than 100 feet from the treatment system to the tie-in for the local sewer lateral (Appendix D).

OMM Groundwater Monitoring and Reporting: Alternative 3 groundwater monitoring would include:

- Measurement of water level elevations and collection of groundwater samples for analysis of VOCs using EPA Method 8260B, 1,4-Dioxane using EPA Method 8270, and field parameters from the number of monitor wells estimated in Table 7-1 on a quarterly frequency for Year 1, semiannually for Years 2 through 5, and annually for Years 6 through 30.

OMM of Treatment System: Alternative 3 treatment system operation and maintenance would include:

- Electrical power for well pumps,
- Filter bag/cartridge replacements,
- LGAC changeouts,
- Labor for extraction well treatment system operation and maintenance,
- Annual city license agreements for well sites and pipelines,

- Analytical costs and labor for discharge permit monitoring and reporting and permit renewal costs,
- Sewer discharge fees for the extracted groundwater, and
- Water replenishment assessment and basin equity assessment fees for extracted groundwater discharged to the sewer.

Cost Estimate: Detailed cost estimates and the assumptions used to generate them for all remedial alternatives are provided in Appendix D. The total NPV costs associated with Alternative 3 are $35,800,000 over an assumed 30-year project lifetime and are summarized as follows:

Cost Analysis for Alternative 3 – Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS

Total Project Lifetime	30 Years
Capital (PDI; Year 1)	$3,100,000
Capital (Design and Construct; Years 2 and 3)	$11,500,000
OMM (Years 4 to 30)	$31,200,000
Total Capital and OMM NPV (2.5% discount rate)	$35,800,000

<u>Sustainability Assessment</u>
The SiteWise Tool for Green and Sustainable Remediation was used to evaluate and semi-quantitatively rank the sustainability of each of the remedial alternatives (NAVFAC, 2018) (Appendix C). The overview of CO_2 emissions, and total energy and electricity used for the construction (PDI and construction) and OMM components are summarized in the following table:

Metric	**Construction**	**OMM**	**Total**
CO_2 Emissions (metric tons)	900	12,000	13,000
Total Energy Used (million British Thermal Units)	260,000	270,000	530,000
Total Electricity Used (Mega Watt Hours)	0	31,000	31,000

7.2.3.4 Alternative 4 – Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to the Basal Sand

Alternative 4 comprises installation of groundwater extraction wells and conveyance piping, treatment using filtration, AOP, LGAC, and RO membrane technologies, and reinjection to the Basal Sand layer through injection wells. These technologies in tandem would produce high quality purified water that meets or exceeds state and federal drinking water standards.

Figure 7-3 illustrates the conceptual groundwater containment alignments where groundwater extraction wells and injection wells would be installed and operated. COCs present in the targeted layers would be extracted, contained, and treated. Groundwater would be hydraulically contained by pumping extraction wells. While this alternative considers collection of groundwater to a central treatment location for the extraction alignments, from an economic standpoint, the cost of constructing a collection pipeline for the small flow of groundwater extracted from alignment G-4 to a central treatment plant may warrant further analysis of other disposal options. In the overall context of the IRM, this has a relatively small influence on selection of remedial alternative, but should this alternative be selected, this alignment might be operated using approaches outlined in Alternatives 3 or 5 as determined during future PDI/design efforts.

This alternative would include the capital costs of installing groundwater extraction and monitor wells and a central treatment system. The O&M costs would be associated with sampling, reporting, signage installation, and 5-year reviews, which would be performed to maintain compliance with IRMs RAOs and until final remedy RAOs are achieved.

Access controls would be implemented at the treatment building to warn of dangers and prohibit unauthorized access to the treatment building. O&M would comprise treatment system equipment maintenance and process monitoring. Groundwater monitoring would be performed to track and evaluate groundwater COC concentrations in OU2.

<u>Overall Protection of Human Health and the Environment</u>
Institutional Controls, Monitoring, and Sealing Legacy Water Supply Wells process options would be a component of this alternative, and they would all provide a similar measure of protectiveness to human health and the environment as a component of this alternative. Similar to Alternative 3, Alternative 4 is protective of human health and the environment, since it would reduce the mass of COCs that would migrate beyond areas in OU2 where it would be applied, thereby reducing potential human health exposures. In addition, maintaining a prohibition on the use of groundwater for potable purposes within OU2, with appropriate notification and planning will provide protection to human health by minimizing the risk of exposure to OU2 COCs in groundwater. COCs in extracted groundwater would be treated to destroy and/or reduce concentrations. Alternative 4 would achieve OU2 COC capture through extraction along the alignments where it would be applied. Extraction in areas of relatively high COC concentrations/mass and at the leading edges of OU2 plumes would maintain containment and prevent further COC migration in these areas, with the exception of cross flow from the Shallow Aquifer System into the Principal Aquifer System through Legacy Water Supply Wells; however, this alternative does begin to mitigate this risk by extracting and treating COCs from the Shallow Aquifer System. Multiple groundwater extraction wells would allow the extraction rates to be varied throughout the containment areas in response to changing groundwater flow conditions.

This alternative would permanently remove contamination from the extracted groundwater and would achieve overall protection of human health and the environment.

<u>Compliance with ARARs</u>
In the context of an IRM this alternative would meet chemical-specific ARARs as water treated would be treated to meet COC MCLs/NLs prior to reinjection. In context of transitioning the IRM to final remedy, this alternative also would meet chemical-specific ARARs associated with the state and federal MCLs for OU2 groundwater COCs by removing these COCs from OU2 groundwater. Alternative 4 would comply with potential action-specific ARARs because extracted groundwater would meet RWQCB WDR prior to injection. Alternative 4 would meet all location-specific ARARs. This alternative would satisfy the USEPA preference for treatment in accordance with 40 CFR Part 264.

Long-Term Effectiveness and Permanence

Alternative 4 would achieve capture of the OU2 COCs where it is applied and therefore meet the IRM RAOs. The groundwater extraction and treatment in this alternative would permanently remove COCs from the groundwater. Alternative 4 provides long-term effectiveness and permanence, provided that the system is operated, maintained and monitored until the final remedy RAOs are met.

Reduction of Toxicity, Mobility, or Volume

The treatment provided under Alternative 4 would reduce the toxicity, mobility, and volume of contaminants from the extracted groundwater. The treatment provided under Alternative 4 would remove contaminants from the extracted groundwater and the treatment processes would reduce the volume and toxicity of compounds present in the extracted groundwater. The treated effluent concentrations would be below those required by the WDR permit for reinjection. The brine produced as part of this alternative would be disposed to the POTW in accordance with the sewer discharge requirements.

Short-Term Effectiveness

Short-term effectiveness of Institutional Controls would be satisfactory to prevent human exposure to OU2 groundwater COCs and operation of Alternative 4 would minimize OU2 COC migration. All construction activities would take place within developed areas and with minimal expected impacts to the environment. Alternative 4 has a small potential for short-term exposure of Site workers to COCs during installation and operation/monitoring of the treatment system components. However, the potential for short-term exposure is reduced by using appropriate work procedures and controls. During remedy construction, noise and dust abatement along with appropriate traffic control would be required to protect the community during the remedy implementation. Standard and/or HAZWOPER OSHA requirements would be protective of workers during the construction.

Implementability

As demonstrated throughout California and at several source sites, containment is implementable. Although application of containment to OU2 groundwater (extraction wells and collection piping) would be limited to non-source site private properties and/or public ROWs, its implementability is considered moderate due to the total length of pipeline and potential availability of land for the treatment system. The resources and materials needed to construct, implement, and maintain this alternative are readily available.

Cost

The extraction well and monitor well costs are the same as Alternative 3. The following sections summarize the major scope elements associated with capital and OMM costs. Capital costs for this alternative include installation and testing of monitor wells (PDI), and design and construction of the remedy. Appendix D provides the detailed assumptions and cost estimates for this alternative.

Construction of Injection Wells: It was assumed that injection into the Basal Sand could be sustained at 50 gpm per injection well. The number of injection wells required for Alternative 4 was then estimated to equal the total extraction rate across all of the well alignments based on the groundwater flow model required to capture groundwater at and upgradient of each alignment, divided by 50 gpm and including several spare injection wells to maintain operational flexibility.

10 Basal Sand injection wells would be constructed. The injection well capital costs were then estimated as the product of the number of injection wells and the unit rate cost for the injection wells (Appendix D).

Construction of Treatment System: Alternative 4 consists of extracting groundwater and treating in a centralized location, with an end use of reinjection to Basal Sand. It is assumed that all extracted groundwater would be routed to one treatment system via collection pipelines, would be pre-filtered, then treated using an AOP system, LGAC adsorption vessels, and RO membrane train.

The total flux from each alignment area required for capture in Alternative 4 is the same as Alternative 3, for a total of 350 gpm. Assuming that the RO membrane train operates with 85% recovery, 300 gpm of treated water would be reinjected into the Basal Sand (Layer 4), and 50 gpm of RO concentrate would be discharged to the sewer.

In addition to the main treatment technologies, the cost estimate also takes into account auxiliary equipment such as pumps, tanks, the treatment facility building, and procurement of one acre of land for the treatment system. Equipment was sized on an approximate basis given the flow rates above, and other aspects of the facility such as mechanical piping, instrumentation and controls, electrical, etc. were approximated as a percent of the total capital cost (Appendix D).

Construction of Collection Piping: Groundwater would be extracted from transects G-1 through G-8, as shown in Figure 7-3, then routed to a single treatment facility that was assumed to be located near transect G-8. This represents a roughly central location relative to the transect locations and provides a reasonable basis for pipeline length estimates.

All collection pipelines would be constructed from double-contained HDPE, ranging from 1"x3" to 6"x10" depending on the estimated required flow capacities. Pipeline lengths represent approximate values based upon logical intersections across alignments and an assumption that lines can be routed along city streets with minimal fittings (Appendix D).

Construction of Injection Well Conveyance Piping: Injection well conveyance piping was evaluated using the same format as collection piping, with the key difference being the injection conveyance pipeline would be constructed from single-contained HDPE rather than double-contained.

The injection well conveyance network would consist of two 4-inch pipelines each carrying 150 gpm to a single treatment facility illustrated on Figure 7-3. Given that the actual pipeline length would vary widely depending on the location of the treatment facility, it was assumed that each pipeline would extend 2500 feet from the facility.

OMM Injection Well Redevelopment: It was assumed that the Basal Sand injection wells would require redevelopment on an annual frequency equaling 27 events over a 30-year duration. The injection well redevelopment costs were then estimated as the product of the number of injection wells and the unit rate cost for the injection well redevelopment (Appendix D).

OMM of Treatment System: Alternative 4 treatment system O&M would include:

- Electrical power for well pumps, treatment system equipment, and the treatment system building,
- Carbon media change-out costs for the LGAC equipment,
- UV lamp replacements for the AOP system,
- Membrane replacement for the RO system,
- Chemical refills, including hydrogen peroxide for the AOP, and sulfuric acid, anti-scalant, and membrane cleaner and periodic replacement for the RO system,
- Annual city license agreements for well sites and pipelines,
- Analytical costs and labor for discharge permit monitoring and reporting and permit renewal costs.
- Labor for extraction well and treatment system operation and maintenance,
- Property taxes for treatment system parcel,
- Sewer discharge fees for the RO concentrate, and
- Water replenishment assessment and basin equity assessment fees for the RO concentrate.

Cost Estimate: Detailed cost estimates and the assumptions used to generate them for all remedial alternatives are provided in Appendix D. The total NPV costs associated with Alternative 4 are $64,000,000 over an assumed 30-year project lifetime and are summarized as follows:

Cost Analysis for Alternative 4 – Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to the Basal Sand

Total Project Lifetime	30 Years
Capital (PDI; Year 1)	$3,600,000
Capital (Design and Construct; Years 2 and 3)	$31,300,000
OMM (Years 4 to 30)	$43,600,000
Total Capital and OMM NPV (2.5% discount rate)	$64,000,000

<u>Sustainability Assessment</u>
The SiteWise Tool for Green and Sustainable Remediation was used to evaluate and semi-quantitatively rank the sustainability of each of the remedial alternatives (NAVFAC, 2018) (Appendix C). The overview of CO_2 emissions, and total energy and electricity used for the construction (PDI and construction) and OMM components are summarized in the following table:

Metric	**Construction**	**OMM**	**Total**
CO_2 Emissions (metric tons)	1,100	17,000	18,000
Total Energy Used (million British Thermal Units)	270,000	400,000	670,000
Total Electricity Used (Mega Watt Hours)	0	47,000	47,000

7.2.3.5 Alternative 5 – In-Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation

Figure 7-4 illustrates eleven conceptual alignments (identified as I-1 through I-11) where ISCO would be applied as part of Alternative 5. ISCO would comprise delivery via injection wells of activated persulfate to OU2 groundwater. Chemical oxidants are intended to destroy COCs, and some oxidants are generally accepted as being effective in oxidizing organic chemicals in source areas of compounds such as VOCs and 1,4-dioxane. The primary considerations for application of ISCO in source areas are the interference of other oxidizable materials in the groundwater and aquifer solids (i.e., utilization of ISCO treatment chemicals by non-target compounds), the ability to deliver chemical oxidants to COCs in the subsurface, and the ability of the oxidant to reduce COC concentrations. Since chemical oxidants, including persulfate are non-selective, any oxidizable materials in the groundwater and aquifer solids would consume the oxidant, which can limit or eliminate the destruction of COCs in the subsurface and decrease the overall efficiency of the treatment. Injection of persulfate to the treatment areas also presents difficulties due to the generally relatively fine-grained nature of OU2 aquifer materials, particularly in Layers 1 and 3.

Use of in-situ technologies in transects as flow-through treatment zones in groundwater factors in the above primary considerations for source area treatment and also has to consider the fact that contaminated groundwater upgradient of the transect treatment zone continues over time until the groundwater upgradient of the transect reaches the RAO for the final remedy. In other words, the transects need to remain active for as long as these conditions exist. Since the groundwater extraction alternatives assume that active extraction continues through year 30, this same assumption is applied to the time for which the transect treatment zone needs to be active. This can result in many reapplications of amendments through the project lifetime.

Alternative 5 would involve the field mixing and injection of activated persulfate solution into a series of injection wells. Density-driven transport of sodium persulfate may result in further distribution of oxidants vertically into the deeper portions of the Layers into which it is injected.

This alternative would include the capital costs of installing groundwater monitor and injection wells.

O&M would comprise periodic injection of ISCO amendments, WDR monitoring, and injection well redevelopment and maintenance. WDR monitoring would be performed to track and evaluate groundwater COC concentrations in OU2. Five-year reviews would be performed to maintain compliance with IRMs RAOs and until the final remedy RAOs are achieved.

<u>Overall Protection of Human Health and the Environment</u>
Institutional Controls, Monitoring, and Sealing Legacy Water Supply Wells process options would be a component of this alternative, and they would all provide a similar measure of protectiveness to human health and the environment as a component of this alternative. Alternative 5 may be protective of human health and the environment, since it would likely reduce the mass of COCs that would migrate beyond areas in OU2 where it would be applied, thereby reducing potential human health exposures; however, potential generation of byproducts, such as hexavalent chromium could pose a risk to environment if the byproduct is persistent. This is particularly challenging where in-situ injection occurs near surface water channels in the southern portion of

the Study Area where groundwater in the uppermost portion of the Shallow Aquifer System flows into these channels. Maintaining institutional controls restricting the use of groundwater for potable purposes within OU2, with appropriate notification and planning, will provide protection to human health by minimizing the risk of exposure to OU2 COCs in groundwater and/or persistent by products of ISCO. COCs that are oxidized by the persulfate are destroyed in place. Alternative 5 has the potential to achieve OU2 COC treatment along the alignments where it would be applied. In-situ oxidation of relatively high COC concentrations/mass and at the leading edges of OU2 plumes could prevent further COC migration in these areas, with the exception of cross flow from the Shallow Aquifer System into the Principal Aquifer System through Legacy Water Supply Wells; however, this alternative does begin to mitigate this risk by treating COCs from the Shallow Aquifer System. Each ISCO alignment would incorporate a relatively dense monitoring network which would allow for ISCO application to be varied in response to changing groundwater flow conditions.

As briefly mentioned above, this alternative has a potential to generate undesired byproducts, such as hexavalent chromium. Chromium is a redox-sensitive and toxic metal, the release of which poses considerable risk to human health and/or the environment. One study investigated the impact of persulfate chemical oxidation on the release of chromium from three soils varying in physical-chemical properties (Kaur and Crimi, 2013). Soils were treated with inactivated and activated persulfate [activated with Fe(II), Fe(II)-EDTA, and alkaline pH] at two different concentrations for 48 hours and 6 months and were analyzed for chromium. Results indicated that release of chromium with persulfate chemical oxidation depends on the soil type and the activation method. Sandy soil with low oxidant demand released more chromium compared to soils with high oxidant demand. More chromium was released with alkaline pH activation. Alkaline pH and high Eh conditions favor oxidation of Cr(III) to Cr(VI), which is the main mechanism of release of chromium with persulfate chemical oxidation.

Elevated concentrations of metals, including hexavalent chromium, were produced at the Ricoh source site as a result of ISCO groundwater remediation using permanganate (WPI, 2010). Baseline (pre-injection) chromium groundwater concentrations in Ricoh monitor well RMW-1 increased from 34 ug/l to a maximum post-injection concentration of 10,400 ug/l; and baseline (pre-injection) chromium groundwater concentrations in monitor well RMW-6S increased from 21 ug/l to a maximum post-injection concentration of 588 ug/l.

Similarly, in the letter to Baxter Healthcare regarding their ISCO groundwater remediation, the RWQCB reiterated the statement, "The analytical data show elevated concentrations of arsenic, chromium, and mercury in the injection and dose-response wells, with maximum concentrations of 63, 170, and 13 micrograms per liter (ug/L), respectively" and further stated, "Based on the presence of metals such as chromium that could become a source for undesirable oxidation byproducts, Board staff agrees that it would be prudent to obtain additional data on the major contaminant horizons, in order to more narrowly and precisely target them, and thereby minimize the chance of producing undesirable compounds" (RWQCB, 2012). Additionally, full-scale ISCO using persulfate was implemented (BBJ Group, 2019). The full-scale ISCO remediation at this source site did not appear to be effective in treating 1,4-dioxane.

Compliance with ARARs

In the context of an IRM this alternative might meet chemical-specific ARARs if the application of ISCO does not create persistent undesirable byproducts and repeated persulfate injection does not exceed Basin Plan water quality objectives or threaten water quality. In context of transitioning the IRM to a final remedy, this alternative could meet chemical-specific ARARs associated with the state and federal MCLs for OU2 groundwater COCs by removing these COCs from OU2 groundwater; however, the potential for persistent undesirable byproducts and/or water quality threats remains a potential concern. Alternative 5 could comply with potential action-specific ARARs provided the ISCO application is compliant with RWQCB WDR outside the treatment zone. As indicated above, the potential for generation of hexavalent chromium that is sufficiently persistent to flow with groundwater into nearby surface water channels in the southern part of the Study Area would be an example of a condition not meeting action-specific ARARs. Alternative 5 would meet all location-specific ARARs. This alternative would satisfy the USEPA preference for treatment in accordance with 40 CFR Part 264.

Long-Term Effectiveness and Permanence

Alternative 5 may permanently destroy COCs in OU2 groundwater where it is applied. However, it has not been an effective remedial technology at several source sites as detailed in Section 5.4.7.3. As previously indicated, application of ISCO as a flow-through treatment technology requires the treatment zone to remain active throughout the 30-year project time frame. Further as described above, ISCO has the potential to generate undesired byproducts, such as hexavalent chromium.

Reduction of Toxicity, Mobility, or Volume

The treatment provided under Alternative 5 would reduce the toxicity, mobility, and volume of COCs in OU2 groundwater. However, it could also increase the TMV of certain compounds/constituents (hexavalent chromium) in OU2 groundwater.

Short-Term Effectiveness

Short-term effectiveness of Institutional Controls would be satisfactory to prevent human exposure to OU2 groundwater COCs and operation of Alternative 5 could minimize OU2 COC migration. Conversely, this alternative could also increase compound/constituent concentrations (e.g., hexavalent chromium) in OU2 groundwater and if these compounds/constituents are persistent and migrate outside the treatment zones this could be a complicating factor. All construction activities would take place within developed areas and with minimal expected impacts to the environment. Alternative 5 has a small potential for short-term exposure of Site workers to COCs and mixed chemical amendments during installation and operation/monitoring of this alternative. However, the potential for short-term exposure is reduced by using appropriate work procedures and controls. During remedy construction, noise and dust abatement along with appropriate traffic control would be required to protect the community during the remedy implementation. Standard and/or HAZWOPER OSHA requirements would be protective of workers during the construction.

Implementability

The process option for ISCO would include injection wells and chemical treatment. ISCO injection wells placed at regular, closely spaced intervals along linear alignments constructed perpendicular to the direction of groundwater flow could provide treatment of COCs migrating through the treatment zone in the Shallow Aquifer System. Construction of injection wells for ISCO in groundwater would be confined to limited areas at non-source site private properties and/or public ROWs. Based on experience at several OU2 source sites, and in Southern California in general, ISCO would require multiple application events at a relatively high frequency related to other process options and may be relatively more burdensome and disruptive to affected property owners or public ROW users.

<u>Cost</u>
The following sections summarize the major scope elements associated with capital and OMM costs. Capital costs for this alternative include installation and testing of monitor wells (PDI), and design and construction of the remedy. Appendix D provides the detailed assumptions and cost estimates for this alternative.

PDI Monitor Well Installation and Testing: Monitor wells would be required as a component of Alternative 5 to monitor the effectiveness of this remedy and to ensure that remedy implementation does not significantly affect any nearby source site remedy(s). Figure 7-4 illustrates eight monitoring areas associated with Alternative 5. Six of the areas encompass the ISCO alignments, and two of the areas are to further evaluate groundwater quality upgradient of alignments I-6 and I-7 illustrated on Figure 7-4.

Construction of ISCO Injection Wells: Figure 7-4 illustrates the conceptual alignments where ISCO would be applied in as part of Alternative 5. The Layers conceptually targeted for Alternative 5 OU2 IRMs follow:

Alignment Number	Layers Conceptually Targeted for Alternative 5 OU2 IRMs
I-1	Layers 1 and 2
I-2	Layers 1 through 3
I-3	Layers 1 through 3
I-4	Layer 1
I-5	Layers 1 and 2
I-6	Layers 1 and 2
I-7	Layers 1 through 3
I-8	Layers 1 through 3
I-9	Layers 1 through 3
I-10 & I-11	Layers 1 through 3

ISCO or in-situ bioremediation has been performed at several source sites, with injections occurring on spacings between injection wells/points ranging from 2.5 feet to approximately 50 feet (Arcadis, 2014; BBJ Group, 2019; SLR, 2018; AECOM, 2016a and 2016b; RWQCB, 2017 and 2020; WPI, 2010). The approximate and average radius of influence (ROI), injection spacing, injection rates, and number of injections are summarized as follows:

Source Site	Average ROI (feet)	Injection Spacing (feet)	Estimated/Observed Injection Rate (gpm)	Source
Baxter	20	40-50	6	a
Bell	6	12	3	b
Ricoh	10	20	10	c
LNP	5	5	6	d
LNP	5	5	6	e
LNP	5	5	6	f
ITT	20	40-50		g
Average	12		6	

ROI = radius of influence
gpm = gallons per minute

a = Arcadis February 9, 2015, Updated Conceptual Site Model and Groundwater Remedial Action Plan

b = AECOM November 1, 2016, WDR Monitoring Report, Former Bell Industries, Inc., Site.

c =WPI, December 28, 2010, Remedial Action Report, Ricoh Electronics Facility.

d = RWQCB Amended Discharge Authorization and Monitoring & Reporting Program No. R8-2018-0092-0005 For Implementation of Full-Scale Replenishment of Biobarriers, The Former LNP Facility; 1831 East Carnegie Avenue, Santa Ana, California. June 16, 2020.

e = Deere Avenue barrier from Amec Foster Wheeler April 1, 2016, Second Addendum to the 2015 Off-Site Remedial Action Plan

f = Alton Parkway barrier from Amec Foster Wheeler April 1, 2016, Second Addendum to the 2015 Off-Site Remedial Action Plan

g = RWQCB Discharge Authorization and Monitoring and Reporting Program No.RS-2013-0029-030 For In-Situ Groundwater Remediation at ITT Cannon Facility. April 24, 2015.

Most of the source site in-situ injections were performed under pressure and it is assumed that the Alternative 5 ISCO injections would be implemented in a similar manner. The total length of the conceptual Alternative 5 ISCO injection alignments is approximately 12,500 feet (Figure 7-4). Based on an average injection ROI of 12 feet, injection wells would be installed on 24-foot spacings. The total number of injection wells was estimated as the total length of the ISCO alignments in each Layer divided by a 24-foot injection well spacing. The total estimated number of injection wells for each layer along each alignment for Alternative 5 ISCO injections follows:

Alignment Identifier	Layer	Approximate Alignment Length (feet)	Estimated Number of Injection Wells Per Layer Based on 24-Foot Spacing	Estimated Number of Injection Wells Per Alignment Based on 24-Foot Spacing
I-1	Layer 1	1,400	58	117
	Layer 2		58	
I-2	Layer 1	500	21	63
	Layer 2		21	
	Layer 3		21	

Alignment Identifier	Layer	Approximate Alignment Length (feet)	Estimated Number of Injection Wells Per Layer Based on 24-Foot Spacing	Estimated Number of Injection Wells Per Alignment Based on 24-Foot Spacing
I-3	Layer 1	1,000	42	
	Layer 2		42	
	Layer 3		42	125
I-4	Layer 1	350	15	15
I-5	Layer 1	1300	54	
	Layer 2		54	108
I-6	Layer 1	3200	133	
	Layer 2		133	267
I-7	Layer 1	1500	63	
	Layer 2		63	
	Layer 3		63	188
I-8	Layer 1	1000	42	
	Layer 2		42	
	Layer 3		42	125
I-9	Layer 1	1000	42	
	Layer 2		42	
	Layer 3		42	125
I-10 & I-11	Layer 1	1300	54	
	Layer 2		54	
	Layer 3		54	163
		TOTAL	1294	1294

The injection well capital costs were estimated as the product of the number of injection wells and the unit rate cost for injection wells (Appendix D).

OMM ISCO Injections: One component of Alternative 5 O&M would include injection of persulfate on a periodic basis. Based on the results of source site ISCO applications and remediation monitoring and on professional judgement, the following were assumed in developing Alternative 5 injection O&M costs:

- ISCO injection wells would be constructed with one separate injection well for each targeted Layer along each of the injection alignments.
- The injection rate would equal the average estimated/observed injection rate per injection well specified above of 6 gpm.
- Approximately 2,600 gallons of amended water would be injected at each injection well.
- Approximately 3,400 pounds of PersulfOx activated persulfate would be injected at each injection well in each layer during each injection event.

- ISCO applications would occur on a frequency based on the estimated ambient groundwater flux through each 24-foot wide (in the direction parallel to groundwater flow) ISCO alignment using the calibrated groundwater model (Appendix E).
- Other assumptions and details are provided in Appendix D.

OMM WDR Monitoring: Another component of Alternative 5 O&M would include WDR groundwater monitoring. ISCO or in-situ bioremediation WDR monitoring has been performed at several source sites (Arcadis, 2014; BBJ Group, 2019; SLR, 2018; AECOM, 2016a and 2016b; RWQCB, 2017 and 2020; WPI, 2010). The approximate number of injection wells/points, number of required monitor wells specified by each source site's RWQCB WDR M&RP or Remedial Action Plan (RAP), and the estimated number of monitor wells per injection well/point at several source sites are summarized as follows:

Source Site	Average ROI (feet)	Injection Spacing (feet)	Estimated / Observed Injection Rate (gpm)	Number of Injections	Number of Required RAP/WDR M&RP Monitor Wells	Number of Monitor Wells Required per Injection Well/Point	Source
Baxter	20	40-50	6	19	5	0.26	a
Bell	6	12	3	16	4	0.25	b
Ricoh	10	20	10	44	6	0.14	c
LNP	5	5	6	232	17	0.07	d
LNP	5	5	6	169	24	0.14	e
LNP	5	5	6	29	4	0.14	f
ITT	20	40-50		8	3	0.38	g
Average	12		6			0.20	

a = Arcadis February 9, 2015, Updated Conceptual Site Model and Groundwater Remedial Action Plan

b = AECOM November 1, 2016, WDR Monitoring Report, Former Bell Industries, Inc., Site.

c =WPI, December 28, 2010, Remedial Action Report, Ricoh Electronics Facility.

d = RWQCB Amended Discharge Authorization and Monitoring & Reporting Program No. R8-2018-0092-0005 For Implementation of Full-Scale Replenishment of Biobarriers, The Former LNP Facility; 1831 East Carnegie Avenue, Santa Ana, California. June 16, 2020.

e = Deere Avenue barrier from Amec Foster Wheeler April 1, 2016, Second Addendum to the 2015 Off-Site Remedial Action Plan

f = Alton Parkway barrier from Amec Foster Wheeler April 1, 2016, Second Addendum to the 2015 Off-Site Remedial Action Plan

g = RWQCB Discharge Authorization and Monitoring and Reporting Program No.RS-2013-0029-030 For In-Situ Groundwater Remediation at ITT Cannon Facility. April 24, 2015.

RAP = Remedial Action Plan

The total estimated number of monitor wells in all layers and along all alignments for Alternative 5 based on 0.2 monitor wells per injection well is estimated to be approximately 259 (the product of 1,294 estimated injection wells and 0.2 required monitor wells per injection well). Groundwater samples would be analyzed for VOCs, 1,4-dioxane, alkalinity, chloride, cations, sulfate, nitrogen, hexavalent chromium, metals, and total dissolved solids (Appendix D).

Cost Estimate: Detailed cost estimates and the assumptions used to generate them for all remedial alternatives are provided in Appendix D. The total NPV cost associated for Alternative 5 is $348,600,000 over an assumed 30-year project lifetime and is summarized as follows:

Cost Analysis for Alternative 5 – In-Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation

Total Project Lifetime	30 Years
Capital (PDI; Year 1)	$7,500,000
Capital (Design and Construct; Years 2 and 3)	$50,500,000
OMM (Years 4 to 30)	$424,600,000
Total Capital and OMM NPV (2.5% discount rate)	$348,600,000

<u>Sustainability Assessment</u>
The SiteWise Tool for Green and Sustainable Remediation was used to evaluate and semi-quantitatively rank the sustainability of each of the remedial alternatives (NAVFAC, 2018) (Appendix C). The overview of CO_2 emissions, and total energy and electricity used for the construction (PDI and construction) and OMM components are summarized in the following table:

Metric	**Construction**	**OMM**	**Total**
CO_2 Emissions (metric tons)	7,400	160,000	170,000
Total Energy Used (million British Thermal Units)	2,400,000	2,600,000	5,000,000
Total Electricity Used (Mega Watt Hours)	0	0	0

7.2.3.6 Alternative 6 – Containment and In-Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with Discharge to POTW and GWRS

Figure 7-5 illustrates the conceptual groundwater containment alignment where groundwater extraction wells would be installed and operated and the conceptual alignments where ISCO would be applied as part of Alternative 6. Alternative 6 utilizes the groundwater extraction well field that is the same as Alternatives 3 and 4 but for the replacement of groundwater extraction at G-8 with in-situ treatment using ISCO. Alternatives 3 and 4 are differentiated by the disposal method for extracted groundwater, with Alternative 3 discharging extracted groundwater to the sewer for POTW and GWRS treatment and Alternative 4 reinjecting extracted groundwater after it is treated by a system inside the Study Area. These Alternatives are very similar when comparing the seven NCP criteria, with the exception of cost, for which Alternative 3 was substantially less. Based on this comparison, Alternative 6 was assembled using the extracted groundwater disposal method outlined in Alternative 3. Alternative 6 also utilizes the in-situ treatment of groundwater using ISCO (see Alternative 5 for additional information), but within a select focused portion of the Study Area.

For the containment portion of this remedy, the capital costs would include installation of groundwater extraction wells, monitor wells, and filtration treatment systems, and the O&M costs would include activity associated with groundwater monitoring, reporting, and signage. For ISCO, the capital costs would include installation of injection and monitor wells, and the O&M costs would include activity associated with periodic amendment application, injection well redevelopment, WDR monitoring, and reporting. Five-year reviews would be performed for the combined remedy to maintain compliance with IRMs RAOs and until the final remedy RAOs are achieved.

<u>Overall Protection of Human Health and the Environment</u>
Institutional Controls, Monitoring, and Sealing Legacy Water Supply Wells process options would be a component of this alternative, and they would all provide a similar measure of protectiveness to human health and the environment as a component of this alternative. Overall Alternative 6 is more likely to be protective of human health and the environment than Alternative 5; however, it still retains the potential generation of byproducts associated with ISCO, such as hexavalent chromium. Although, the risk to environment is less than Alternative 5 because the ISCO application is in the northern portion of the Study Area where surface water channel bottoms do not intersect shallow groundwater. Maintaining institutional controls restricting the use of groundwater for potable purposes within OU2, with appropriate notification and planning will provide protection to human health by minimizing the risk of exposure to OU2 COCs in groundwater and/or persistent by products of ISCO.

For the containment portion of the alternative, COCs in extracted groundwater would be treated to destroy and/or reduce concentrations by the POTW and the GWRS. This portion of Alternative 6 would achieve OU2 COC capture through extraction along the alignments where it would be applied. Extraction in areas of relatively high COC concentrations/mass and at the leading edges of OU2 plumes would maintain containment and prevent further COC migration in these areas, with the exception of cross flow from the Shallow Aquifer System into the Principal Aquifer System through Legacy Water Supply Wells; however, this alternative does begin to mitigate this risk by extracting and treating COCs from the Shallow Aquifer System. Multiple groundwater extraction wells would allow the extraction rates to be varied throughout the containment areas in response to changing groundwater flow conditions.

For the ISCO portion of the alternative, COCs that are oxidized by the persulfate are destroyed in place. This portion of Alternative 6 has the potential to achieve OU2 COC treatment along the alignments where it would be applied. In-situ oxidation of relatively high COC concentrations/mass and at the leading edges of OU2 plumes could prevent further COC migration in these areas, with the exception of cross flow from the Shallow Aquifer System into the Principal Aquifer System through Legacy Water Supply Wells; however, this alternative does begin to mitigate this risk by treating COCs from the Shallow Aquifer System. Each ISCO alignment would incorporate a relatively dense monitoring network which would allow for ISCO application to be varied in response to changing groundwater flow conditions.

<u>Compliance with ARARs</u>
For the containment portion of this alternative, in the context of an IRM this alternative would meet chemical-specific ARARs as water treated at the POTW and GWRS meets applicable discharge requirements. In context of transitioning the IRM to final remedy, this alternative also would meet chemical-specific ARARs associated with the state and federal MCLs for OU2 groundwater COCs by removing these COCs from OU2 groundwater. The containment portion of Alternative 6 would comply with potential action-specific ARARs because extracted groundwater would meet POTW pre-treatment requirements prior to discharge. Treatment of

extracted groundwater at the POTW and GWRS would be conducted prior to discharge in accordance with requirements for these systems.

For the ISCO portion of the alternative, in the context of an IRM this alternative might meet chemical-specific ARARs if the application of ISCO does not create persistent undesirable byproducts and repeated persulfate injection does not exceed Basin Plan water quality objectives or threaten water quality. In context of transitioning the IRM to final remedy, this alternative could meet chemical-specific ARARs associated with the state and federal MCLs for OU2 groundwater COCs by removing these COCs from OU2 groundwater; however, the potential for persistent undesirable byproducts and/or water quality threats remain a potential concern. The ISCO portion of Alternative 6 could comply with potential action-specific ARARs provided the ISCO application is compliant with RWQCB WDR outside the treatment zone.

Alternative 6 would meet all location-specific ARARs. This alternative would satisfy the USEPA preference for treatment in accordance with 40 CFR Part 264.

Long-Term Effectiveness and Permanence
The containment portion of Alternative 6 would achieve capture of the OU2 COCs where it is applied and therefore meet the IRM RAOs. The groundwater extraction and treatment in this alternative would permanently remove COCs from the groundwater. The containment portion of Alternative 6 provides long-term effectiveness and permanence, provided that the treatment system is operated, maintained, and monitored until the final remedy RAOs are met.

The ISCO portion of Alternative 6 may permanently destroy COCs in OU2 groundwater where it is applied. However, it has not been an effective remedial technology at several source sites as detailed in Section 5.4.7.3. As previously indicated, application of ISCO as a flow through treatment technology requires the treatment zone to remain active throughout the 30-year project time frame. Further as described above, ISCO has the potential to generate undesired byproducts, such as hexavalent chromium.

Reduction of Toxicity, Mobility, or Volume
Alternative 6 would reduce the toxicity, mobility, and volume of contaminants from the extracted groundwater. The treatment provided under the containment portion of Alternative 6 would remove contaminants from the extracted groundwater and the treatment processes would reduce the volume and toxicity of compounds present in the extracted groundwater. The treated effluent concentrations would be below those required by the POTW and the GWRS.

The ISCO portion of Alternative 6 would reduce the toxicity, mobility, and volume of COCs in OU2 groundwater. However, it could also increase the TMV of certain compounds/constituents (hexavalent chromium) in OU2 groundwater.

Short-Term Effectiveness
Short-term effectiveness of Institutional Controls would be satisfactory to prevent human exposure to OU2 groundwater COCs and operation of Alternative 6 would minimize OU2 COC migration. Conversely, in areas where ISCO is applied there could be an increase compound/constituent concentration (hexavalent chromium) in OU2 groundwater and if these compounds/constituents are persistent and migrate outside the treatment zones this could be a complicating factor.

All construction activities would take place within developed areas and with minimal expected impacts to the environment. Alternative 6 has a small potential for short-term exposure of Site workers to COCs (and mixed chemical amendments where ISCO is applied) during installation and operation/monitoring of the treatment system components. However, the potential for short-term exposure is reduced by using appropriate work procedures and controls. During remedy construction, noise and dust abatement along with appropriate traffic control would be required to protect the community during the remedy implementation. Standard and/or HAZWOPER OSHA requirements would be protective of workers during the construction.

Implementability

Alternative 6 is implementable. Although application of Alternative 6 will be limited to non-source site private properties and/or public ROWs, its implementability is considered relatively high. The resources and materials needed to construct, implement, and maintain this alternative are readily available.

Cost

The following sections summarize the major scope elements associated with capital and OMM costs. Capital costs for this alternative include installation and testing of monitor wells (PDI), and design and construction of the remedy. Appendix D provides the detailed assumptions and cost estimates for this alternative.

PDI Monitor Well Installation and Testing: Monitor wells would be required as a component of Alternative 6 to monitor the effectiveness of this remedy and to ensure that remedy implementation does not significantly affect any nearby source site remedy(s). Figure 7-5 illustrates eight monitoring areas associated with Alternative 6: six of the areas encompass the alignments, and two of the areas are to further evaluate groundwater quality upgradient of alignments G-6 and G-7 illustrated on Figure 7-5.

Construction of Extraction Wells: Figure 7-5 illustrates seven alignments (identified as G-1 through G-7) where extraction wells would be installed along alignments as part of Alternative 6. The groundwater extraction rate and number of extraction wells are the same as the applicable alignments for Alternative 3 and summarized in the following table:

	Alignment Identifier								
	G-1	G-2	G-3	G-4	G-5	G-6	G-7	G-8	Sub-total
Number Extraction Wells Layer 1			2	1					3
Number Extraction Wells Layer 2	15				11	13			39
Number Extraction Wells Layer 2/3		7	17				8		32
								TOTAL	**74**

Extraction well capital costs were estimated based on the number of extraction wells along each alignment in each layer and the unit rate cost for extraction wells (Appendix D).

Construction of Injection Wells for ISCO: Figure 7-5 illustrates the conceptual alignments where ISCO would be applied as part of Alternative 6. The number of ISCO injection wells for

Alternative 6 was estimated using the same methods and assumptions that were described for Alternative 5.

Alignment Identifier	Layer	Approximate Alignment Length (feet)	Estimated Number of Injection Wells Per Layer Based on 24-Foot Spacing	Estimated Number of Injection Wells Per Alignment Based on 24-Foot Spacing
I-8	Layer 1	1,000	42	125
	Layer 2		42	
	Layer 3		42	
I-9	Layer 1	1,000	42	125
	Layer 2		42	
	Layer 3		42	
I-10	Layer 1	700	29	88
	Layer 2		29	
	Layer 3		29	
TOTAL			338	338

Construction of Treatment Systems: Treatment systems would be required for Alternative 6 to provide filtration of extraction groundwater prior to discharge to the sewer. It is assumed that a total of eight filtration systems would be required: one for each of six conceptual groundwater containment alignments (G-1 through G-5 and G-7) and two for the G-6 alignment (one on each side of SR 55). Each filtration system would be located within the respective alignment and would consist of a fenced concrete pad area for cartridge or bag-filter housings, LGAC vessels, instrumentation and control, power drop/panel/distribution for each extraction well within the respective alignment, discharge flowmeter, and tie-in to local sewer lateral. Total treatment system costs are then estimated as the product of the number of treatment systems and the total cost per treatment system. Assumptions for groundwater treatment systems are provided in Appendix D.

Construction of Collection Piping: The collection piping cost estimate is based on the total length of the seven conceptual groundwater containment alignments, totaling 9,400 feet, with the treatment system assumed to be located within the respective alignment. The disposal piping length is assumed to be 800 feet based on an assumed distance of no more than 100 feet from the treatment system to the tie-in for the local sewer lateral. Assumptions for groundwater collection and disposal piping are provided in Appendix D.

OMM Treatment Systems: Alternative 6 treatment system OMM would include:

- Electrical power for well pumps,
- Filter bag/cartridge replacements,
- LGAC changeouts,
- Labor for extraction well treatment system operation and maintenance,

- Annual city license agreements for well sites and pipelines,
- Analytical costs and labor for discharge permit monitoring and reporting and permit renewal costs,
- Sewer discharge fees for the extracted groundwater, and
- Water replenishment assessment and basin equity assessment fees for extracted groundwater discharged to the sewer.

OMM ISCO Injections: One component of a portion of Alternative 6 O&M would include injection of persulfate on a periodic basis. Based on the results of source site ISCO applications and remediation monitoring and on professional judgement, the following were assumed in developing Alternative 6 injection O&M costs:

- ISCO injection wells would be constructed with one separate injection well for each targeted Layer along each of the injection alignments.
- The injection rate would equal the average estimated/observed injection rate per injection well specified above of 6 gpm.
- Approximately 2,600 gallons of amended water would be injected at each injection well.
- Approximately 3,400 pounds of PersulfOx activated persulfate would be injected at each injection well in each layer during each injection event.
- ISCO applications would occur on a frequency based on the estimated ambient groundwater flux through each 24-foot wide ISCO alignment (in the direction parallel to groundwater flow) using the calibrated groundwater model (Appendix E).

OMM Groundwater Monitoring, ISCO Groundwater Monitoring: Consistent with the assumptions and approach described for Alternative 5, the total number of WDR monitor wells required for this alternative was estimated as the product of the estimated number of injection wells and 0.2 monitor wells per injection well/point, which equals 68 monitor wells (the product of 338 and 0.2). Groundwater samples would be analyzed for VOCs, 1,4-dioxane, alkalinity, chloride, cations, sulfate, nitrogen, hexavalent chromium, metals, and total dissolved solids (Appendix D).

<u>OMM Groundwater Monitoring, Containment</u>
Alternative 6 containment groundwater monitoring would include:

- Collection of groundwater samples from the number of monitor wells estimated in Table 7-1 on a semiannual frequency for analysis of VOCs using EPA Method 8260B, 1,4-Dioxane using EPA Method 8270, and field parameters.

Cost Estimate: Detailed cost estimates and the assumptions used to generate them for all remedial alternatives are provided in Appendix D. The total NPV costs associated with Alternative 6 are $103,400,000 over an assumed 30-year project lifetime and are summarized as follows:

Cost Analysis for Alternative 6 – Containment and In-Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with Discharge to POTW and GWRS

Total Project Lifetime	30 Years
PDI (Year 1)	$4,500,000
Design and Construct (Years 2 and 3)	$24,300,000
OMM (Years 4 to 30)	$109,200,000
Total Capital and OMM NPV (2.5% discount rate)	$103,400,000

ISCO Cost Sensitivity Analysis

During the December 1, 2021 TAC meeting, the concept of performing a sensitivity analysis of the ISCO injection spacing was discussed (Appendices Q and S). It was agreed that costs for Alternative 6 would be developed for the ISCO portion of this alternative, assuming a radius-of-influence (ROI) of 25 feet (an injection spacing of 50 feet), which is the largest implemented as-built injection spacing that has been used for in-situ injections in the Study Area. The following were assumed in performing a cost sensitivity analysis of the ISCO portion of Alternative 6:

- ISCO injection wells would be constructed with one separate injection well for each targeted Layer along each of the injection alignments.
- The injection rate would equal the average estimated/observed injection rate per injection well specified above of 6 gpm.
- Approximately 11,600 gallons of amended water would be injected at each injection well.
- Approximately 14,800 pounds of PersulfOx activated persulfate would be injected at each injection well in each layer during each injection event.
- ISCO applications would occur on a frequency based on the estimated ambient groundwater flux through each 50-foot wide ISCO alignment (in the direction parallel to groundwater flow) using the calibrated groundwater model (Appendix E).

OMM Groundwater Monitoring, ISCO Groundwater Monitoring: Consistent with the assumptions and approach described for Alternative 5, the total number of WDR monitor wells required for this alternative was estimated as the product of the estimated number of injection wells and 0.2 monitor wells per injection well/point, which equals 32 monitor wells (the product of 162 and 0.2). Groundwater samples would be analyzed for VOCs, 1,4-dioxane, alkalinity, chloride, cations, sulfate, nitrogen, hexavalent chromium, metals, and total dissolved solids (Appendix D).

Since the ROI increased from 12 feet to 25 feet and the injection spacing increased from 24 feet to 50 feet, the treatment zone pore volume calculated to receive amended water at each injection location increased from approximately 17,100 gallons to 74,800 gallons. Since the main cost drivers for ISCO injections are the cost of the persulfate and the injection field labor, increasing the ROI from 12 feet to 25 feet results in a cost increase of the ISCO portion of Alternative 6 of approximately $5,200,000 (Appendix D):

Alternative 6: Comparison of 24-feet on-center (OC) injection spacing (12-feet ROI) versus 50-feet OC injection spacing (25-feet ROI) for ISCO portion of remedy

Item	Cost ($)[1]		
	24 feet OC	50 feet OC	Variance ($)
Capital Cost	$ 10,031,253	$ 4,846,658	$ (5,184,595)
Persulfate	$ 43,635,628	$ 59,206,334	$ 15,570,706
Injection Labor	$ 2,739,617	$ 3,716,849	$ 977,232
Monitoring Labor	$ 1,678,255	$ 814,447	$ (863,808)
Reporting	$ 1,350,000	$ 1,180,000	$ (170,000)
Traffic Control, Application	$ 714,951	$ 221,778	$ (493,173)
Traffic Control, Monitoring	$ 254,320	$ 123,420	$ (130,900)
Laboratory	$ 2,783,904	$ 1,351,012	$ (1,432,892)
WDR Permitting	$ 140,000	$ 140,000	$ -
ISCO Well Development	$ 4,836,683	$ 2,311,335	$ (2,525,348)
ISCO Well Easement	$ 3,329,667	$ 1,595,295	$ (1,734,372)
Percent Add On[2]	$ 5,737,066	$ 6,942,407	$ 1,205,341
Totals	**$ 77,231,344**	**$ 82,449,536**	**$ 5,218,192**

[1] = Costs are based only on the ISCO portion of Alternative 6.

[2] = Percent add ons include additions for permitting, project management, scope contingencies, and bid contingencies. Percentages applied can be found in Table D-6 and Table D-6a.

Sustainability Assessment

The SiteWise Tool for Green and Sustainable Remediation was used to evaluate and semi-quantitatively rank the sustainability of each of the remedial alternatives (NAVFAC, 2018) (Appendix C). The overview of CO_2 emissions, and total energy and electricity used for the construction (PDI and construction) and OMM components are summarized in the following table:

Metric	Construction	OMM	Total
CO_2 Emissions (metric tons)	2,700	54,000	57,000
Total Energy Used (million British Thermal Units)	830,000	940,000	1,800,000
Total Electricity Used (Mega Watt Hours)	0	31,000	31,000

7.3 IRM Compatibility with Source Site Remedial Efforts

The following sections discuss evaluation of the IRM compatibility with ongoing or planned source site remedial efforts.

7.3.1 Alternative 1

Alternative 1 is the No Action alternative which is compatible with source site remedial efforts.

7.3.2 Alternative 2

Alternative 2, Monitored Natural Attenuation, would include installation, monitoring, and maintenance of groundwater monitor wells and is compatible with source site remedial efforts.

7.3.3 Alternatives 3 through 6

The following subsections discuss the compatibility of Alternatives 3 through 6 with source site remedial efforts that are ongoing or planned in proximity to the conceptual IRMs associated with these alternatives. The compatibility of the groundwater containment portions of Alternatives 3, 4, 5, and 6 was evaluated by comparing model simulated changes in groundwater fluxes that may result from IRM groundwater extraction; and by comparing source site published groundwater level elevation contours and directions of groundwater flow with model-simulated particle tracks at and near source sites with ongoing or planned remedial actions that may result from implementation of these alternatives (Figures 7-2 through 7-19B). These figures illustrate the model-simulated particle tracks for all layers as a single color. Alternative 5 and the ISCO portion of Alternative 6 were evaluated by estimating the changes in geochemical conditions at and near source sites with ongoing or planned remedial actions that may result from implementation of these alternatives (Figures 7-4 and 7-5). In response to comments received from SoCo West, Inc., (SOCO) (Appendix V), the OU2 groundwater flow model grid spacing was refined to incorporate the approved SOCO source area remedy which has yet to be installed. This refined model was used to evaluate the change in groundwater flow direction and change in hydraulic gradient at the SOCO property to assess the influence of OU2 groundwater extraction in the vicinity of the SOCO source control remedy.

For Alternatives 3, 4, and 6, generally, there were relatively small changes in groundwater fluxes and flow directions in Layers 1 through 3 (the only layers where source site remedial actions are being or will be applied) at and near most of the source sites. Changes in groundwater flux are dictated by changes in horizontal hydraulic gradients. It is common to have changes in horizontal hydraulic gradients under ambient conditions. For example, water level elevation contours for the upper and lower portions of the Shallow Aquifer System within the Study Area published in the July 2020 South Basin Supplemental Remedial Investigation Report (H+A, 2020) indicated that horizontal hydraulic gradients under ambient conditions ranged from a high of 0.0028 to low of 0.002 and 0.0017 to 0.001, respectively. These variable ambient groundwater gradients represent changes in groundwater flux values ranging between a factor of 1.4 to 1.7. Therefore, simulated groundwater flux increases of less than a factor of 1.5 from ambient (non-IRM pumping conditions) are considered within ambient variability, negligible, and are not further discussed below. The potential effect that IRMs may have on the groundwater flow directions at and near source sites with ongoing or planned remedial actions was evaluated by comparing source site published groundwater level elevation contours and directions of groundwater flow with model-simulated particle tracks and changes in groundwater flow directions that may result from IRM groundwater extraction. As further described below, there are several source sites where the simulated changes in groundwater flux and/or groundwater flow directions in Layers 1 and/or 2 resulting from IRM extraction were, respectively, higher than a factor of 1.5 and/or qualitatively different from localized groundwater flow conditions over limited areas.

For Alternative 5 and the ISCO portion of Alternative 6, it is anticipated that, except for the Cherry Aerospace source site described below, changes in geochemical conditions would be limited to the relatively narrow injection width of approximately 24 feet of each ISCO injection alignment parallel with the direction of groundwater flow, with some relatively small changes in geochemical conditions at relatively short distances downgradient of each alignment. With this exception, Alternative 5 and the ISCO portion of Alternative 6 are not anticipated to significantly affect ongoing or planned source site remedial efforts; however, potential generation of byproducts, such as hexavalent chromium (as described in Section 7.2.3.5, Overall Protection of Human Health and the Environment) could affect source sites downgradient of the alignments if the byproduct is persistent. The risk of byproduct generation is greatest where source sites are relatively close to ISCO applications, most notably near Cherry Aerospace.

The following subsections discuss compatibility of Alternatives 3 through 6 with source site remedial efforts that are ongoing or planned in proximity to the conceptual IRMs. The subsections also correlate the individual source site hydrostratigraphic unit (HSU) designations with the OU2 hydrostratigraphic and model Layers 1 through 4 described in the SRI Report and herein.

7.3.3.1 Allen T. Campbell Trust

This source site may consider application of dual-phased extraction (DPE) with ERH in the A-Zone (Layer 1), and application of groundwater extraction to contain contaminants in the B1(50)-Zone and B1(60)-Zone (Layer 2) (BEC, 2020).

Alternatives 3, 4, and 6 assume groundwater extraction from Layers 1 through 3 along alignments G-2 and G-3, which are located approximately 1,000 and 1,200 feet south and southwest of this source site, respectively (Figures 7-2, 7-3, and 7-5). Groundwater model simulations indicate that groundwater extraction for Alternatives 3, 4, and 6 would result in (Figures 7-6 and 7-7A through 7-7C):

- Layer 1: negligible changes in groundwater fluxes. This source site has published A-Zone groundwater elevation contours indicating that A-Zone groundwater flows radially inward toward and converges on monitor well MW10A (Figure 7-7A). This A-Zone groundwater flow direction appears to be an artifact of either the vertical well screen placement of MW10A relative to other A-Zone monitor wells, or of a gap or hole in aquitard materials in the area of this monitor well that could result in predominantly vertical downward flow converging on and near MW10A. The OCWD model simulated particle tracks are consistent with the southern direction of groundwater flow observed in shallow groundwater near this source site at the scale of the Study Area.
- Layer 2: an increase of the groundwater flux near this source site by a factor of approximately 1.6, with negligible changes in groundwater flow directions (Figures 7-7B and 7-7C).

Alternatives 5 and 6 ISCO injection alignments are located downgradient of this source site and would not affect remedial actions that may be implemented at this source site (Figures 7-4 and 7-5).

7.3.3.2 Gallade Chemical

This source site is implementing groundwater extraction and treatment using DPE and groundwater extraction wells (Integral, 2020). Groundwater is extracted from Shallow Zone Groundwater (Layer 1) and from Deep A Zone Groundwater (Layer 2).

Alternatives 3, 4, and 6 assume groundwater extraction from Layers 1 through 3 along alignments G-2 and G-3, which are located approximately 1,100 and 650 feet southeast and south of this source site, respectively (Figures 7-2, 7-3, and 7-5). Groundwater model simulations indicate that groundwater extraction for Alternatives 3, 4, and 6 would result in (Figures 7-6 and 7-8A through 7-8D):

- Layers 1 and 2: negligible changes in groundwater fluxes. The OCWD model simulated particle tracks are consistent with the south/southwestern groundwater flow directions observed in these Layers throughout and at the scale of the Study Area and with the south/southwestern groundwater flow direction observed in Shallow Zone groundwater beneath roughly the southern half of the Gallade property (EA, 2021a) and in Deep A Zone Groundwater south of Deep A Zone monitor wells MW-32A and MW-25 near the southern property boundary of the Gallade property (Figure 7-8C).

Alternatives 5 and 6 ISCO injection alignments are located downgradient of this source site and would not affect remedial actions currently being implemented at this source site (Figures 7-4 and 7-5).

7.3.3.3 Embee Plating

This source site is implementing in-situ remediation by injecting/recirculating emulsified vegetable oil (EVO), sodium lactate, bicarbonate, surfactant, microbial nutrients, and calcium polysulfide into the A-Zone (Layer 1) and the C-Zone (Layer 2) (Stantec, 2020b).

Alternatives 3, 4, and 6 assume groundwater extraction from Layers 1 through 3 along alignments G-2 and G-3, which are located approximately 350 and 400 feet southeast and southwest of this source site, respectively (Figures 7-2, 7-3, and 7-5). Groundwater model simulations indicate that groundwater extraction for Alternatives 3, 4, and 6 would result in (Figures 7-6, 7-9A and 7-9B):

- Layer 1: negligible changes in groundwater fluxes. The published A-Zone groundwater flow directions are different than the model-simulated particle tracks (Figure 7-9A). This difference appears to be a result of the perched groundwater conditions represented in the published A-Zone groundwater elevation contours, as stated by Embee's consultant: "The 9.5 to 48 feet bgs zone is dominated by clay with discontinuous sand stringers leading to perching of groundwater and variable flow direction and gradient" (Stantec, 2021). The OCWD model simulated particle tracks are consistent with the south/southwestern groundwater flow direction observed throughout and at the scale of the Study Area.
- Layer 2: an increase of the groundwater flux near this source site by a factor of approximately 1.6 and negligible changes in groundwater flow directions.

Alternatives 5 and 6 ISCO injection alignments are located downgradient of this source site and would not affect remedial actions currently being implemented at this source site (Figures 7-4 and 7-5).

7.3.3.4 Soco West, Inc., Former Service Chemical Facility

This source site reportedly is planning to implement a surface cap, MNA, slurry walls, and EISB into HSU 3 (Layer 2) using injection wells and a PRB north of Warner Avenue (Geosyntec Consultants, 2015).

Alternatives 3, 4, and 6 assume groundwater extraction from Layers 1 through 3 along alignments G-2 and G-3, which are located approximately 250 and 400 feet southeast and southwest of this source site, respectively (Figures 7-2, 7-3, and 7-5). In response to comments received by SOCO (Appendix V), the model grid was refined, and additional modeling was performed to further evaluate the potential effects of OU2 groundwater extraction on SOCOs approved source control remedy by reducing the grid spacing across the SOCO site. The revised OU2 groundwater flow model was modified by incorporating the slurry walls, flow gates and permeable reactive barriers (PRB[s]) into the model using the available SOCO design parameters (*Feasibility Study/Remedial Action Plan, Former Service Chemical Facility, 1341 East Maywood Avenue, Santa Ana, California*, prepared by Geosyntec Consultants, dated July 14, 2015 and *Remedial Design and Implementation Plan, Former Service Chemical Facility 1341 E. Maywood Avenue, Santa Ana, California*, prepared by Geosyntec Consultants, dated November 2016) in order to simulate OU2 FS pumping with the SOCO remedy in place (refer to Appendix V, Attachment 1). The model simulations indicated that the direction of groundwater flow within the SOCO treatment area was relatively unaffected by OU2 FS pumping. This indicates that OU2 FS pumping has a lesser effect on the change in groundwater flow direction through the SOCO source area than was presented in the April 2022 Draft OU2 FS Report. The hydraulic gradient within the SOCO treatment area was then calculated with and without OU2 FS pumping. Given the refinement of the OU2 groundwater flow model grid and incorporation of the SOCO source area remedy into the model, a more direct comparison of change in groundwater flux (amount of groundwater flow) through the SOCO source area remedy was evaluated. The groundwater flux through the SOCO treatment area was assessed using the refined OU2 groundwater flow model with and without OU2 FS pumping. The amount of water flowing through the SOCO treatment zone increased by approximately 1.7 with OU2 pumping as compared to the non-OU2 pumping condition. This change in flux through the SOCO source area remedy is smaller than was inferred based on the change in hydraulic gradient, indicating a lesser influence than was presented in the April 2022 Draft OU2 FS Report.

Groundwater model simulations indicate that groundwater extraction for Alternatives 3, 4, and 6 would result in (Figures 7-6 and 7-10A and 7-10B):

- Layer 1: negligible changes in groundwater fluxes and directions of flow.
- Layer 2: an increase of the groundwater flux near this source site by a factor of approximately 1.7, and negligible changes in groundwater flow directions.

Alternatives 5 and 6 ISCO injection alignments are located downgradient of this source site and would not affect remedial actions currently being implemented at this source site (Figures 7-4 and 7-5).

7.3.3.5 Former Diceon Electronics Facility

This source site reportedly is planning to implement soil excavation and ISCR using S-MicroZVI, a sulfidated ZVI, into the lower portion of HSU A-Zone (Layer 1), B-Zone (Layer 2) and the upper portion of the C- Zone (Layer 2/3) using direct-push injection methods along an on-property alignment in the southern-central portion of and off-property alignment immediately south of the former Diceon property (see Figure 16 from Black Rock Geosciences, 2021).

Alternatives 3, 4, and 6 assume groundwater extraction from Layers 1 through 3 along alignments G-2 and G-3, which are located approximately 800 and 320 feet southeast and south of this source site, respectively (Figures 7-2, 7-3, and 7-5). Groundwater model simulations indicate that groundwater extraction for Alternatives 3, 4, and 6 would result in (Figures 7-6 and 7-11A through 7-11D):

- Layer 1: negligible changes in groundwater fluxes. Diceon's consultant has published A-Zone groundwater elevation contours indicating that A-Zone groundwater flows radially inward toward and converges on monitor well MW4-A and possibly MW6-A (Black Rock Geosciences, 2021). This A-Zone groundwater flow direction appears to be an artifact of either the relatively deeper vertical well screen placement of MW4-A (MW4-A well screen is 5-feet vertically deeper that the well screens for MW3-A, 5-A and 6-A), or of a gap or hole in aquitard materials in the area of monitor wells MW4-A/MW6-A that could result in predominantly vertical downward flow converging on and near these wells. Additionally, if the ISCR injection alignments are meant to treat the lower portion of A-Zone groundwater beneath and downgradient of the Diceon source site (Figure 16 of Black Rock Geosciences, 2021 illustrates a vertical treatment interval that overlaps the lower portions of A-Zone monitor wells MW5-A and MW9-A well screens), they are not aligned perpendicular to Diceon's published A-Zone groundwater flow directions, which may limit A-Zone groundwater treatment effectiveness.
- Layer 2: an increase of the groundwater flux near this source site by a factor of approximately 1.6, and negligible changes in flow directions toward the south/southwest.
- Layer 3: negligible changes in the groundwater flux and flow directions at and near this source site.

Alternatives 5 and 6 ISCO injection alignments are located downgradient of this source site and would not affect remedial actions currently being implemented at this source site (Figures 7-4 and 7-5).

7.3.3.6 Cherry Aerospace

This source site is implementing and plans on expanding groundwater extraction and treatment using DPE wells and groundwater extraction wells (CDM Smith, 2020). Groundwater is to be extracted from the Shallow (Upper) Zone (Layer 1), from Sand A (Layer 2) and from Sand B (Layers 2 and 3).

Alternatives 3, 4, and 6 assume groundwater extraction from Layers 1 through 3 along alignments G-2, G-3, and G-8, which are located approximately 800 feet, immediately adjacent to, and 600 feet east, north, and southeast of this source site, respectively (Figures 7-2, 7-3, and 7-5). Groundwater model simulations indicate that groundwater extraction for Alternatives 3, 4, and 6 would result in (Figures 7-6 and 7-12A through 7-12C):

- Layers 1, 2, and 3: negligible changes in groundwater fluxes and directions of flow.

Further, the conceptual OU2 IRM Alternatives 3, 4, and the containment portion of Alternative 6, may act to prevent or minimize upgradient COCs from continuing to migrate beneath the Cherry Aerospace property and/or into the Cherry Aerospace source site extraction well network, which would be beneficial for this source site's remedial actions.

Alternatives 5 and 6 ISCO injection alignments are located immediately north, east, and southeast of this source site (Figures 7-4 and 7-5). The potential changes in groundwater geochemistry that may result from implementation of these alternatives (generation of undesired byproducts) could negatively affect the ongoing and planned expansion of groundwater extraction and treatment for this source site. If selected, Alternative 5 and the ISCO portion of Alternative 6 must be implemented in a manner that allows for the detection and evaluation of potential negative effects on this source site's remedial actions, and for cessation or adjustment of the IRMs, if such negative effects were observed.

Based on the preceding, the conceptual OU2 IRM Alternatives 3, 4, and the containment portion of Alternative 6 may be beneficial to the ongoing and planned remedial actions at this source site. Alternative 5 and the ISCO portion of Alternative 6 have a relatively high potential to generate undesired byproducts, such as hexavalent chromium in close proximity to the Cherry Aerospace property and the existing or planned Cherry Aerospace source site extraction well network.

7.3.3.7 Steelcase Incorporated

This source site has implemented and continues to implement groundwater extraction and treatment using groundwater extraction wells in Zone B (Layer 1) on the source site property (ERM, 2020). This source site responsible party has recently informed the RWQCB about their plan to submit a work plan proposing mass removal for impacted soil and in-situ remediation of contaminated groundwater at this source site.

Alternatives 3, 4, and 6 assume groundwater extraction from Layer 1 along alignment G-4, which is located approximately 450 feet south of this source site (Figures 7-2, 7-3, and 7-5). Groundwater model simulations indicate that groundwater extraction for Alternatives 3, 4, and 6 would result in (Figures 7-6 and 7-13A and 7-13B):

- Layers 1 and 2: negligible changes in groundwater fluxes and directions of flow.

Alternative 5 ISCO injection alignment I-4 is located approximately 450 feet downgradient of this source site and would not affect remedial actions that may be implemented at this source site (Figure 7-4).

7.3.3.8 Troy Computer

This source site has implemented EISB using Hydrogen Release Compound™ (HRC) and 3-D Microemulsion™ (3DMe) (Bryant Geoenvironmental, Inc., 2010). The RWQCB has directed Troy Computer to address the source of impacts in the vadose zone, which will be followed by a request for work plans to fully delineate the extent of VOCs (and potentially 1,4-dioxane) impacts in vadose zone soil and groundwater (RWQCB, 2021c). The RWQCB has indicated that the potential selection and implementation of a groundwater remedy is on hold, pending further groundwater investigation and a feasibility study (Appendix S).

Alternatives 3, 4, and 6 assume groundwater extraction from Layer 1 along alignment G-4, which is located approximately 50 feet south of this source site (Figures 7-2, 7-3, and 7-5). Groundwater model simulations indicate that groundwater extraction for Alternatives 3, 4, and 6 would result in (Figures 7-6 and 7-14A and 7-14B):

- Layer 1: an increase of the groundwater flux near this source site by a factor of approximately 3.7 and negligible changes in groundwater flow directions.

Alternative 5 ISCO injection alignment I-4 is located downgradient of this source site and would not affect remedial actions that may be implemented at this source site (Figure 7-4).

7.3.3.9 GE Plastics

This source site has implemented and continues to implement on-property in-situ bioremediation using EVO and acetic acid-amended water and groundwater extraction and treatment using groundwater extraction wells in the First Water-Bearing Zone (Layer 1); and off-property in-situ bioremediation using perchlorate along biobarriers installed along Deere Avenue (First Water Bearing Zone and Second Water Bearing Zone) and Alton Parkway (Second Water-Bearing Zone (Amec, 2014; Amec Foster Wheeler, 2016; Wood, 2020, 2021a and 2021b).

Alternatives 3, 4, and 6 assume groundwater extraction from Layer 1 along alignment G-4, which is located approximately 500 feet north of this source site (Figures 7-2, 7-3, and 7-5). Groundwater model simulations indicate that groundwater extraction for Alternatives 3, 4, and 6 would result in (Figures 7-6 and 7-15A and 7-15B):

- Layers 1 and 2: negligible to no changes in groundwater fluxes and directions of flow.

Alternative 5 ISCO injection alignment I-4 is located 500 feet upgradient of this source site and the modest conceptual ISCO injection effort in this area is not anticipated to affect remedial actions ongoing at this source site (Figure 7-4). The conceptual IRM at G-4 associated with Alternatives 3 through 6 would have a beneficial effect by reducing the potential for migration of COCs beneath the GE Plastics source site.

7.3.3.10 ITT Cannon

This source site is implementing near off-property groundwater extraction and treatment using groundwater extraction wells (Arcadis, 2020). Groundwater is extracted from the Intermediate Unit, which is further subdivided into Sand A (Layer 2) and Sand B (Layer 2); and has implemented and reportedly plans to implement additional far off-property ISB (Arcadis, 2020; RWQCB, 2021b).

Alternatives 3, 4, and 6 assume groundwater extraction from Layers 1 and 2 along alignment G-5, which is located immediately north/northeast of this source site and groundwater extraction from Layers 1 and 2 along alignment G-6, which is located approximately 1,150 feet south-southwest of the southern-most off-property in-situ remediation area implemented by this source site (Figures 7-2, 7-3, and 7-5). Groundwater model simulations indicate that groundwater extraction for Alternatives 3, 4, and 6 would result in (Figures 7-6 and 7-16A through 7-16D):

- Layer 1 on- and off-Property and Layer 2 on-and near-property: negligible changes in groundwater fluxes and directions of flow.
- Layer 2 far off-property: an increase of the groundwater flux near the southern-most off-property in-situ remediation area implemented by this source site by a factor of approximately 1.6, and negligible changes in groundwater flow directions.

The conceptual OU2 IRM Alternatives 3, 4, and the containment portion of Alternative 6, may act to prevent or minimize upgradient COCs from migrating beneath the ITT property and/or into the ITT site extraction well network, which would be beneficial for this source site's remedial actions.

Alternative 5 ISCO injection alignment I-5 is located immediately north/northeast of this source site (Figure 7-4). The potential changes in groundwater geochemistry that may result from implementation of this alternative (generation of undesired byproducts) could negatively affect the ongoing groundwater extraction and treatment at this source site. If selected, Alternative 5 must be implemented in a manner that allows for the detection and evaluation of potential negative effects on this source site's remedial actions, and for cessation or adjustment of the IRMs, if such negative effects were observed.

Based on the preceding, the conceptual OU2 IRM Alternatives 3, 4, and the containment portion of Alternative 6 may be beneficial to the ongoing and planned remedial actions at this source site. Alternative 5 has a potential to generate undesired byproducts, such as hexavalent chromium near the ITT property and their near off-property extraction well network.

7.3.3.11 Former Ricoh Electronics Facility

This source site has implemented ISCO using potassium permanganate (WPI., 2010) and reportedly planned to implement enhanced ISB pilot testing using lactate (WPI, 2019). The previous and planned injections were/will be into the Upper Zone (Layer 1 and Layer 2) and into the Lower Zone (Layer 3) on the property.

Alternatives 3, 4, and 6 assume groundwater extraction from Layers 1 and 2 along alignment G-6, which is located approximately 150 feet south of this source site (Figures 7-2, 7-3, and 7-5). Groundwater model simulations indicate that groundwater extraction for Alternatives 3, 4, and 6 would result in (Figures 7-6 and 7-17A and 7-17B):

- Layer 1: negligible changes in groundwater fluxes and directions of flow.

- Layer 2: an increase of the groundwater flux near this source site by a factor of approximately 2.8. The Lower Zone groundwater level data from this source site does not appear to have been historically contoured; however, the published groundwater level elevations in the Lower Zone are similar to those in the Upper Zone, which implies Lower Zone groundwater flow directions are similar to those in the Upper Zone, and negligible changes in Lower Zone groundwater flow directions.
- Layer 3: an increase of the groundwater flux near this source site by a factor of approximately 1.6, and unknown changes in flow direction, since this source site has no groundwater level elevation contours for this HSU.

Alternative 5 ISCO injection alignment I-6 is located downgradient of this source site and would not affect remedial actions currently being implemented at this source site (Figure 7-4).

7.3.3.12 Baxter Healthcare

This source site has implemented ISCO using persulfate in the "underlying sand-dominated zone…" (Layer 2) (Arcadis, 2015) and has performed additional pilot scale ISCO groundwater remediation using activated persulfate into the intervals 28 to 38 feet bgs (Layer 1) and 40 to 50 feet bgs (Layer 2) on the property (BBJ Group, 2020 and 2021; RWQCB, 2020b).

Alternatives 3, 4, and 6 assume groundwater extraction from Layers 1 and 2 along alignment G-7, which is located approximately 450 feet south of this source site (Figures 7-2, 7-3, and 7-5). Groundwater model simulations indicate that groundwater extraction for Alternatives 3, 4, and 6 would result in (Figures 7-6 and 7-18A and 7-18B):

- Layers 1 and 2: negligible changes in groundwater fluxes and directions of flow.

Alternative 5 ISCO injection alignment I-7 is located downgradient of this source site and would not affect remedial actions that may be implemented at this source site (Figure 7-4).

7.3.3.13 Bell Industries

This source site is implementing off-property groundwater extraction and treatment using groundwater extraction wells (Atlas Environmental Engineering, Inc., 2021). Groundwater is extracted from the Local Shallow Zone (Layer 1), the Local Intermediate Zone (Layer 2), and the Local Deep Zone (Layer 2/3).

Alternatives 3, 4, and 6 assume groundwater extraction from Layers 1 and 2 along alignment G-1, which is located approximately 1,200 feet south and downgradient of the southern-most extraction well associated with this source site (Figures 7-2, 7-3, and 7-5). Groundwater model simulations indicate that groundwater extraction for Alternatives 3, 4, and 6 would result in (Figures 7-6 and 7-19A and 7-19B):

- Layers 1 and 2: negligible changes in groundwater fluxes. The OCWD model simulated particle tracks are consistent with the south/southwestern groundwater flow direction observed near this source site and throughout and at the scale of the Study Area.

Alternative 5 ISCO injection alignment I-1 is located approximately 1,200 feet downgradient of the southern-most extraction well associated with this source site and would not affect remedial actions that may be implemented at this source site (Figure 7-4).

7.3.3.14 Other Source Sites

The conceptual IRMs would have negligible changes in groundwater fluxes and/or groundwater flow directions in the vicinity of the following source sites with ongoing or planned remedial efforts (Figure 7-6):

- Dyer Business Park
- GE's downgradient remediation areas
- BFM Energy
- Astech

7.4 IRM Compatibility with Armstrong Channel

In a letter dated March 25, 2021, the RWQCB transmitted their comments on the FSISE to OCWD (RWQCB, 2021a), one of which stated:

> "Since the bottom of the channel is unpaved and its elevation is below the water table, please explain how this remedy [Alternative 5] could be implemented effectively. In addition, please explain how the release of ISCO reagent into the channel will be avoided."

Alternative 5 ISCO injection alignment I-7 is located approximately 50 feet north of the center of Armstrong Channel (Figure 7-4). Since the bottom of the channel is unpaved and its elevation is below the water table, there is a risk that ISCO reagents and/or undesired reaction byproducts that could be generated (hexavalent chromium) could migrate toward and flow into the channel. There does not appear to be a way to balance the likely relatively high volume and repeated applications of ISCO reagents that would be necessary for Alternative 5 along alignment I-7 to be effective in this area, while preventing potential and likely undesired discharge into the channel. This could result in negative environmental impacts to the surface water quality in the channel and ineffective groundwater treatment and remedy failure. For these reasons, implementability of Alternative 5 has lower relative Balancing Criteria rankings compared with Alternatives 3, 4, and 6.

8.0 COMPARATIVE ANALYSIS

Table 8-1 summarizes the general response actions and process options included in each of the six remedial alternatives.

Table 8-2 summarizes a relative comparison and ranking of the six remedial alternatives regarding the degree to which each one satisfies the two threshold criteria and the five balancing criteria. The six alternatives also are compared and relatively ranked in terms of the green or sustainable practices anticipated during IRM implementation. In general, the distinguishing factors that result in ranking certain alternatives more favorably than others are their ability to meet threshold criteria, their implementability and their cost effectiveness. Except for Alternative 1 (No Action), Institutional Controls, Monitoring, and Sealing Legacy Water Supply Wells process options would be a component of all applied IRMs, and they would all provide a similar measure of protectiveness to human health and the environment as a component of each alternative.

8.1 Alternatives – Comparative Analysis

8.1.1 **Threshold Criteria**

Comparing the overall Threshold Criteria of each alternative, Alternatives 3 and 4 rank highest, Alternative 6 ranks moderately high, Alternative 5 has modest ranking, Alternative 2 has a relatively low ranking and Alternative 1 is lowest in rank (Table 8-2).

Alternative 1 (No Action) does not meet the primary threshold criteria of protectiveness of human health and the environment. With excess risk present, this alternative was not retained for consideration as a preferred alternative because of its inability to meet the basic threshold criteria of protectiveness.

Alternative 2 (MNA) also does not meet the primary threshold criteria of protectiveness of human health and the environment with the exception of protection of human exposure to groundwater containing COCs through institutional controls (Table 8-2). Regarding MNA in OU2, the RWQCB stated: “Please be advised that we do not consider natural attenuation a ‘cleanup action,’ because it is a passive remedy” (RWQCB, 2021a) and thus they do not view MNA as a stand-alone remedial action for OU2 groundwater. However, MNA was evaluated as a potential stand-alone remedial action herein for the purposes of completeness and consistency with the NCP. In the context of an IRM and since there is no active remediation being implemented, there are no chemical-specific ARARs identified for Alternative 2; however, in context of transitioning an IRM to a final remedy, this alternative would not comply with the chemical-specific ARARs associated with the state and federal MCLs for OU2 groundwater COCs in a reasonable timeframe. Alternative 2 does meet the location- and action-specific ARARs.

Alternatives 3 and 4 (Containment with POTW/GWSRS and Local Treatment with Reinjection, respectively) meet the primary threshold criteria protectiveness of human health and the environment and compliance with ARARs (Table 8-2).

Alternative 5 (ISCO) might meet the threshold criteria for protectiveness of human health and the environment; however, the potential for generation of persistent undesirable byproducts, particularly near some source sites and in close proximity to the surface water channels in the southern portion of the Study Area, are of concern (Table 8-2). The potential for generation of persistent undesirable byproducts along with potential for not complying with Basin Plan Water Quality Objectives (WQOs) due to repeated application of relatively large volumes of amendments to groundwater are also of concern when evaluating compliance with ARARs.

Alternative 6 (Containment and ISCO) is effectively a mix of Alternatives 3 and 5, with a smaller application area for ISCO, thereby reducing, but not eliminating protectiveness of human health and the environment and ARARs (Table 8-2).

8.1.2 Balancing Criteria

Comparing the overall Balancing Criteria of each alternative, Alternative 3 ranks highest followed closely by Alternative 4, Alternative 6 ranks moderately high, Alternative 5 has a moderate ranking, Alternative 2 has a relatively low ranking, and Alternative 1 is lowest in rank (Table 8-2).

Alternative 1 (No Action) ranks low in long-term effectiveness, reduction of TMV, and short-term effectiveness, and high in implementability (Table 8-2). It was not ranked in cost.

Alternative 2 (MNA) ranks low in reduction of TMV and short-term effectiveness, relatively low in long-term effectiveness and high in implementability and cost (Table 8-2).

Alternative 3 (Containment with POTW/GWRS) ranks moderately high in cost and high in long-term effectiveness, reduction of TMV, short-term effectiveness and implementability (Table 8-2).

Alternative 4 (Containment with Reinjection) ranks moderately in cost, moderate to high in implementability and high in long-term effectiveness, reduction of TMV and short-term effectiveness (Table 8-2).

Alternative 5 (ISCO) ranks low in cost and moderately in long-term effectiveness, reduction of TMV, short-term effectiveness and implementability (Table 8-2).

Alternative 6 (Containment and ISCO) ranks relatively low in cost and relatively high in long-term effectiveness, reduction of TMV, short-term effectiveness and implementability (Table 8-2).

8.1.3 Green and Sustainable Practices

Comparing the overall sustainability of each alternative, Alternative 2 ranked highest followed closely by Alternative 3, Alternative 4 has modest ranking, Alternative 6 has a relatively low ranking, and Alternative 5 has a low ranking (Table 8-2).

The SiteWise Tool for Green and Sustainable Remediation was used to evaluate and semi-quantitatively rank the sustainability of each of the remedial alternatives (NAVFAC, 2018) (Appendix C). The overview of CO_2 emissions, and total energy electricity used for the construction (PDI and construction) and OMM components for Alternatives 2 to 6 are summarized in the following table:

Remedial Alternatives	GHG Emissions	Total Energy Used	Electricity Usage
	metric ton	MMBTU	MWH
Alt 2 - MNA	970	280,000	-
Alt 3 - GWE POTW&GWRS	13,000	530,000	31,000
Alt 4 - GWE Reinjection	18,000	670,000	47,000
Alt 5 - ISCO	170,000	5,000,000	-
Alt 6 - ISCO + GWE POTW&GWRS	57,000	1,800,000	31,000

The following table provides a relative comparison of Alternatives 2 to 6, with relative ranking of Low to High, which indicates the level of impact. Low impacts are more desirable and indicate a higher level of sustainability than Medium and High impacts (Table 8-2).

Remedial Alternatives	GHG Emissions	Energy Usage	Electricity Usage
Alt 2 -MNA	Low	Low	Low
Alt 3 -GWE POTW&GWRS	Low	Low	Medium
Alt 4 -GWE Reinjection	Low	Low	High
Alt 5 -ISCO	High	High	Low
Alt 6 -ISCO + GWE POTW&GWRS	Medium	Medium	Medium

8.1.4 **Other Considerations**

The six remedial alternatives were evaluated relative to one another based on compatibility with source site remediation and the Armstrong Channel (Table 8-2). Alternatives 1 and 2 are compatible with source remediation systems and with Armstrong Channel. Alternative 5 is slightly more compatible with source site remediation systems when compared to Alternatives 3, 4 and 6; however, this alternative is not compatible with Armstrong Channel. Alternatives 3 and 4 are compatible with source site remediation and with Armstrong Channel, given the flexibility and reversibility of these remedial alternatives. In instances where these alternatives may not have negligible effects, the IRM containment alignments are located relatively close to the subject source site remedial areas. At these containment alignments, options for IRM implementation include not installing extraction wells or balancing extraction rates during implementation to moderate and minimize the effects that OU2 extraction may have on selected source site remedial efforts.

8.2 Conclusions and Recommendations

This FS evaluated a broad set of remedial alternatives in detail. Comparing the overall Threshold Criteria of each alternative, Alternatives 3 and 4 rank highest, Alternative 6 ranks moderate to high, Alternative 5 has a moderate ranking, Alternative 2 has a low to moderate ranking and Alternative 1 is lowest in rank (Table 8-2).

Comparing the overall Balancing Criteria of each alternative, Alternatives 3 and 4 rank highest, Alternative 6 ranks moderate to high, Alternative 5 has a moderate ranking, and Alternatives 1 and 2 are ranked lowest (Table 8 2).

Comparing green and sustainability practices for active remediation alternatives (excluding MNA), Alternative 3 ranks highest, Alternative 4 ranks moderate, Alternative 6 ranks low to moderate, and Alternative 5 ranks lowest (Table 8-2).

It is recommended that these evaluations should be used to support selection of the OU2 IRM.

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TABLES

Table 1-1 Study Area Water Supply Well Inventory, United States Geological Survey 1904

Well Number	Date Completed	Class of Well / Diameter	Well Depth (feet bls)
Legacy wells located within the Study Area			
650	1892	Bored, 7 inch	250
654	1899	Bored, 7 inch	260
656	--	Bored, 10 inch	64
657	--	--	260(2)
658	1903	Hydraulic, 2 inch	224
674	--	Hydraulic, 2 inch	260(2)
675	--	Hydraulic, 2 inch	27
676	--	Bored, 7 inch	27
677	--	Bored, 4 inch	--
678	1884(1)	Bored, 5 inch	--
679	1899	Hydraulic, 2 inch	180
680	1898	Hydraulic, 2 inch	180(1)
681	--	Bored, 7 inch	200
682	--	Bored, 7 inch	196
683	1892	Bored, 4 inch	53
684	--	Bored, 5 inch	200(1)
685	--	--	50(1)
686	1904	Hydraulic, 3 inch	--
687	1903	Hydraulic, 2 inch	210(1)
688	1904	Bored, 2 inch	212
689	1900	Bored, 4 inch	200(2)
691	1901	Hydraulic 3 inch	212
692	1902	Bored, 7 inch	220
693	--	Hydraulic, 2 inch	200(2)
694	1903	Driven, 2 inch	239
695	--	Bored, 4 inch	40
696	1904	Hydraulic, 2 inch	239
698	--	Bored, 7 inch	--
699	--	Hydraulic, 2 inch	200(2)
701	--	Hydraulic, 2 inch	35
702	1900	Bored, 7 inch	214
703	1904	Hydraulic, 3 inch	196
704	1897	Hydraulic, 2 inch	194
705	1886	Bored, 4 inch	132

Table 1-1 Study Area Water Supply Well Inventory, United States Geological Survey 1904

Well Number	Date Completed	Class of Well / Diameter	Well Depth (feet bls)
706	--	Hydraulic, 4 inch	218
707	1904	Bored, 10 inch	490
708	1878	Bored, 5 inch	200(1)
709	1884	Bored, 3 inch, inside of 7 inch	--
710	1903	Hydraulic, 2 inch	264
711	1899	Bored, 7 inch	331
712	1903	Hydraulic, 3 inch	250
713	1887	Bored, 7 inch	34
Legacy wells located within the Study Area (continued)			
714	1890	Bored, 4 inch	196
715	1904	Bored, 10 inch	284
717	1900	Hydraulic, 3 inch	299
718	1904	Hydraulic, 2 inch	312
719	1899	Hydraulic, 2 inch	150(1)
720	1892	Bored, 7 inch	185
721	--	Hydraulic, 3 inch	--
722	--	--	--
873	1899	Bored, 10-inch, reduced to 6-inch	360(2)
962	1878	Bored, 7 Inch	200(1)
982	1898	Hydraulic, 2 inch	204
983	1898	Hydraulic, 2 inch	138
990	1899	Hydraulic, 4 inch	351
991	1899	Hydraulic, 4 inch	183
1046	1901	Bored, 10 inch	193
1075	1904	Hydraulic, 4 inch	394
1077	1904	Hydraulic, 4 inch	415
1131	1902	Hydraulic, 2.5 inch	108
Proximal Legacy Wells Located West of the Study Area			
651	1870	Bored, 4 inch	50
652	1901	Bored, 7 inch	400(2)
653	1901(1)	Hydraulic, 2 inch	264
660	1888	Bored, 7 inch	80
661	1888	Bored, 7 inch	60
664	1898	--	21

Table 1-1 Study Area Water Supply Well Inventory, United States Geological Survey 1904

Well Number	Date Completed	Class of Well / Diameter	Well Depth (feet bls)
665	1896	Bored, 7 inch	380(2)
666	1888	Bored, 4 inch	380(2)
667	--	Hydraulic, 2 inch	260(1)
668	--	Hydraulic, 3 inch	260(2)
669	1902	Bored, 7 inch	63
670	1903	Bored, 3 inch	265
744	1904	Bored 9.5 inch	114
745	--	Bored, 4 inch	--
747	--	Bored, 4 inch	56
748	--	Dug, 5 by 5 ft	3
828	--	Hydraulic 3 inch	--
Proximal Legacy Wells Located East of the Study Area			
898	--	Bored, 8 inch	--
904	1880	Bored, 4 inch	120(2)
907	--	Hydraulic, 2 inch	200
984	1899	Hydraulic, 2 inch	150
1066	1903	Hydraulic, 4 inch	75
1128	1900	Bored, 7 Inch	284
1129	1900	Bored, 7 Inch	282

Source:

From Table 2-1 Supplemental Remedial Investigation Report (Hargis, 2020)

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Approximate well locations illustrated on Figure 1-4.
Current well status unknown.

Notes:

(1) = Value recorded as "doubtful"
(2) = Value recorded as "includes tank in column"
bls = below land surface

Table 1-2 Water Supply Wells in Vicinity of Study Area

Well ID	Owner/Operator	Status	Feet Below Land Surface			Well Use
			Top Screened Interval	Bottom Screened Interval	Borehole Depth	
IRWD-2/1	Irvine Ranch Water District	Active	385	855	1450	Potable Water Supply
IRWD-3/1	Irvine Ranch Water District	Active	484	1270	1309	Potable Water Supply
IRWD-5/1	Irvine Ranch Water District	Active	554	1028	1075	Potable Water Supply
IRWD-52/1	Irvine Ranch Water District	Inactive	635	1290	1400	Potable Water Supply
NDW-1	Niagra Bottling, LLC	Inactive	Unknown	Unknown	510	Domestic
SA-26/1	Santa Ana	Active	Unknown	Unknown	1186	Potable Water Supply
SAKI-SAJ1	Sakioka & Sons	Inactive	Unknown	Unknown	187	Domestic
SAKI-SAJ3	Sakioka & Sons	Active	Unknown	Unknown	463	Irrigation
SCGC-I[1]	Southern California Gas Co.	Active	Unknown	Unknown	300	Industrial
SNDR-SA	Lakeside Partners Hutton, LLC	Active	Unknown	Unknown	1030	Irrigation
T-ED/1	Tustin	Active	Unknown	Unknown	1492	Potable Water Supply
IRWD-51/1	Irvine Ranch Water District	Inactive	310	880	1077	Potable Water Supply
FOLLOWING FROM WRMS DATABASE, 2008						
B-8168	Unknown	Destroyed	Unknown	Unknown	87	Unknown
B-8187	Unknown	Destroyed	Unknown	Unknown	72	Unknown
W-16259	South Main Mutual Water Co.	Abandoned	Unknown	Unknown	150	SMSYS
W-16269	Burmah Oil & Gas Co.	Abandoned	Unknown	Unknown	565	Industrial
W-16275	South Main Mutual Water Co.	Abandoned	Unknown	Unknown	260	SMSYS
W-16277	South Main Mutual Water Co.	Abandoned	Unknown	Unknown	260	SMSYS
W-16307	Private	Abandoned	Unknown	Unknown	700	Agricultural/Irrigation
W-16311	Private	Abandoned	Unknown	Unknown	1478	Domestic
W-16315	Sakioka Farms	Abandoned	Unknown	Unknown	450	Agricultural/Irrigation
W-16317	Sakioka Farms	Abandoned	Unknown	Unknown	Unknown	Agricultural/Irrigation
W-16319	Private	Abandoned	Unknown	Unknown	454	Agricultural/Irrigation
W-16321	Private	Abandoned	Unknown	Unknown	240	Agricultural/Irrigation

Table 1-2 Water Supply Wells in Vicinity of Study Area

Well ID	Owner/Operator	Status	Feet Below Land Surface			Well Use
			Top Screened Interval	Bottom Screened Interval	Borehole Depth	
SAKI-SAD1	Sakioka Farms	Destroyed	Unknown	Unknown	Unknown	Agricultural/Irrigation
TIC-1240	The Irvine Company - Irvine	Unknown	Unknown	Unknown	512	Domestic
TIC-1253	The Irvine Company - Irvine	Unknown	Unknown	Unknown	1430	Unknown
TIC-1257	The Irvine Company - Irvine	Unknown	Unknown	Unknown	304	Unknown
TIC-51	The Irvine Company - Irvine	Destroyed	Unknown	Unknown	775	Industrial
TIC-51R	The Irvine Company - Irvine	Destroyed	Unknown	Unknown	750	Agricultural/Irrigation
TIC-676	The Irvine Company - Irvine	Unknown	Unknown	Unknown	415	Unknown
TIC-81	The Irvine Company - Irvine	Unknown	Unknown	Unknown	1186	Unknown
TIC-89	The Irvine Company - Irvine	Abandoned	Unknown	Unknown	Unknown	Agricultural/Irrigation
TIC-90	The Irvine Company - Irvine	Abandoned	Unknown	Unknown	Unknown	Agricultural/Irrigation
TIC-91[2]	Private	Destroyed	403	1208	1235	Monitoring
W-11887	Irvine Ranch Water District	Unknown	Unknown	Unknown	Unknown	Agricultural
W-14831	Private	Destroyed	Unknown	Unknown	143	Agricultural/Irrigation
W-15835	Sakioka, John	Destroyed	Unknown	Unknown	480	Agricultural/Irrigation
W-15837	Sakioka Farms	Unknown	Unknown	Unknown	200	Agricultural
W-17203	Birtcher-Pacific	Abandoned	Unknown	Unknown	980	Agricultural/Irrigation
W-1823	The Irvine Company - Irvine	Unknown	Unknown	Unknown	800	Unknown
W-1825	Private	Unknown	Unknown	Unknown	430	Domestic
W-1881	The Irvine Company - Irvine	Abandoned	Unknown	Unknown	355	Domestic
W-1887	Private	Unknown	Unknown	Unknown	1063	Industrial
W-1889	Private	Unknown	Unknown	Unknown	350	Unknown
W-1891	Holly Sugar Company	Abandoned	Unknown	Unknown	1010	Industrial
W-1893	Holly Sugar Company	Unknown	Unknown	Unknown	602	Industrial
W-1895	Private	Abandoned	Unknown	Unknown	845	Industrial
W-1897	Private	Unknown	Unknown	Unknown	585	Industrial

Table 1-2 Water Supply Wells in Vicinity of Study Area

Well ID	Owner/Operator	Status	Feet Below Land Surface			Well Use
			Top Screened Interval	Bottom Screened Interval	Borehole Depth	
W-1899	Private	Abandoned	Unknown	Unknown	615	Agricultural/Irrigation
W-1901	Private	Unknown	Unknown	Unknown	250	Agricultural
W-1903	The Irvine Company - Irvine	Unknown	Unknown	Unknown	592	Unknown
W-1907	Unknown	Unknown	Unknown	Unknown	850	Unknown
W-1911	Private	Destroyed	Unknown	Unknown	351	Industrial
W-1913	Private	Unknown	Unknown	Unknown	440	Industrial
W-3783	Southern California Edison	Inactive	Unknown	Unknown	458	Domestic
W-4465	So. California Sugar Company	Unknown	Unknown	Unknown	1197	Unknown
W-4467	So. California Sugar Company	Unknown	Unknown	Unknown	508	Unknown
W-4470	So. California Sugar Company	Unknown	Unknown	Unknown	508	Unknown
W-4471	So. California Sugar Company	Unknown	Unknown	Unknown	Unknown	Unknown
W-4472	So. California Sugar Company	Unknown	Unknown	Unknown	508	Unknown
W-4473	Unknown	Unknown	Unknown	Unknown	504	Unknown
W-4474	Unknown	Unknown	Unknown	Unknown	1370	Unknown
W-4645	Private	Abandoned	Unknown	Unknown	350	Unknown

Source:

Data Source: Table 2-2 from Supplemental Remedial Investigation Report (Hargis, 2020)

Notes:

[1] Upon further evaluation by OCWD, this well was determined to be a cathodic protection well

[2] TIC-91 based on WRMS database from Aquilogic (2015)

Table 5-1 Summary of General Response Actions and Screening of Remedial Technologies and Process Options

General Response Action	Remedial Technology	Process Option/End Use-Discharge Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments	Retained Y/N
No Action	None	None	The no-action general response action is required by U.S. Environmental Protection Agency (EPA) guidance (EPA, 1988) as a baseline for comparison with other remedial alternatives.	Low	High	Low	The no-action option does not include active remediation, institutional controls, sealing Legacy Water Supply Wells, or monitoring.	Y
Institutional Controls		Land Use Covenants/Deed Restrictions	Legal or physical means to prevent potential exposure to chemicals of concern by limiting the use of the property.	Low	Moderate	Low	Land use covenants/deed restrictions cannot be applied to private or public properties overlying impacted OU2 groundwater. However, an institutional control requiring any party proposing the installation and operation of water supply wells in the Study Area to apply for a well construction permit from the OCHCA is currently in place as a County ordinance. An additional institutional control that is feasible for implementation is notification of OCWD, RWQCB, DTSC and water suppliers in the Study Area by OCHCA of any water supply well construction permit applications.	Y
		Notifications to Potential Receptors of Risk	Commonly used action to make public aw	Low	High	Low		
Monitoring			Monitoring of groundwater in accordance with applicable plans, permits, or Orders	Low	High	Moderate	Monitoring will be part of all remedial action alternatives.	Y
Containment	Groundwater Extraction	Groundwater Extraction Wells	This response action reduces the mobility of chemicals, eliminates exposure pathways, and prevents the migration of contamination in groundwater.	High	High	High	Commonly used and effective method to contain contaminant migration and remove contaminant mass in the subsurface; would require consideration of potential interference with source site remedial efforts. Would require significant off-site access and permitting effort.	Y

Table 5-1 Summary of General Response Actions and Screening of Remedial Technologies and Process Options

General Response Action	Remedial Technology	Process Option/End Use-Discharge Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments	Retained Y/N
Containment	Physical Barriers	Slurry Walls, Grout Curtains, Sheet Piling	Physical containment barriers designed to prevent or minimize movement of groundwater past the barrier structures.	Low	Low	Very High	Not retained for Slurry Walls, Grout Curtains, Sheet Piling: High relative cost. Mounding of water behind barriers can divert groundwater to other areas, so treatment would be incomplete. Incompatible with plume configuration and with off-site access and encumbrance limitations. Retained for sealing Legacy Water Supply Wells: not effective as a stand-alone alternative, but retained as part of all remedial alternatives.	Y
Ex-Situ Groundwater Cleanup	Physical Treatment of Extracted Groundwater	Air Stripping	Contacts influent groundwater with air to remove VOCs. Specific technologies include packed/tray tower aeration, low-profile aeration, bubble diffusion, or aspiration/centrifugal. Efficiency highly dependent on contaminant volatility and air/water ratio. Likely to require treatment of the effluent air stream with VGAC or an oxidizer.	Moderate to High	Low	Moderate to High	Commonly used for VOC removal, air stream often requires treatment; high operational complexity; scaling and biological fouling on packing or trays are common issues; regular maintenance is required. May require pretreatment processes, such as pH adjustment, water softening, anti-scalant addition, or water heating.	N
		Liquid-Phase Granular Activated Carbon (LGAC) Adsorption	In an LGAC system, water flows through the carbon bed vessels and many organic compounds are selectively adsorbed onto the carbon media surface. After the carbon adsorption capacity is reached, this carbon is regenerated off-site by a vendor. Systems typically include multiple vessels to maintain continuous operation and prevent breakthrough. LGAC is also an effective method for quenching/decomposing residual hydrogen peroxide after UV/peroxide treatment with minimal loss of efficiency over time.	High	High	Moderate	Commonly used for VOC treatment and peroxide decomposition; not effective for 1,4-dioxane. Relatively simple system that doesn't require much operational supervision; commonly used as a component of a remedial alternative; small footprint requirement.	Y

Table 5-1 Summary of General Response Actions and Screening of Remedial Technologies and Process Options

General Response Action	Remedial Technology	Process Option/End Use-Discharge Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments	Retained Y/N
Ex-Situ Groundwater Cleanup	Physical Treatment of Extracted Groundwater	Membrane Processes (Reverse Osmosis, Nanofiltration, etc.)	Applicable to remove dissolved solids and other contaminants to meet discharge requirements. Uses a semi-permeable membrane that allows certain constituents to pass through while blocking others. Membranes require periodic cleaning which may present operational challenges.	High	High	High	High cost. Not effective for the removal of VOCs or 1,4-dioxane. Membranes create a concentrated waste stream requiring further treatment and/or disposal. Generates a high-purity permeate suitable for storm drain or surface water disposal. Membrane processes retained for reduction of natural/anthropogenic inorganic constituents for injection to deeper groundwater.	Y
		Evaporation / Condensation	Applicable for removing potentially all dissolved solids and other contaminants to produce high quality distilled water.	Low	Moderate	High	High cost and very energy intensive, since electrical power drives the evaporation process. Process fouling may occur depending upon dissolved solids content.	N
		Ion Exchange	Potentially applicable for the removal of perchlorate and inorganic ions. Extracted water is filtered to remove any suspended solids and passed through a vessel packed with a strong base anion exchange resin. When spent, the resin is regenerated using a strong acid, strong base, or high concentration brine wash to remove the exchanged ions.	High	High	Moderate to High	Effective technology for perchlorate and dissolved ions; however, cost can be driven by presence of other constituents that may compete for the resin. The regenerating wash solution may present operational and/or disposal challenges.	N
Ex-Situ Groundwater Cleanup	Chemical Treatment of Extracted Groundwater	Advanced Oxidation Process	Use UV light or ozone and a chemical oxidant, which react to form hydroxyl radicals. This process destroys a variety of organic compounds, including 1,4-dioxane, NDMA, and many VOCs.	High	High	High	High relative cost. Effective for 1,4-dioxane and chlorinated alkene VOCs, such as PCE and TCE, may require downstream LGAC or Bio-LGAC to treat oxidation byproducts that may be formed. Pretreatment required to maximize transmission of UV and minimize scale on UV lamps.	Y
	Biological Treatment of Extracted Groundwater	Biological Liquid-Phase Granular Activated Carbon (Bio-LGAC) Adsorption	The process allows limited buildup of a biological film on the carbon that can remove a range of VOCs not easily treated by LGAC alone. The Bio-LGAC system needs to be cleaned periodically by backwashing; however, the carbon does not need to be replaced.	High	Moderate	Moderate to High	Commonly used for VOC or perchlorate treatment; moderate operational complexity with maintaining the biomass; commonly used as a component of a remedial alternative; may require off-gas treatment with VGAC or oxidizer, and may require post-filtration or treatment to remove biomass that escapes the Bio-LGAC vessel.	N

Table 5-1 Summary of General Response Actions and Screening of Remedial Technologies and Process Options

General Response Action	Remedial Technology	Process Option/End Use-Discharge Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments	Retained Y/N
Ex-Situ Groundwater Cleanup	Biological Treatment of Extracted Groundwater	Biological Treatment	Add nutrients to extracted water to sustain microbes that are capable of anaerobic degradation. Potentially effective for the removal of perchlorate and many VOCs; can be operated anaerobically, aerobically, or both using separate compartments.	High	Moderate	Moderate to High	Commonly used for perchlorate and VOC treatment. High operational complexity to maintain system, need to remove excess biomass periodically.	N
Treated Water Discharge or End Use	Treated Water Discharge or End Use Options	Injection	Discharge into injection wells in off-site p	High	Low	High	High cost. Would require consideration of potential interference with source site remedial efforts. Would require significant off-site access and permitting effort. Shallow injection not desirable due to low injection capacity, likely displacement of high concertation groundwater; and enhanced vertical short circuiting through water wells. Basal Sand injection alternative retained.	Y
		Storm Drain	Discharge to storm drain.	Moderate	Low	Moderate to High	Would require NPDES permitting; treatment may be complex to meet discharge standards; the discharge capacity to storm drains or storm channels could be completely utilized during and after precipitation events, which would require temporary termination or cycling of groundwater containment extraction wells and would negatively impact the effectiveness of the overall remedy. Requires groundwater replenishment assessment.	N

Table 5-1 Summary of General Response Actions and Screening of Remedial Technologies and Process Options

General Response Action	Remedial Technology	Process Option/End Use-Discharge Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments	Retained Y/N
Treated Water Discharge or End Use	Treated Water Discharge or End Use Options	Public Owned Treatment Works (POTW) and OCWD Groundwater Replenishment System Advanced Wastewater Purification Facility (GWRS)	Discharge to sewer for POTW and GWRS	High	High	Moderate	Effective discharge option; requires VOC treatment prior to discharge and local POTW has expressed a desire to receive the treated water. Provides a sustainable alternative, as the effluent from the GWRS is used for basin replenishment. Moderate cost for a sewer permit, flow fees, and GWRS incremental costs, but overall relative lowest cost discharge/end use option.	Y
		Non-Potable Reclaimed Water	Discharge to recycled (RECLAIM) water system for industrial water supply or irrigation use.	Low	Low	High	No nearby reclaimed water pipeline network; high cost; requires multiple agency approvals and coordination; flow rate may intermittently exceed demand and cyclical demand could result in reduced containment effectiveness during periods where groundwater extraction rates and related groundwater capture zone(s) could be diminished over prolonged periods of time.	N
In-Situ Groundwater Cleanup	In-Situ Groundwater Treatment	Monitored Natural Attenuation	Treatment of contaminants by natural proc	Low	High	Moderate	Remediation duration would be relatively long; would naturally be part of remedial actions, since some level of natural attenuation would always be occurring. Potential for incomplete VOC degradation/Byproduct generation. Potential for vertical short circuiting through water wells along groundwater flow path.	Y
		Active In-Situ Bioremediation	Treatment of contaminants by injection of gasses and/or nutrients (can be enhanced with the addition of microorganisms) to stimulate subsurface biodegradation of contaminants; can be either aerobic or anaerobic; not practical if plume is large and wide range of contaminant types are present.	Low	Moderate	Moderate to High	Likely would require repeated application cycles and relatively prolonged remediation duration. Potential for incomplete VOC degradation/Byproduct generation and persistence as demonstrated at several source sites.	N

Table 5-1 Summary of General Response Actions and Screening of Remedial Technologies and Process Options

General Response Action	Remedial Technology	Process Option/End Use-Discharge Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments	Retained Y/N
In-Situ Groundwater Cleanup	In-Situ Groundwater Treatment	Chemical Processes	Chemical oxidation by injecting oxidizing agents such as hydrogen peroxide, sodium persulfate, or potassium permanganate through a series of injection wells or into direct-push boreholes using specialized injection tooling.	Moderate	Moderate	High	Has been successfully used at some source sites for VOC and 1,4-dioxane treatment (limited to persulfate amendment). Can be oxidant delivery problems due to reactive transport and aquifer heterogeneities. Natural oxidant demand may be high in some soil/aquifers. Short persistence of some oxidants due to fast reaction rates in the subsurface. Best suited for localized areas of relatively high concentration. Potential for transient mobilization of oxidized metals (iron, manganese, hexavalent chromium, nickel). Typically requires multiple application events at a relatively high frequency related to other process options and may be more burdensome and disruptive to affected property owners or public ROW users where it will be applied. Based on the effectiveness of source site ISCO, OU2 chemical oxidation process option would be limited to ISCO using activated persulfate. This in-situ process option is being retained for the purposes of a more detailed evaluation as part of the Feasibility Study.	Y

Table 5-1 Summary of General Response Actions and Screening of Remedial Technologies and Process Options

General Response Action	Remedial Technology	Process Option/End Use-Discharge Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments	Retained Y/N
In-Situ Groundwater Cleanup	In-Situ Groundwater Treatment	Chemical Processes	Chemical reduction by injecting reducing agents such as zero valent iron, calcium polysulfide, or sodium dithionite through a series of injection wells; into direct-push boreholes using specialized injection tooling; or through pneumatic emplacement into open boreholes.	Low (would not treat 1,4-dioxane)	High	Moderate to High	Would not treat 1,4-dioxane. Can be non-uniform and less efficient reductant delivery in fine-grained, heterogeneous systems. Reductants can be utilized by non-target compounds. For ZVI, potential risk of soil permeability reduction during treatment resulting from ZVI solids occupying pore-space. Potential for transient mobilization of reduced compounds (iron, arsenic, manganese).	N
		Thermal Processes	Thermal processes commonly use electrical resistance heating, thermal conduction heating, steam injection, and hot air injection; often combined with SVE.	High	Low	Very High	Very high cost. Not efficient for the widespread OU2 groundwater plumes. Energy requirements would be prohibitively high. Would require SVE wells and treatment system(s) in inaccessible off-site areas. Incompatible with the off-site access constraints and encumbrance limitations (would require off-site electrodes and electrical piping and SVE wells/piping).	N
		Physical Processes	Physical processes such as air sparging with SVE are commonly accomplished with air sparge wells, compressors, vacuum blowers, and vapor extraction wells. Collected and contaminated vapors would require treatment prior to discharge to the atmosphere.	Low	Low	Very High	Very high cost. Low/no treatment effectiveness for 1,4-dioxane. Not efficient for widespread off-site OU2 plumes. Energy requirements would be prohibitively high. Would require off-site SVE wells and sparging wells in inaccessible off-site areas. Incompatible with the off-site access constraints and encumbrance limitations (would require off-site SVE and air sparging wells/piping).	N

IRM	Interim Remedial Measures
ISCO	In-Situ Chemical Oxidation
NDMA	N-nitrosodimethylamine
OCHCA	Orange County Health Care Agency
OCWD	Orange County Water District
PCE	Perchloroethylene or Tetrachloroethylene
ROW	Right of Way
RWQCB	Regional Water Quality Control Board
SVE	Soil Vapor Extraction
SWRCB	State Water Resources Control Board
UV	Ultraviolet
VOC	Volatile Organic Compound
ZVI	Zero Valent Iron

Table 7-1. Estimated Number of Monitor Wells for each Conceptual Remedial Alternative

Area	Alternative 2 MNA					Alternatives 3 & 4 Groundwater Containment					Alternative 5 ISCO					Alternative 6 Containment + ISCO				
	Layer 1	Layer 2	Layer 3	Layer 4	Subtotal	Layer 1	Layer 2	Layer 3	Layer 4	Subtotal	Layer 1	Layer 2	Layer 3	Layer 4	Subtotal	Layer 1	Layer 2	Layer 3	Layer 4	Subtotal
1	14	14	14	4	46	6	6	6	4	22	28	28	28	8	92	21	21	21	5	68
2	12	12	12		36	4	4			8	11	11	6		28	4	4	2		10
3	2	2	2		6	4	2			6	3	2			5	4	2			6
4	6	6	6	3	21	6	6	4		16	12	12	12	6	42	6	6	4		16
5	2	2	2		6	3	3	2		8	3	3	2		8	3	3	2		8
6	6	6	6		18	3	3	2		8	3	3	2		8	3	3	2		8
7	12	12	12		36	6	6	4		16	20	20	10		50	6	6	4		16
8	6	6	6		18	4	4	2		10	12	12	12	6	42	4	4	2		10
Subtotal	60	60	60	7	187	36	34	20	4	94	92	91	72	20	275	51	49	37	5	142

Notes:
MNA= Monitored Natural Attenuation
ISCO= In-situ chemical oxidation

Table 7-2 Monitored Natural Attenuation Monitoring Schedule

Sample Parameter	Parameter Type	Method of Analysis	Year 1 Semiannual (Initial Base-Line + additional sample)	Semiannual Years 2 through 5	Annual Years 6 through 30	Prior to each 5-yr remedy review	Rationale for Parameter
Dissolved Oxygen	Electron Acceptors	field meter	X	X	X	X	Changes in DO may occur downgradient of the treatment areas as a result of the in-situ groundwater corrective actions.
Oxidation-Reduction Potential (ORP)	General Groundwater Parameters	field meter	X	X	X	X	ORP is a measure of groundwater electron activity and indicates the relative tendency of a solution to accept or transfer electrons.
pH	General Groundwater Parameters	field meter	X	X	X	X	pH can influence groundwater geochemical conditions and the potential for biodegradation of certain compounds.
Electrical Conductivity	General Groundwater Parameters	field meter	X	X	X	X	Electrical conductivity is impacted by changes in ionic character of groundwater.
Temperature	General Groundwater Parameters	field meter	X	X	X	X	Groundwater temperature affects redox and groundwater geochemical conditions within the groundwater system.
Turbidity	General Groundwater Parameters	field meter	X	X	X	X	Turbidity can affect the concentrations of certain analytes, such as dissolved metals.
Chloride	General Groundwater Parameter	EPA 300.0	X			X	Transient changes (increases) in chloride concentrations may occur downgradient of the treatment areas due to release of chloride from VOCs.
Nitrate and Sulfate	Electron Acceptors	EPA 300.0	X			X	Nitrate and sulfate are used as electron acceptors when oxygen is depleted.
Ferrous Iron	Electron Acceptor	EPA 200.7	X			X	Ferrous Iron is produced when Ferric iron in the soil matrix is used as an electron acceptor; it may precipitate as FeS if sulfide is present.
Dissolved Manganese	Groundwater Parameters	EPA 200.8	X			X	Dissolved manganese is produced when manganese in the soil matrix is used as an electron acceptor; it may precipitate as manganese sulfide if sulfide is present.
Dissolved sulfide	Groundwater Parameter	EPA 376.2	X			X	Endproduct of sulfate reduction, sulfide precipitates with dissolved iron and/or manganese if they are present and pH is appropriate
Volatile Organic Compounds	Contaminants of Concern	EPA 8260B	X	X	X	X	VOC analysis will be used to evaluate changes in VOC concentrations in the target treatment zone.
1,4-Dioxane	Contaminant of Concern	EPA 8270C	X	X	X	X	1,4-Dioxane analysis will evaluate the distribution of 1,4-Dioxane down gradient of treatment areas.
Perchlorate	Contaminant of Concern	EPA 314.0	X	X	X	X	Perchlorate analysis will be used to evaluate the distribution of perchlorate down gradient of known sources only.
Arsenic	Contaminant of Concern, Byproduct of Concern	EPA Method 6020	X	X	X	X	Evaluate the potential for mobilizing arsenic due to change in groundwater chemistry down gradient of reducing areas only

Table 7-2 Monitored Natural Attenuation Monitoring Schedule

Sample Parameter	Parameter Type	Method of Analysis	Year 1 Semiannual (Initial Base-Line + additional sample)	Semiannual Years 2 through 5	Annual Years 6 through 30	Prior to each 5-yr remedy review	Rationale for Parameter
Hexavalent Chromium	Groundwater Parameters	EPA 7199	X	X	X	X	Evaluate the potential for mobilizing Cr due to change in groundwater chemistry down gradient of known Cr sources only.
Total Organic Carbon	Groundwater Parameters	SM 5310B, EPA Method 9060	X			X	Total organic carbon (TOC) is an indicator of continued biodegradation potential.
Methane/Ethene/Ethane	Dissolved Gasses	RSK 175	X			X	Ethene and ethane are final, harmless byproducts of reductive dechlorination of CVOCs; their presence indicates biodegradation is occurring. Methane is and indicator of deep reducing conditions.

Notes:
ORP = Oxidation Reduction Potential
DO = Dissolved Oxygen
VOC = Volatiale Organic Compound
Cr = Chromium
TOC = Total Organic Carbon
CVOC = Chlorinated Volatile Organic Compound

Table 8-1 Remedial Technologies/Process Options Evaluated for OU2 Interim Remedial Measures Alternatives

General Response Action	Remedial Technology	Process Option/Treated Water Discharge or End Use	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
No Further Action	None	None	X					
Monitoring	Sampling and Analysis	Well Construction and Groundwater Monitoring		X	X	X	X	X
Institutional Controls	Institutional Controls	Water Well Permit, Notification, Design and Coordination Requirements		X	X	X	X	X
Containment	Groundwater Extraction	Groundwater Extraction Wells			X	X		X
	Physical Barriers	Sealing Legacy Water Supply Wells		X	X	X	X	X
Ex-situ Groundwater Cleanup	Physical Treatment of Extracted Groundwater	Filtration			X	X		X
		Liquid Phase Granular Activated Carbon (LGAC)			X	X		X
		Membrane Processes (Reverse Osmosis, Nanofiltration, etc.)				X		
	Chemical Treatment of Extracted Groundwater	Advanced Oxidation Process				X		
Treated Water Discharge or End Use	NA	Injection Wells, piping, treatment system(s)				X		
	NA	Discharge to sewer (for conveyance to POTW and GWRS)			X			X
In-Situ Groundwater Cleanup	In-Situ Groundwater Treatment	Monitored Natural Attenuation		X				
		Chemical Processes					X	X

Notes:

1. "X" indicates that the remedial technology/process option is evaluated as a potential component of the identified remedial alternative.
2. Shaded cells indicate process options that are not considered for the identified remedial alternative(s).
3. Remedial technologies/process options are presented in Table 5-1.

Alternatives:

Alternative 1 – No Action

Alternative 2 – Monitored Natural Attenuation

Alternative 3 – Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with discharge to POTW and GWRS

Alternative 4 – Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to Shallow Aquifer System

Alternative 5 – In-Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation

Alternative 6 – Containment and In-Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with discharge to POTW and GWRS

Abbreviations:

POTW = Publicly-owner treatment works
GWRS = Orange County Water District Groundwater Replenishment System Advanced Wastewater Purification Facility

Table 8-2. Threshold and Balancing Criteria Evaluation for OU2 Interim Remedial Measures Alternatives, Sustainability Assessment and Other Considerations

			Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
			No Action	**Monitored Natural Attenuation**	**Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS**	**Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to the Basal Sand**	**In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation**	**Containment and In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with discharge to POTW and GWRS**
THRESHOLD CRITERIA	Protective of Human Health and Environment	**Overall Ranking**	1	2	5	5	3	4
		Prevent Lateral and Vertical Migration of High Concentration COCs[1]	Low	Low	Moderate to High Removes and treats COCs from groundwater	Moderate to High Removes and treats COCs from groundwater	Moderate Treats COCs in groundwater, may generate undesirable byproducts	Moderate to high Removes and treats COCs from groundwater, may generate undesirable byproducts in limited area
		Prevent Further Degradation of Groundwater Resource	Low	Low	High Contains groundwater COCs in Leading Edge	High Contains groundwater COCs in Leading Edge	High Assuming effective in situ treatment in Leading Edge	High Contains groundwater COCs in Leading Edge
		Prevent COC Exceeding Ecological Receptors Threshold	Low	Low	High Removes and treats COCs from groundwater in southern study area	High Removes and treats COCs from groundwater in southern study area	Low to Moderate Relatively high potential for generation of undesirable byproducts	High Removes and treats COCs from groundwater in southern study area
		Prevent Human Exposure to Groundwater Containing COCs	Low	Moderate to High Through institutional controls	Moderate to High Through institutional controls	Moderate to High Through institutional controls	Moderate to High Through institutional controls	Moderate to High Through institutional controls
	Compliance with ARARs	**Overall Ranking**	0	3	5	5	2	4
		Chemical-Specific	None	In context of IRM, meets ARARs, not likely to be effective at meeting final remedy ARARs in timely manner	Meets	Meets	Potential issues: generation of persistent undesirable byproducts; meeting basin WQOs with frequent application of amendments; and incompatibility with Armstrong Channel	Hybrid of Alternatives 3 and 5
		Location-Specific	None	Meets	Meets	Meets	Meets	Meets
		Action-Specific	None	Meets	Meets	Meets	Potential issue of persistent undesirable byproducts generation	Hybrid of Alternatives 3 and 5

Table 8-2. Threshold and Balancing Criteria Evaluation for OU2 Interim Remedial Measures Alternatives, Sustainability Assessment and Other Considerations

			Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
			No Action	Monitored Natural Attenuation	Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS	Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to the Basal Sand	In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation	Containment and In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with discharge to POTW and GWRS
BALANCING CRITERIA	Long-Term Effectiveness and Permanence	Overall Ranking	1	1	5	5	3	4
		Magnitude of residual waste or treatment residuals	Depends solely on natural attenuation processes, with low/untreated residual waste likely to migrate beyond current extent	Depends solely on natural attenuation processes, with low/untreated residual waste likely to migrate beyond current extent	Active treatment effective at reducing residual waste in OU2 coupled with effective source control at individual properties	Active treatment effective at reducing residual waste in OU2 coupled with effective source control at individual properties	Treats COCs in groundwater, may generate undesirable treatment residuals	Hybrid of Alternatives 3 and 5
		Adequacy and reliability of controls for long-term	No institutional controls or active treatment. Not likely to achieve IRM or final remedy RAOs in reasonable time frame.	No active treatment, has high likelihood of requiring contingency action, not likely to achieve IRM or final remedy RAOs in reasonable time frame. Institutional controls, which are moderately effective, would have to be relied on for longer period.	Proven technology, contingency actions, if needed, tend to be relatively simple to implement. Institutional controls are moderately effective.	Proven technology, reinjection adds complexity to process, contingency actions, if needed, tend to be relatively simple to implement, except for potential to spread unknown untreated emergent compounds within injection zone. Institutional controls are moderately effective.	In-situ distribution of amendments difficult to control, has moderate likelihood of continency actions. Institutional controls are moderately effective.	Hybrid of Alternatives 3 and 5
	Reduction of Toxicity, Mobility, or Volume	Overall Ranking	1	1	5	5	3	4
		Treatment processes	Limited to natural processes	Limited to natural processes	Removal and treatment of COCs in groundwater	Removal and treatment of COCs in groundwater	Treats COCs in groundwater, may generate undesirable byproducts/treatment residuals	Hybrid of Alternatives 3 and 5

Table 8-2. Threshold and Balancing Criteria Evaluation for OU2 Interim Remedial Measures Alternatives, Sustainability Assessment and Other Considerations

			Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
			No Action	Monitored Natural Attenuation	Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS	Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to the Basal Sand	In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation	Containment and In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with discharge to POTW and GWRS
BALANCING CRITERIA	Reduction of Toxicity, Mobility, or Volume	**Amount of hazardous substances to be destroyed**	Slowest rate of destruction, potential for stalling at intermediate byproducts	Slowest rate of destruction, potential for stalling at intermediate byproducts	Fastest rate of destruction	Fastest rate of destruction	Fastest rate of destruction if amendment delivery successful, potential for undesirable byproduct generation/treatment residuals	Hybrid of Alternatives 3 and 5
		The degree of expected reduction in toxicity, mobility and volume	Slowest rate, potential for stalling at intermediate by products that are mobile and toxic	Slowest rate, potential for stalling at intermediate by products that are mobile and toxic	Reduction in mobility almost immediate through hydraulic control, fastest attainment of reduction in toxicity and volume through extraction and treatment	Reduction in mobility almost immediate through hydraulic control, fastest attainment of reduction in toxicity and volume through extraction and treatment	Reduction in toxicity and volume through in situ treatment if amendment can be delivered to affected portions of groundwater. Potential for generation of negative byproducts that are mobile and toxic	Hybrid of Alternatives 3 and 5
		The degree to which the treatment process is irreversible	Natural processes are irreversible for organic compounds, limited potential for long-term generation of hexavalent chromium if oxidation state of groundwater changes	Natural processes are irreversible for organic compounds, limited potential for long-term generation of hexavalent chromium if oxidation state of groundwater changes	Once COCs are removed from groundwater, the process is irreversible	Once COCs are removed from groundwater, the process is irreversible	Once organic COCs are destroyed, the process is irreversible. There is a modest potential for generation hexavalent chromium due to increased oxidation state in the area of injection	Hybrid of Alternatives 3 and 5

Table 8-2. Threshold and Balancing Criteria Evaluation for OU2 Interim Remedial Measures Alternatives, Sustainability Assessment and Other Considerations

			Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
			No Action	Monitored Natural Attenuation	Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS	Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to the Basal Sand	In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation	Containment and In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with discharge to POTW and GWRS
BALANCING CRITERIA	Reduction of Toxicity, Mobility, or Volume	The residuals that will remain following treatment	No treatment residuals as there is no active remediation	No treatment residuals as there is no active remediation	Limited: potential for disposal of carbon in off-site treatment process	Limited: potential for disposal of carbon in on-site treatment process	Moderate: potential for negative byproduct formation of hexavalent chromium and change in groundwater chemistry due to in situ reactions	Hybrid of Alternatives 3 and 5
		The degree to which treatment reduces inherent hazards	No incremental reduction over natural processes	No incremental reduction over natural processes	Reduction achieved through containment and extracted groundwater treatment	Reduction achieved through containment and extracted groundwater treatment	Reduction achieved through in-situ treatment	Hybrid of Alternatives 3 and 5
	Short-Term Effectiveness	Overall Ranking	1	1	5	5	3	4
		Risks to community during implementation	Will not attain IRM RAOs	Requires extensive monitoring network, can attain protection of human health through institutional controls, does not attain remaining IRM RAOs	Can attain protection of human health through containment zones along alignments that develop soon after start up	Can attain protection of human health through containment zones along alignments that develop soon after start up	Can attain protection of human health through in-situ treatment that can develop soon after start up if delivery and amendment application concentration is adequate, potential for generation of persistent undesirable byproducts	Hybrid of Alternatives 3 and 5
		Potential Impacts of workers	None	Managed through health and safety plans	Managed through health and safety and operations, maintenance and monitoring plans	Managed through health and safety and operations, maintenance and monitoring plans	Managed through health and safety and operations, maintenance and monitoring plans	Hybrid of Alternatives 3 and 5

Table 8-2. Threshold and Balancing Criteria Evaluation for OU2 Interim Remedial Measures Alternatives, Sustainability Assessment and Other Considerations

			Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
			No Action	Monitored Natural Attenuation	Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS	Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to the Basal Sand	In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation	Containment and In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with discharge to POTW and GWRS
BALANCING CRITERIA	Short-Term Effectiveness	Potential Environmental Impacts during implementation	Will not attain IRM RAOs	Can attain protection of human health through institutional controls, does not attain remaining IRM RAOs	May require installation of additional extraction wells to improve performance, low potential for environmental impact	May require installation of additional extraction wells to improve performance, treatment system and/or extraction system may require upgrades/expansion to address unknown untreated emergent compounds, can require expansion of well field into injection zone.	May require additional injections or contingency actions if delivery not effective and/or negative byproduct formation	Hybrid of Alternatives 3 and 5
		Time until protection achieved	Will not attain IRM RAOs.	Can attain protection of human health through institutional controls, does not attain remaining IRM RAOs	Can attain protection of human health through institutional controls, reduce threat of vertical migration through Legacy Water Supply Wells in moderate term by removing and treating high concentration groundwater and attain the remaining RAOs through containment zones along alignments that develop soon after start up	Can attain protection of human health through institutional controls, reduce threat of vertical migration through Legacy Water Supply Wells in moderate term by removing and treating high concentration groundwater and attain the remaining RAOs through containment zones along alignments that develop soon after start up	Can attain protection of human health through institutional controls, reduce threat of vertical migration through Legacy Water Supply Wells in moderate term by treating high concentration groundwater and attain the remaining RAOs through in situ treatment along alignments; however, there is potential generation of undesirable byproducts that could delay, complicate, or not achieve attainment of RAOs	Hybrid of Alternatives 3 and 5

Table 8-2. Threshold and Balancing Criteria Evaluation for OU2 Interim Remedial Measures Alternatives, Sustainability Assessment and Other Considerations

			Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
			No Action	Monitored Natural Attenuation	Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS	Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to the Basal Sand	In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation	Containment and In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with discharge to POTW and GWRS
BALANCING CRITERIA	Implementability	Overall Ranking	5	5	4	3	3	4
		Technical feasibility	Nothing required	Requires construction of monitor wells with long-term monitoring	Requires construction of monitor/extraction wells/simple filtration systems and LGAC treatment and long-term operation and monitoring	Requires construction of monitor/extraction wells / injection wells / complicated treatment system and long-term operation and monitoring	Requires construction of large number of ISCO injection wells / monitor wells and long-term frequent doing of injection wells with monitoring	Hybrid of Alternatives 3 and 5
		Administrative feasibility	No administrative requirements	Institutional controls can be instituted access in rights of way would require agreements and potentially access fees	Institutional controls can be instituted access in rights of way would require agreements and potentially access fees, obtaining operational permits relatively easy	Institutional controls can be instituted access in rights of way would require agreements and potentially access fees, obtaining operational permits will require additional effort but is achievable, procurement of treatment system property may be limited by available land	Institutional controls can be instituted access in rights of way would require agreements and potentially access fees, obtaining operational permits will require additional effort but is achievable, will require relatively comprehensive traffic control plans on relatively frequent basis	Hybrid of Alternatives 3 and 6
		Availability of services and materials	No services or materials required	Services and materials readily available	Services and materials readily available	Services and materials readily available	Services and materials normally available, quantity of amendment may pose some challenges	Services and materials readily available
	Cost	Overall Ranking	0	5	4	3	1	2
		NPV Cost	$0	$24,600,000	$35,800,000	$64,000,000	$348,600,000	$103,400,000

Table 8-2. Threshold and Balancing Criteria Evaluation for OU2 Interim Remedial Measures Alternatives, Sustainability Assessment and Other Considerations

			Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
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Sustainability Assessment		**Overall Ranking**	0	5	4	3	1	2
		CO_2 Emissions (metric tons)	0	970	13,000	18,000	170,000	57,000
		Total Energy Used (million BTU)	0	280,000	530,000	670,000	5,000,000	1,800,000
		Total Electricity Used (Mega Watt hours)	0	0	31,000	47,000	0	31,000
OTHER CONSIDERATIONS	**Compatibility with Source Site Remedies**	Allen T. Campbell	Compatible	Compatible	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux	Compatible	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux
		Gallade Chemical	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
		Embee Plating	Compatible	Compatible	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux	Compatible	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux
		Soco West, Former Service Chemical	Compatible	Compatible	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux	Compatible	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux

Table 8-2. Threshold and Balancing Criteria Evaluation for OU2 Interim Remedial Measures Alternatives, Sustainability Assessment and Other Considerations

			Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
			No Action	Monitored Natural Attenuation	Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS	Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to the Basal Sand	In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation	Containment and In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with discharge to POTW and GWRS
OTHER CONSIDERATIONS	Compatibility with Source Site Remedies	Former Diceon Electronics Facility	Compatible	Compatible	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux	Compatible	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux
		Cherry Aerospace	Compatible	Compatible	Compatible	Compatible	Moderate potential for generation of persistent undesirable byproducts upgradient of extraction system.	Potential generation of persistent undesirable byproducts upgradient of extraction system.
		Steelcase Incorporated	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
		Troy Computer	Compatible	Compatible	Adjacent extraction alignment, affects groundwater flow direction, high influence on groundwater flux	Adjacent extraction alignment, affects groundwater flow direction, high influence on groundwater flux	Compatible	Adjacent extraction alignment, affects groundwater flow direction, high influence on groundwater flux
		GE Plastics	Compatible	Compatible	Compatible	Compatible	Low potential generation of persistent undesirable byproducts upgradient of extraction system.	Compatible
		ITT Cannon	Compatible	Compatible	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux	Moderate potential for generation of persistent undesirable byproducts upgradient of extraction system.	Adjacent extraction alignment, affects groundwater flow direction and low influence on groundwater flux

Table 8-2. Threshold and Balancing Criteria Evaluation for OU2 Interim Remedial Measures Alternatives, Sustainability Assessment and Other Considerations

			Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
			No Action	Monitored Natural Attenuation	Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS	Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to the Basal Sand	In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation	Containment and In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with discharge to POTW and GWRS
OTHER CONSIDERATIONS	Compatibility with Source Site Remedies	Former Ricoh Electronics Facility	Compatible	Compatible	Adjacent extraction alignment, affects groundwater flow direction and moderate influence on groundwater flux	Adjacent extraction alignment, affects groundwater flow direction and moderate influence on groundwater flux	Compatible	Adjacent extraction alignment, affects groundwater flow direction and moderate influence on groundwater flux
		Baxter Health Care	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
		Bell Industries	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
		Dyer Business Park	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
		BFM Energy	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
		Astech	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
	Compatibility with Armstrong Channel		Incompatible, does not address IRM RAO	Incompatible, does not address IRM RAO	Compatible	Compatible	Low compatibility due to generation of undesirable byproducts	Compatible

[1] It is understood that cross flow from the Shallow Aquifer System into the Principal Aquifer System through Legacy Water Supply Wells is difficult to address for any of the alternatives; however, alternatives that begin to mitigate this risk by extracting/treating COCs from the Shallow Aquifer System are given a moderate to high ranking.

ARAR	Applicable or Relevant and Appropriate Requirements
BTU	British Thermal Units
COCs	Chemical(s) of Concern
GWRS	OCWD Groundwater Replenishment System Advanced Wastewater Purification Facility
IRM	Interim Remedial Measures
ISCO	In-Situ Chemical Oxidation
LGAC	Liquid-phase granular activated carbon
POTW	Public Owned Treatment Works
RAO	Remedial Action Objectives
WQO	Water Quality Objectives from Santa Ana Basin Plan

Criteria Ranking

0 None/Not Applicable
1 Low
2 Low to Moderate
3 Moderate
4 Moderate to High
5 High

Table 8-2A. Summary of Reversibility and Potential Conflict and Contingency Action Evaluation for OU2 Interim Remedial Measures Alternatives

			O&M			
Remedial Alternative	**Construction**	**Treatment**	**Potential Conflicts with Source Site Remedies and/or the Groundwater Basin**	**Potential Contingency Actions**	**Potential Conflicts with Final Remedy**	**Potential for Back Diffusion [(a)]**
Alternative 1 - No Action	NA	NA	NA	NA	NA	NA
Alternative 2 - Monitored Natural Attenuation	Minor and transient changes in groundwater quality may occur during well installation, which are relatively short-lived and reversible	Natural processes are irreversible for organic compounds; however, there is potential for COC degradation to stall at intermediate daughter product(s), limited potential for long-term generation of hexavalent chromium if oxidation state of groundwater changes.	No conflicts with Source Site remedies. The COC concentrations are not consistent with the designated beneficial use of groundwater and this alternative requires longer time to reduce COC concentrations in comparison to Alternatives 3 to 6.	If the monitoring network or frequency is insufficient, then installation and monitoring of additional monitor wells and/or increased monitoring frequency could be required. If alternative is ineffective or there is detection of an existing or future emergent compound that is not sufficiently attenuated, then construction and operation of a contingency active technology could be required.	There is a moderate to high conflict with final remedy to the extent timely restoration of aquifer to the designated beneficial use is a RAO. This alternative has a relatively short list of low to moderate complexity contingency actions; however, one of the contingency actions requires changing the remedial alternative.	Since this alternative does not have active treatment zone, the back diffusion will occur throughout OU2 at similar rates to areas outside active treatment zones for other alternatives.
Alternative 3 - Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS	Minor and transient changes in groundwater quality may occur during well installation, which are relatively short-lived and reversible	Once COCs are removed from groundwater and treated, the process is irreversible.	Undesirable reversible changes in groundwater gradients and fluxes, and to a lesser extent groundwater quality, may occur that could affect source site remedial efforts and/or the Groundwater Basin	If the alternative does not provide sufficient containment, extraction wells can be added or extraction rates can be modified to enhance performance of remedy. If higher than expected contaminant concentrations must be treated or there is future detection of an existing or future emergent compound(s) that require treatment, then local pre-treatment technology(ies) could be added prior to POTW discharge to address the respective condition(s). If there are undesirable changes in groundwater gradients and fluxes, reducing/relocating extraction locations and/or reducing extraction rates can mitigate this condition.	This alternative is consistent with final remedy to the extent timely restoration of aquifer to the designated beneficial use is a RAO. This alternative has a relatively short list of low to moderate complexity contingency actions.	Back diffusion processes in the vicinity of the extraction wells can be locally accelerated by capturing lower concentration groundwater within the capture zone. Back diffusion will occur at similar rates to other alternatives in areas away from extraction wells.
Alternative 4 - Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to the Basal Sand	Minor and transient changes in groundwater quality may occur during well installation, which are relatively short-lived and reversible	Once COCs are removed from groundwater and treated, the process is irreversible.	Undesirable reversible changes in groundwater gradients and fluxes, and to a lesser extent groundwater quality, may occur that could affect source site remedial efforts and/or the Groundwater Basin	If the alternative does not provide sufficient containment, extraction wells can be added or extraction rates can be modified to enhance performance of remedy. If higher than expected contaminant concentrations must be treated or there is detection an existing for future emergent compound(s) that require treatment, then the treatment technology(ies) could be enhanced or expanded to address the respective condition(s) and/or an alternate end use, for example discharge to POTW and GWRS, could be utilized. If there are undesirable changes in groundwater gradients and fluxes, reducing/relocating extraction locations and/or reducing extraction rates can mitigate this condition. It there are insufficient number of injection wells to dispose of treated groundwater, additional injection wells can be installed or an alternate end use can be evaluated. If the injected groundwater contained a future identified emergent compound that was not treated and required containment in the injection interval (Basal Sand), then the extraction well field could be expanded into the affected portions of the reinjection interval requiring containment.	This alternative is consistent with final remedy to the extent timely restoration of aquifer to the designated beneficial use is a RAO. This alternative has a relatively long list of moderately complex contingency actions.	Back diffusion processes in the vicinity of the extraction wells can be locally accelerated by capturing lower concentration groundwater within the capture zone. Back diffusion will occur at similar rates to other alternatives in areas away from extraction wells.

Table 8-2A. Summary of Reversibility and Potential Conflict and Contingency Action Evaluation for OU2 Interim Remedial Measures Alternatives

			O&M			
Remedial Alternative	**Construction**	**Treatment**	**Potential Conflicts with Source Site Remedies and/or the Groundwater Basin**	**Potential Contingency Actions**	**Potential Conflicts with Final Remedy**	**Potential for Back Diffusion [(a)]**
Alternative 5 - In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation	Minor and transient changes in groundwater quality may occur during well installation, which are relatively short-lived and reversible	Once organic COCs are destroyed, the process is irreversible. Moderate to high transient changes in groundwater quality may occur, some of which may be reversible over a relatively moderate time period (e.g., those that occur to changes in geochemical conditions) and some which may persist for relatively longer periods of time (e.g. salt loading due to amendment application).	Short-term, transient, reversible undesirable changes in groundwater gradients and fluxes may occur in the vicinity of the injection alignments; moderate to high transient changes in groundwater quality may occur, some of which may be reversible over a relatively moderate time period (e.g., those that occur to changes in geochemical conditions) and some which may persist for relatively longer periods of time throughout and after the ISCO treatment duration (e.g. salt loading due to amendment application).	If this alternative does not provide sufficient treatment along transects, the location and number of injection points and/or amendment dosing/frequency of application can be modified to improve performance. If the amendment selected for this alternative is ineffective, then an alternate amendment could be evaluated; although changing amendments is more complex given modifications to subsurface geochemistry by prior amendment use. Groundwater extraction and treatment could also be evaluated as a contingency. If performance monitoring indicates unacceptable migration of treatment byproducts that may influence source site remedies, reducing/relocating injection locations and/or reducing injection frequencies or amendment mass-loading can be implemented; if such undesirable changes could not be mitigated alternate in-situ applications to neutralize undesirable impacts or groundwater extraction and treatment could be implemented. If salt loading appears to be an issue based on monitoring results and/or application rates and it was not practical to modify process, then groundwater extraction and treatment could be implemented.	This alternative is consistent with final remedy to the extent timely restoration of aquifer to the designated beneficial use is a RAO. This alternative has a relatively long list of moderate to highly complex contingency actions.	Back diffusion processes in the vicinity of the amendment injection points can be locally accelerated by injecting amended water without COCs, coupled with rapid reduction of COCs in the immediate vicinity of the injection locations. Back diffusion will occur at similar rates to other alternatives in areas away from injection points.
Alternative 6 - Containment and In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with discharge to POTW and GWRS	Hybrid of Alternatives 3 and 5					

Footnotes:

(a) All alternatives are subject to back diffusion, whether it is in areas upgradient of containment/treatment zones or within the immediate vicinity of the active technology.

FIGURES

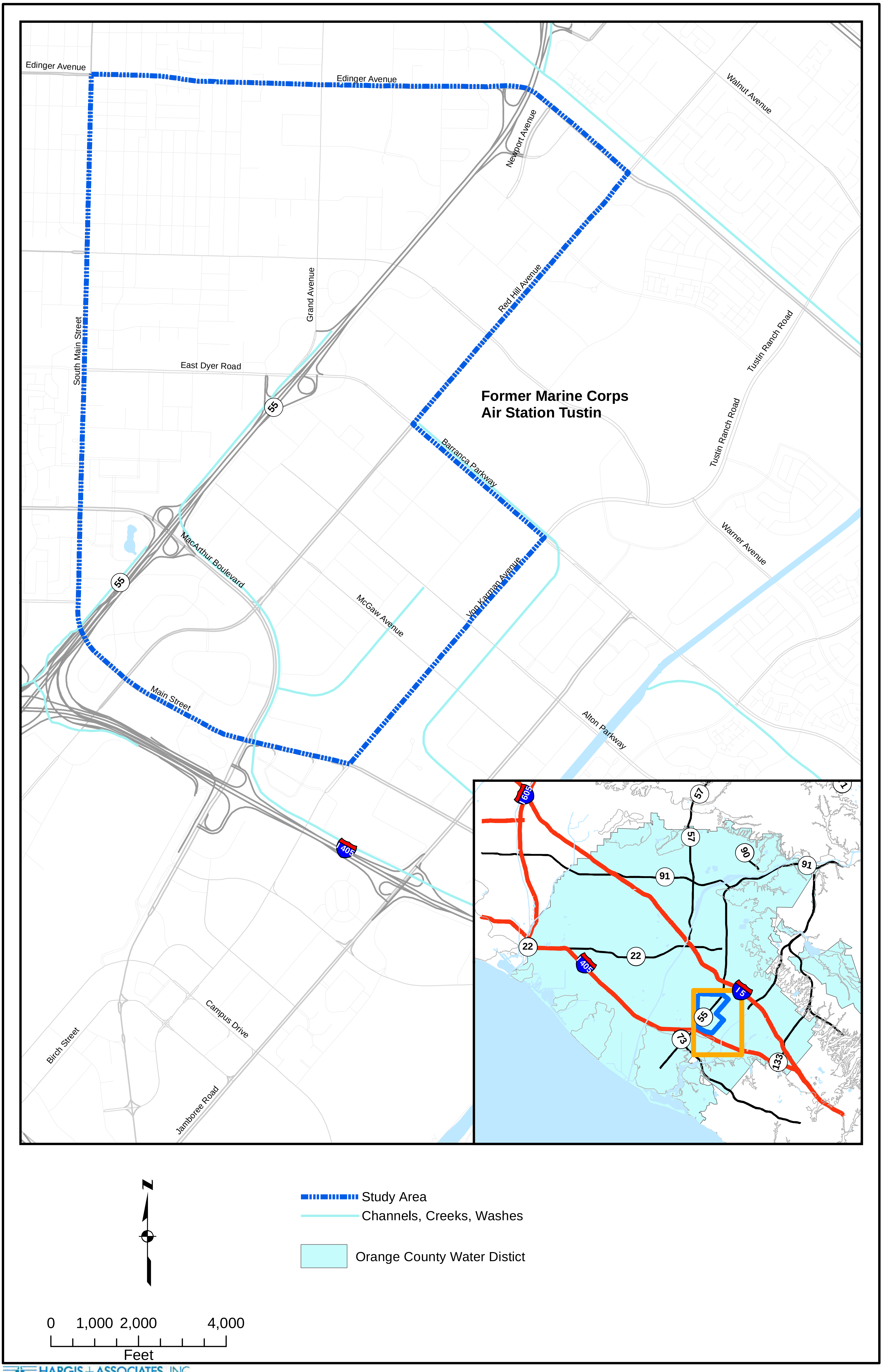

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FIGURE 1-1. STUDY AREA

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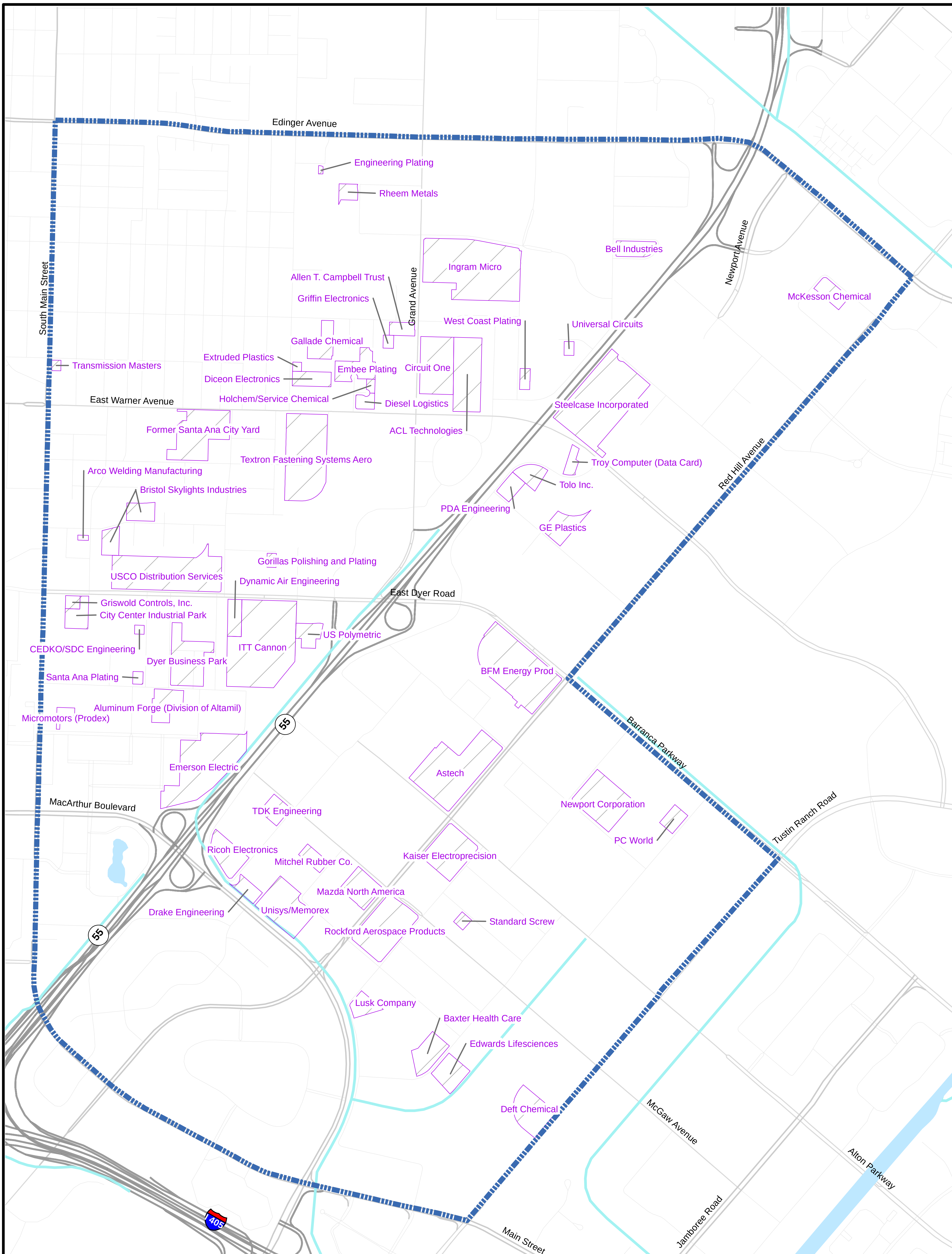

Explaination

- Source Sites
- Study Area
- Channels, Creeks, Washes

N

0 750 1,500 3,000 Feet

ORANGE COUNTY WATER DISTRICT
SOUTH BASIN GROUNDWATER
PROTECTION PROJECT

SOURCE SITE LOCATIONS

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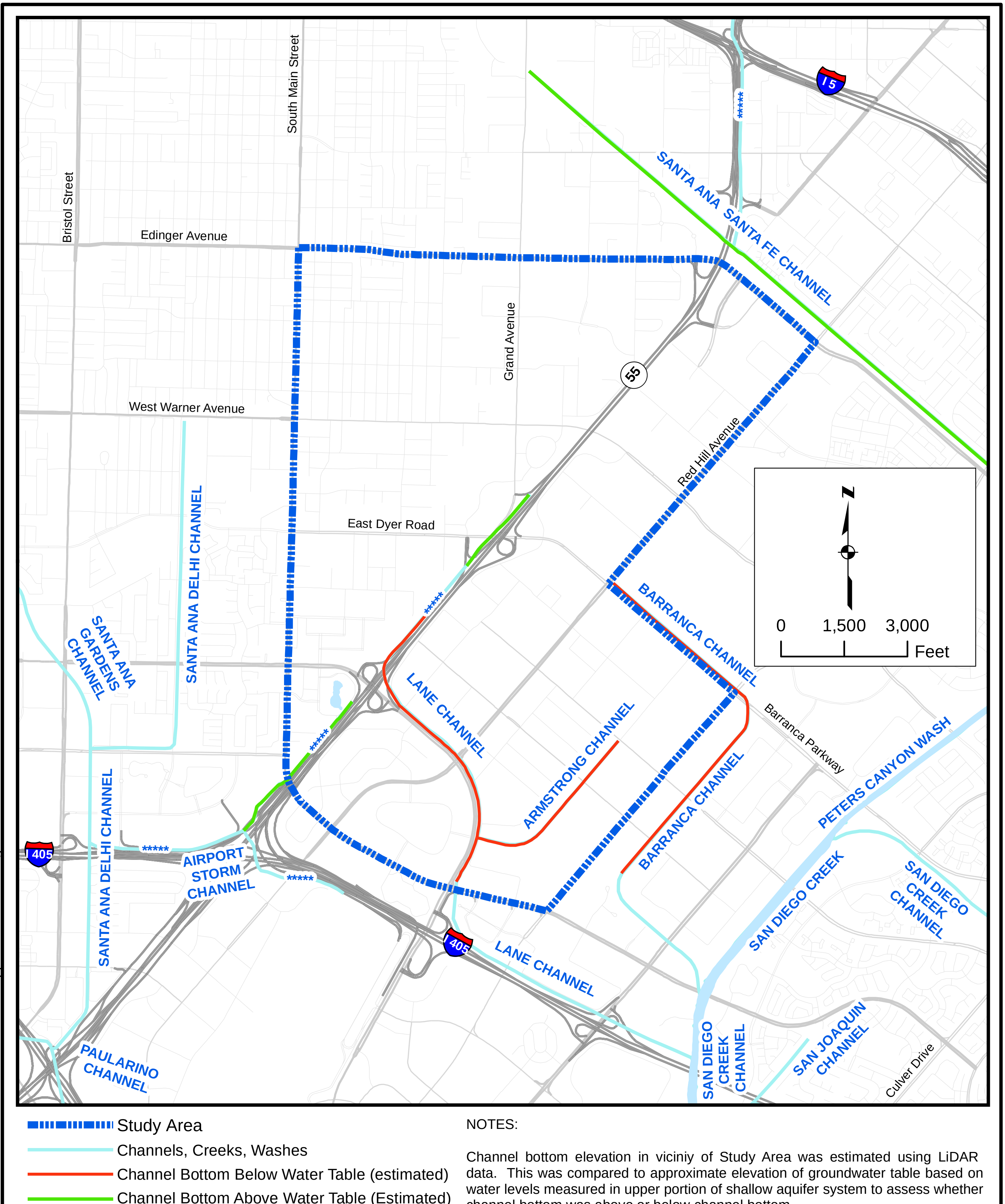
PREP BY NES

FIGURE 1-2

Document Path: C:\GIS\1170_OCWDSB_FD\Applications\1170_Fig_2-3_Surface Water Features.mxd 4/14/2019 1:26:44 PM



NOTES:

Channel bottom elevation in viciniy of Study Area was estimated using LiDAR data. This was compared to approximate elevation of groundwater table based on water levels measured in upper portion of shallow aquifer system to assess whether channel bottom was above or below channel bottom.

Portions of channels that are not indcated to be above or below channel were either too close to assess or not in Study Area.

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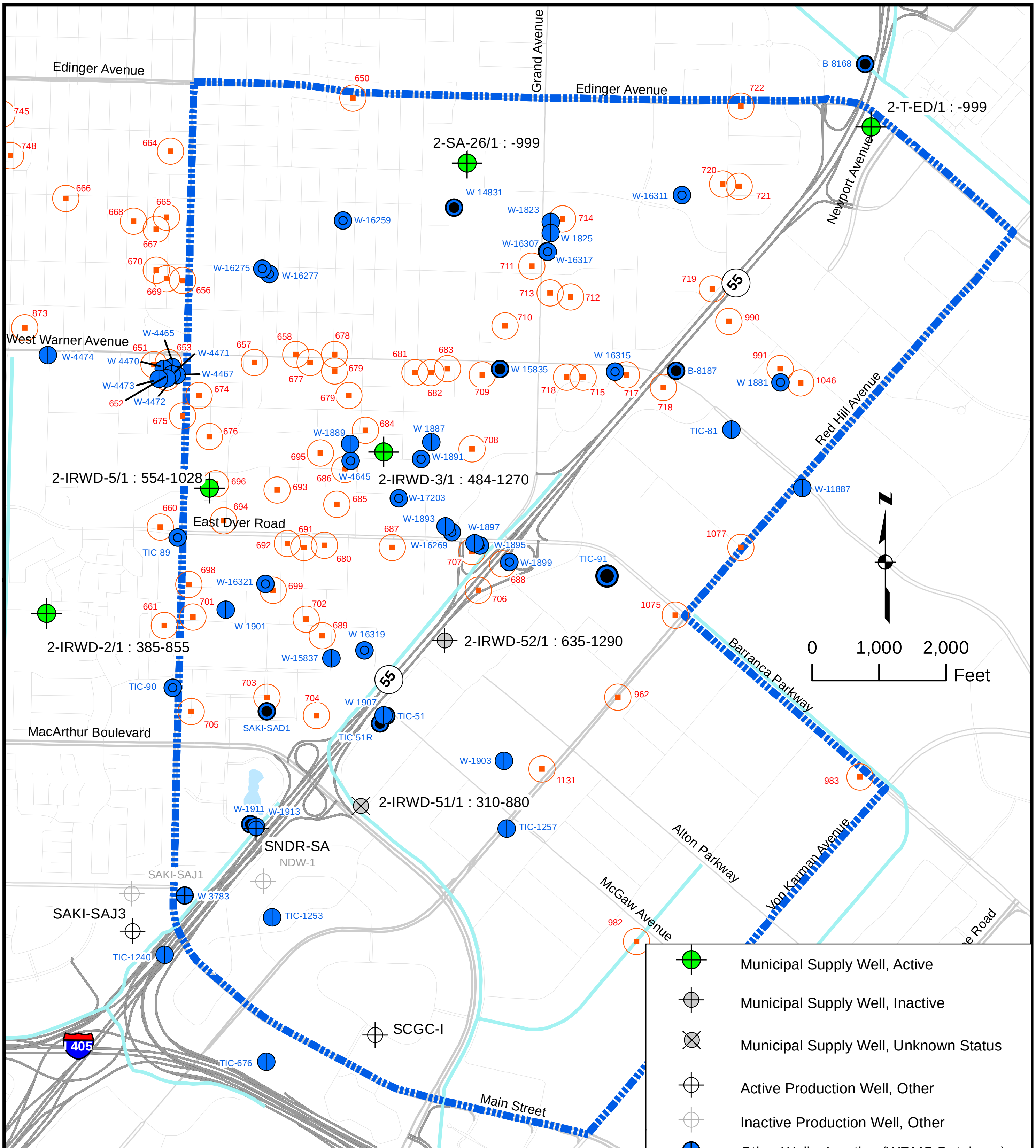
FIGURE 1-3. SURFACE WATER FEATURES WITHIN VICINITY OF STUDY AREA



NOTES:

Well Identifiers include top and bottom of screened interval, where known (feet below land surface) (-999 indicates depths unknown).

Historical well locations based on Mendenhall 1905, there is consideratble uncertainty as to location. Other wells based on Orange County Water District WRMS database, also uncertainty as to location. In addition, there are likley other historical wells in area that are not illustrated.

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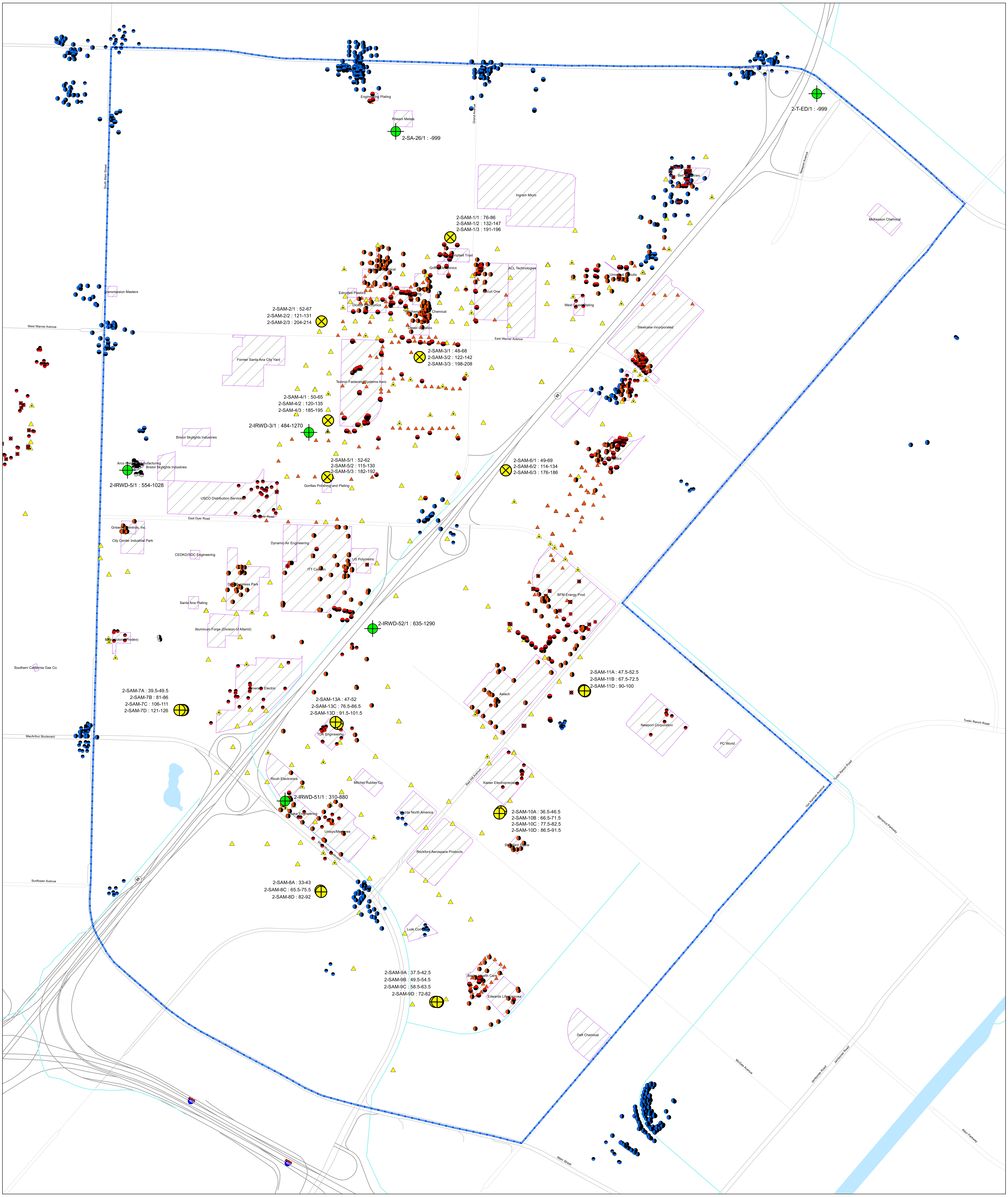
FIGURE 1-4. LOCATION OF PRODUCTION WELLS IN STUDY AREA VICINITY



StudyArea
Channels, Creeks, Washes
Production Wells
Monitor Well (Construced In 2017, OCWD)
Monitor Well (Constructed Prior to 2010, OCWD)

Monitor/Remediation Well - No Pre-2010 samples (PRP, Aquilogic Database)
Monitor/Remediation Well - Pre- and Post-2010 samples (PRP, Aquilogic Database)
Monitor/Remediation Well - Only Pre-2010 samples (PRP, Aquilogic Database)
Monitor/Remediation Well - No Pre-2010 samples (Geotracker Database)
Monitor/Remediation Well - Pre- and Post-2010 samples (Geotracker Database)
Monitor/Remediation Well - Only Pre-2010 samples (Geotracker Database)

Unknown Sample Type - Pre- and Post-2010 Samples (PRP, Aquilogic Database)
Unknown Sample Type - Only Pre-2010 Samples (PRP, Aquilogic Database)
Destroyed Monitor/Remediation Well - No Pre-2010 samples (PRP, Aquilogic Database)
Destroyed Monitor/Remediation Well - Installed Pre-2010, Samples 2010+ (PRP, Aquilogic Database)
Destroyed Monitor/Remediation Well - Pre-2010 (PRP, Aquilogic Database)
Grab Samples - 2012-2013 (OCWD)
Grab Samples - 2010-2011 (OCWD)
Source Sites
Grab Samples - Pre-2010 (OCWD)
Grab Samples - Post-2010 (PRP, Aquilogic Database)

NOTES:

Well Identifiers include top and bottom of screened interval, where known (feet below land surface) (-999 indicates depths unknown).

Does not include well locations for wells that do not have spatial reference from respective database.

Site names from Aquilogic shapefile.

N

0 500 1,000 2,000 Feet

ORANGE COUNTY WATER DISTRICT
SOUTH BASIN GROUNDWATER
PROTECTION PROJECT

GROUNDWATER SAMPLE AND WELL LOCATIONS

HARGIS + ASSOCIATES, INC.
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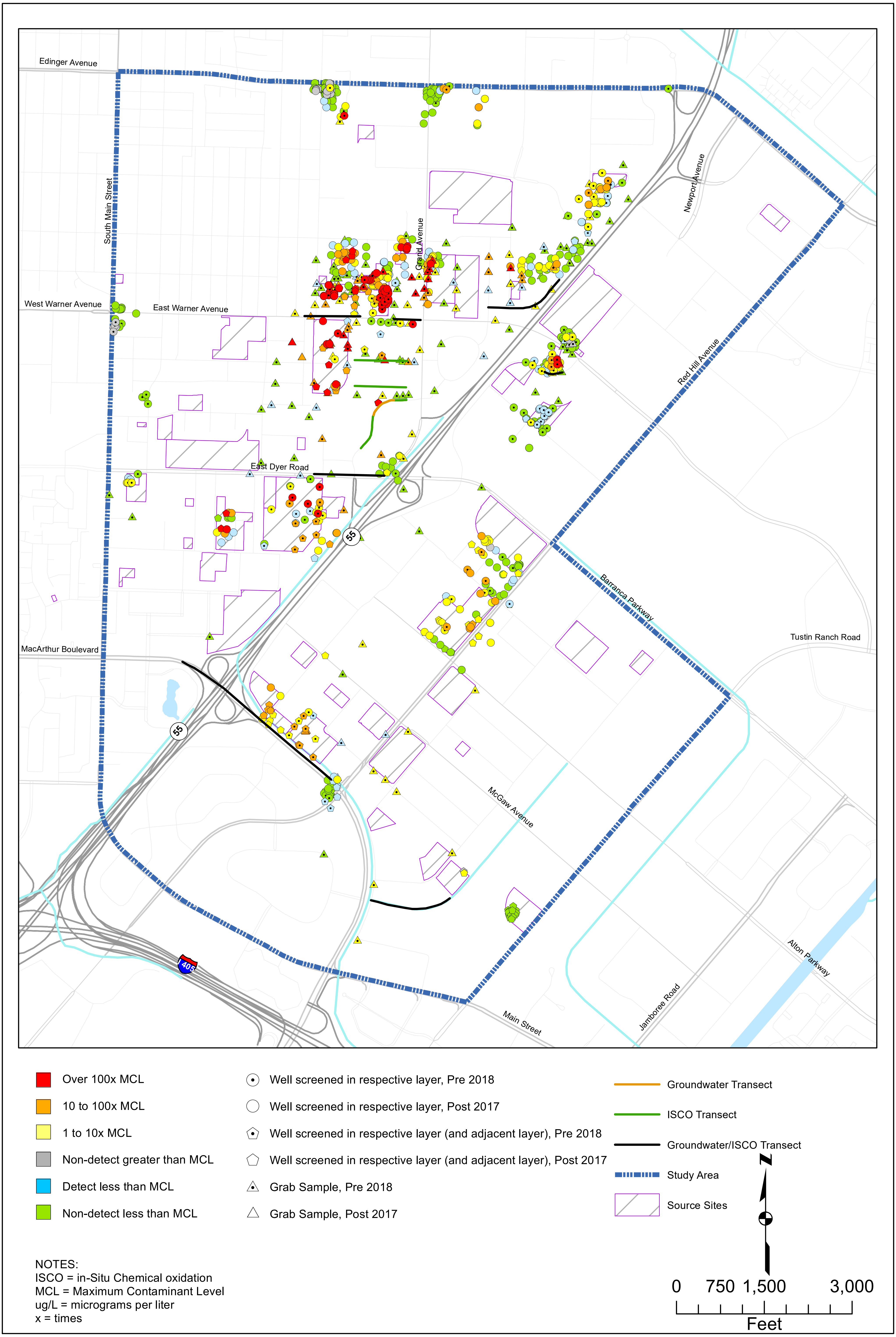
PREP BY ___ REV BY ___ RPT NO ___

FIGURE 1-5



NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

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FIGURE 1-6: Trichloroethylene in Layer 1 Groundwater
Orange County Water District South Basin

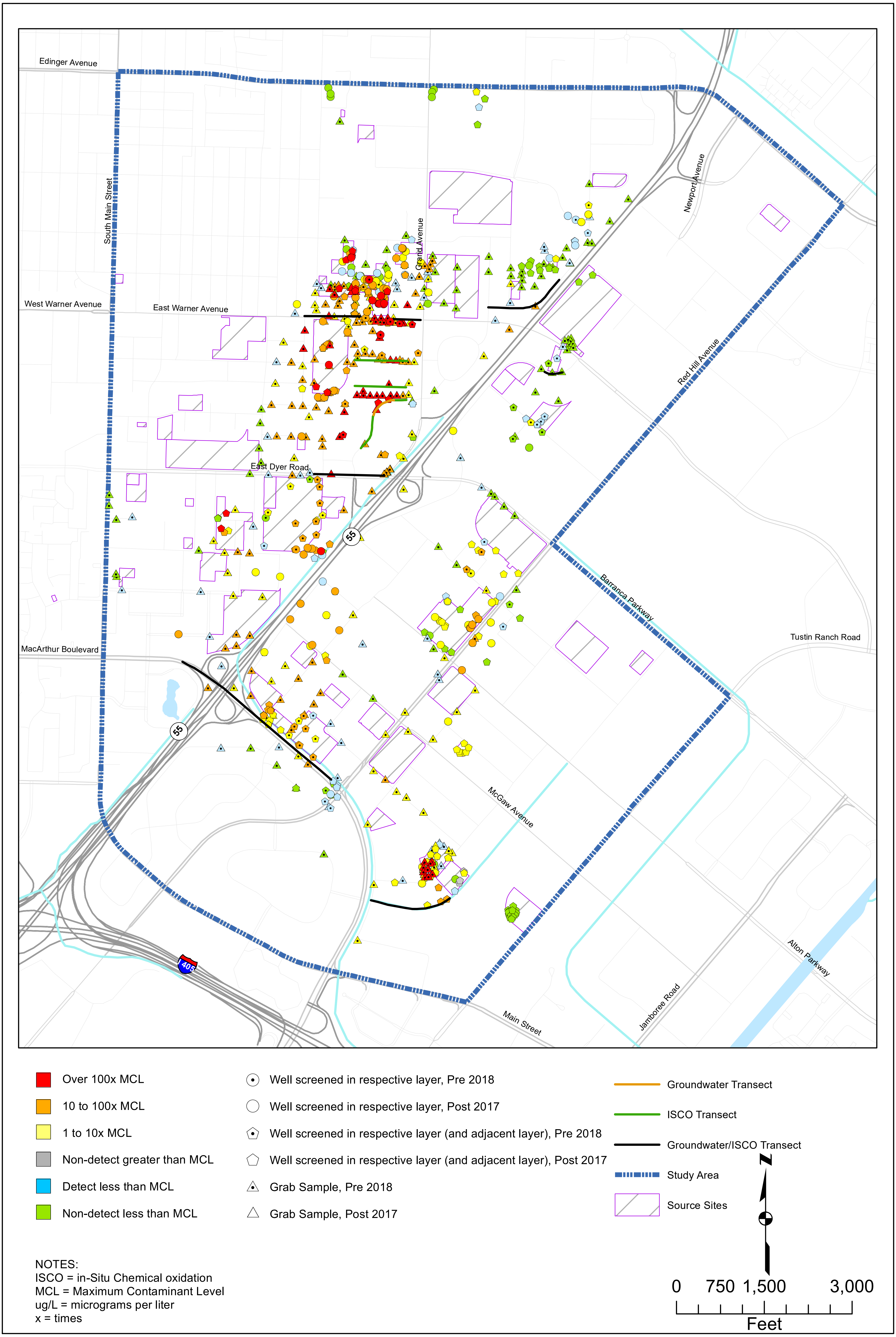

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FIGURE 1-7: Trichloroethylene in Layer 2 Groundwater
Orange County Water District South Basin

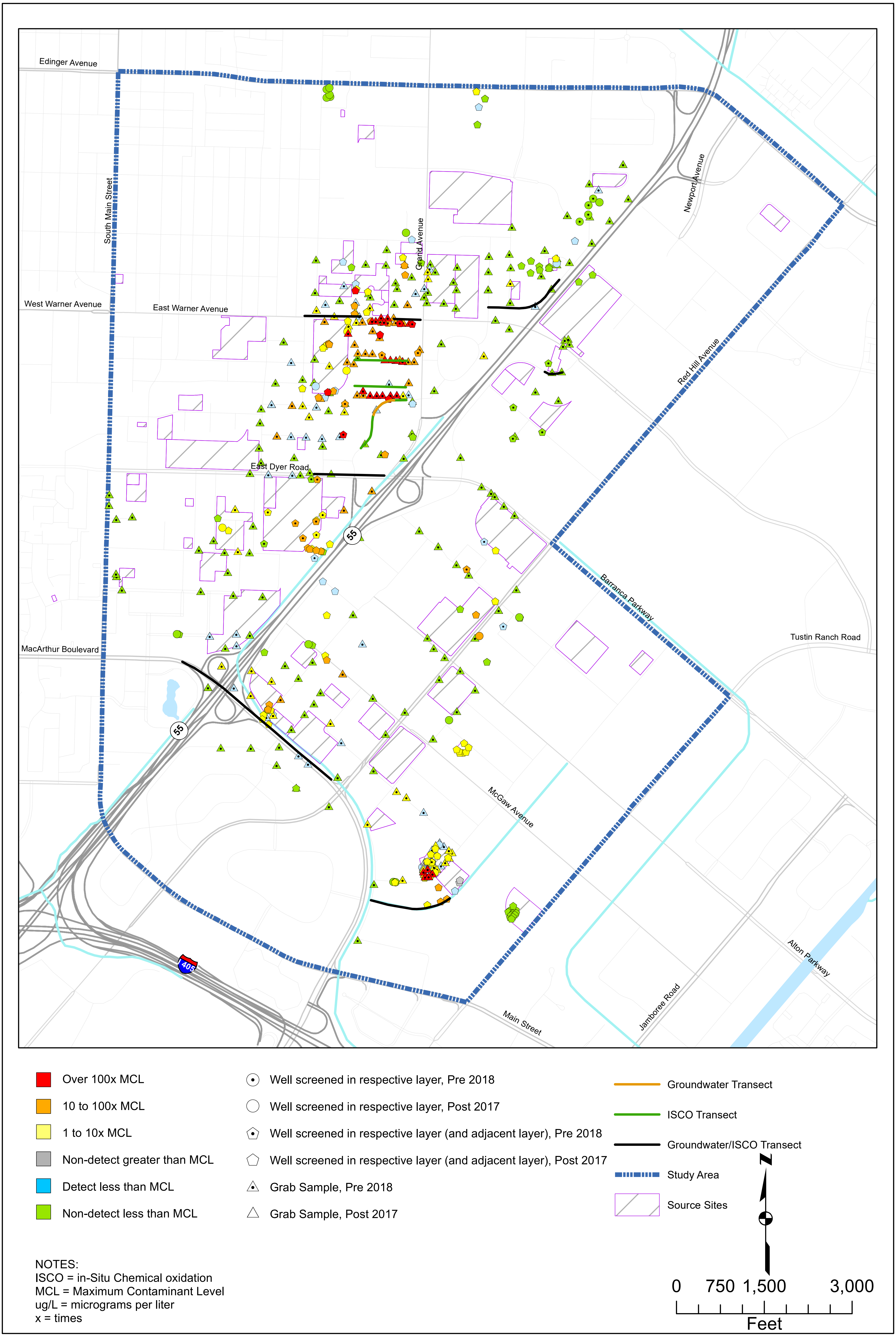

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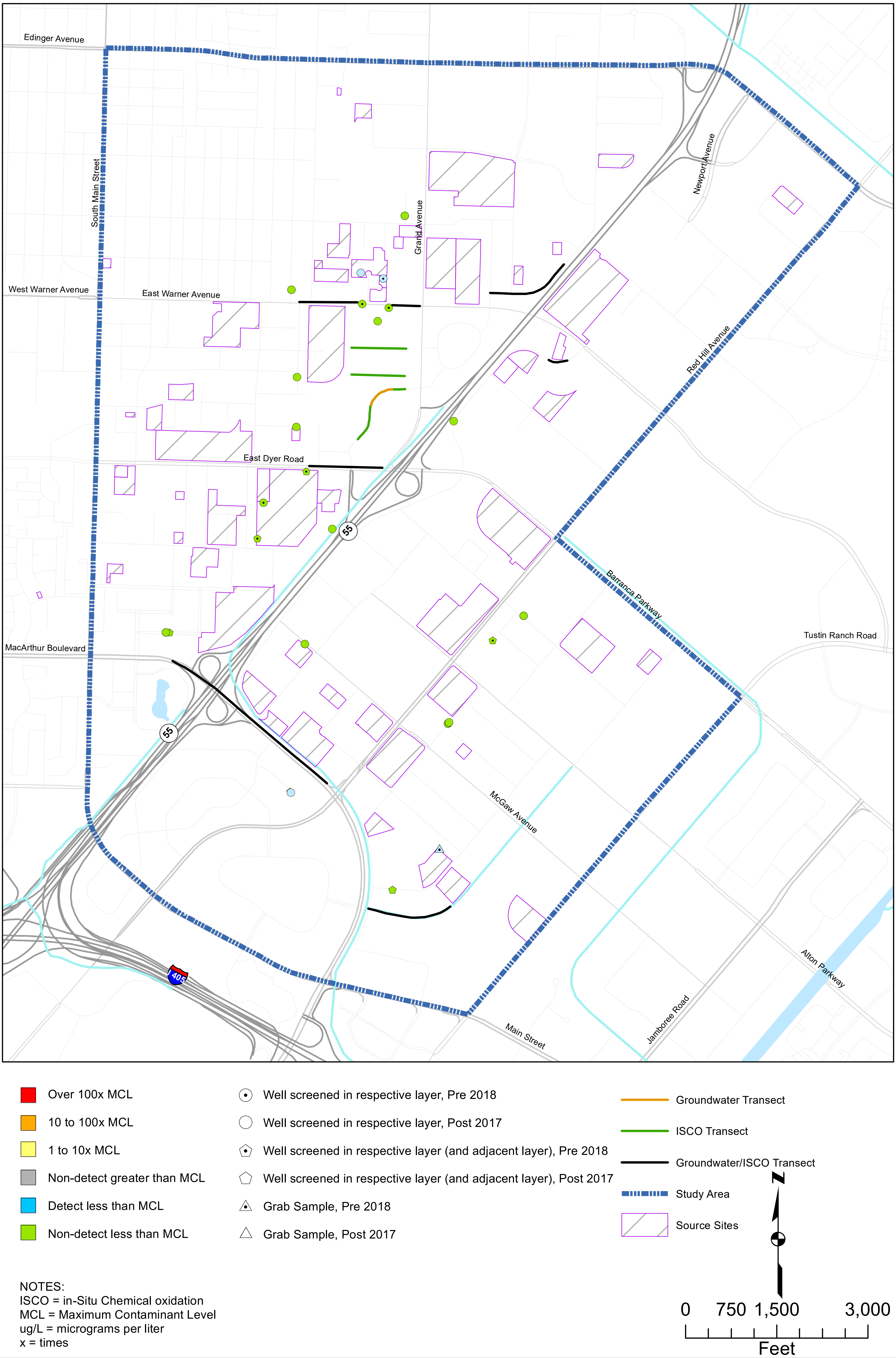
FIGURE 1-8: Trichloroethylene in Layer 3 Groundwater
Orange County Water District South Basin



NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

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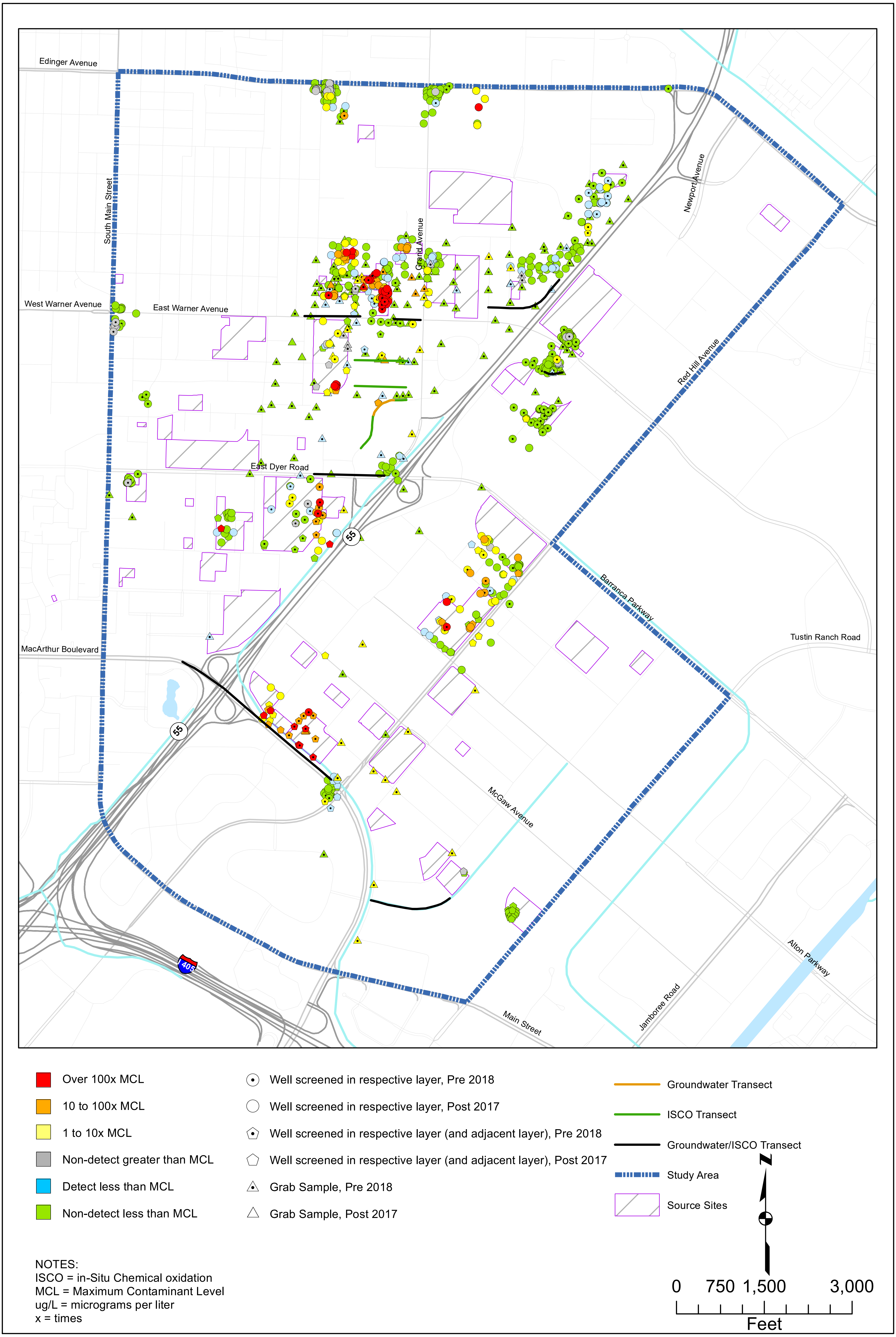
FIGURE 1-9: Trichloroethylene in Layer 4 Groundwater
Orange County Water District South Basin



NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

Engineering Analytics, Inc.

FIGURE 1-10: Tetrachloroethylene in Layer 1 Groundwater
Orange County Water District South Basin

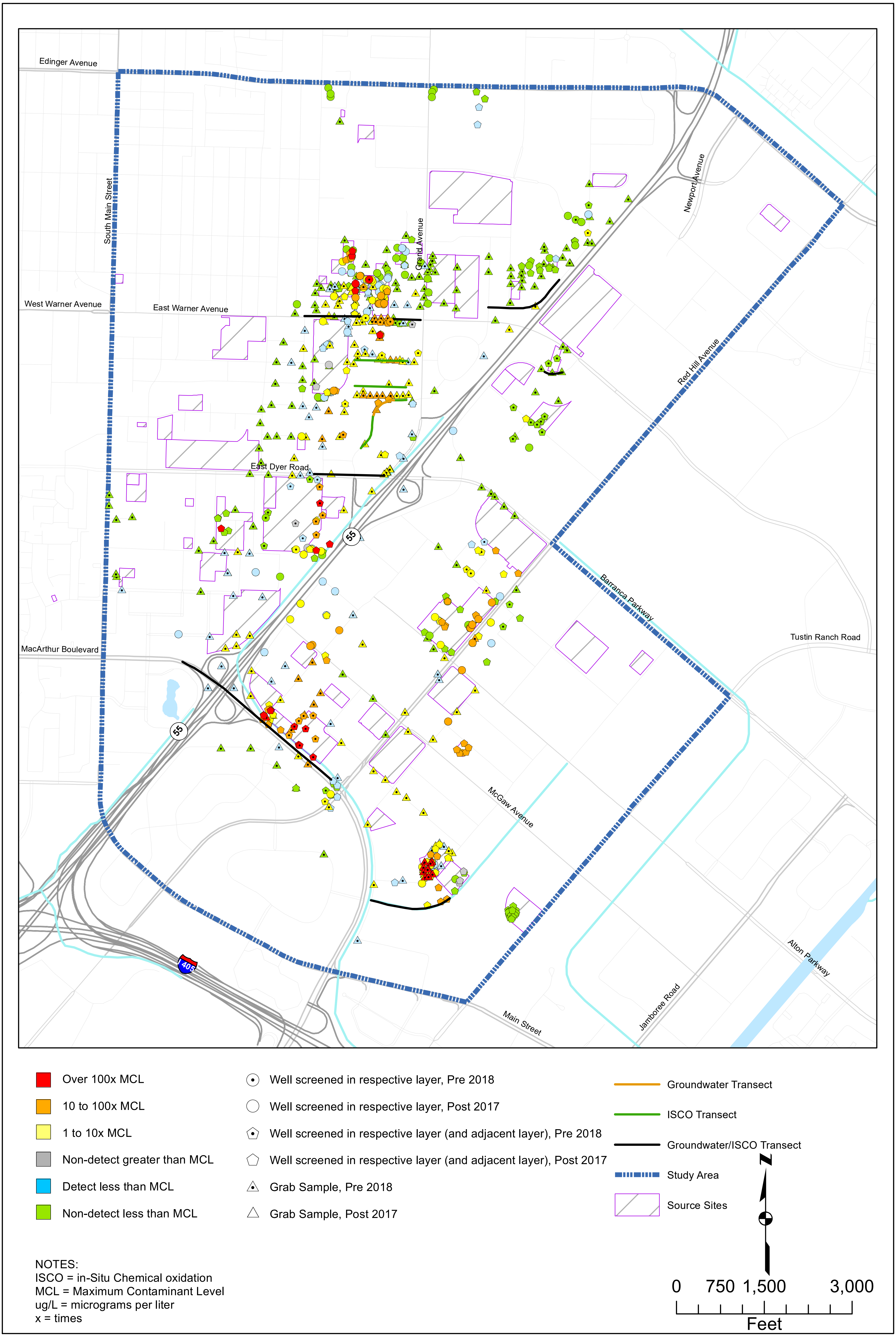


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FIGURE 1-11: Tetrachloroethylene in Layer 2 Groundwater
Orange County Water District South Basin

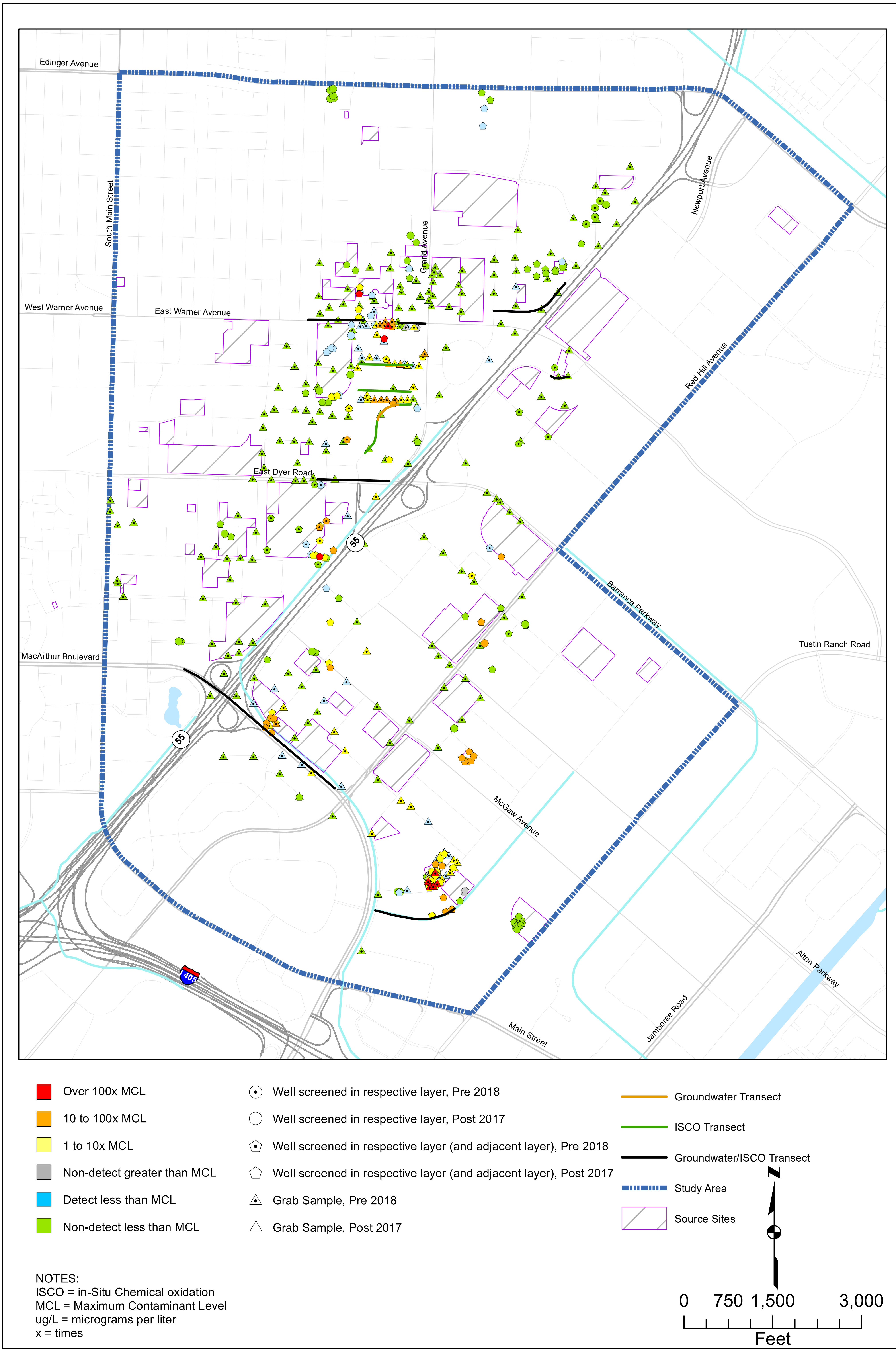

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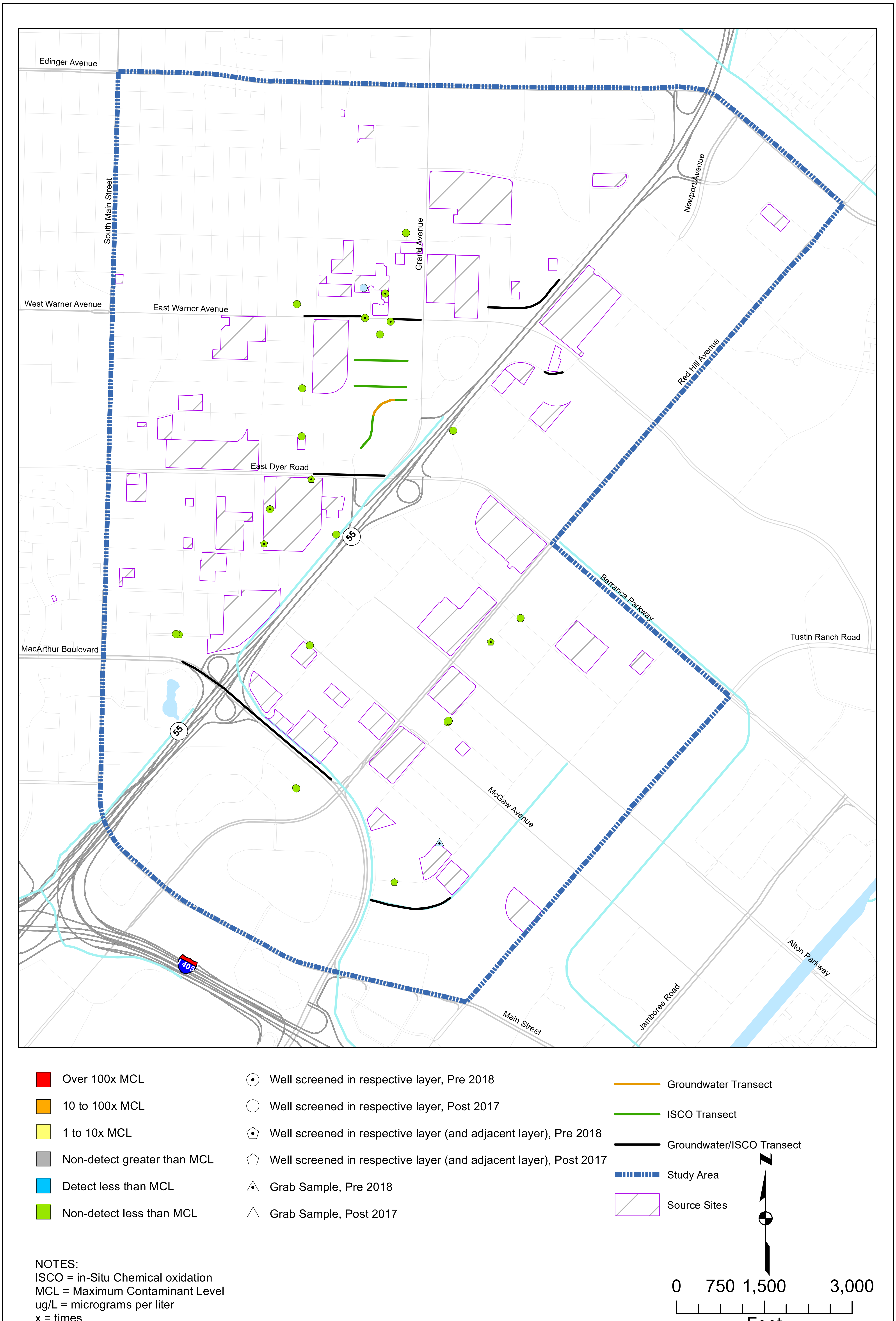
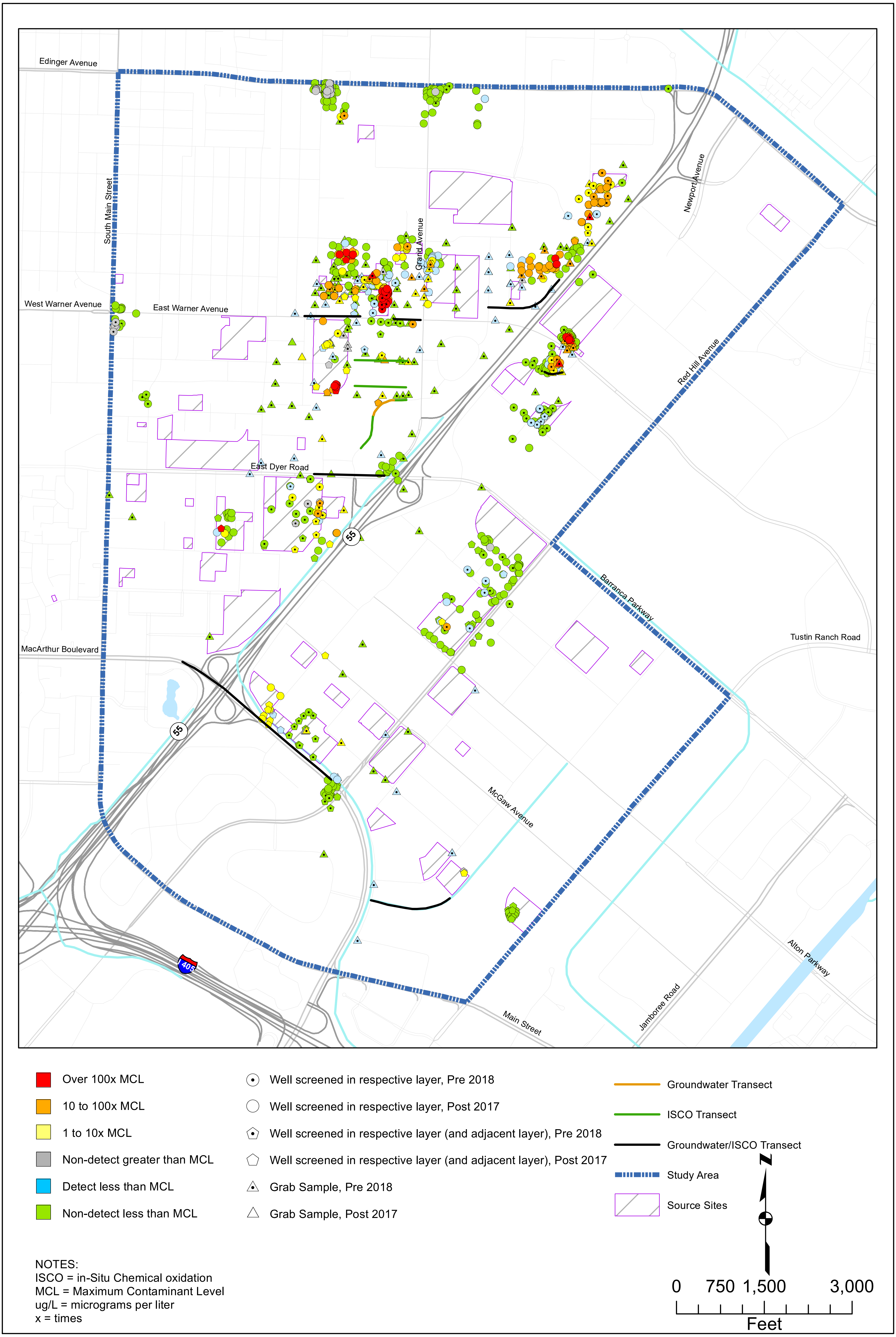
FIGURE 1-12: Tetrachloroethylene in Layer 3 Groundwater
Orange County Water District South Basin



NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

Engineering Analytics, Inc.

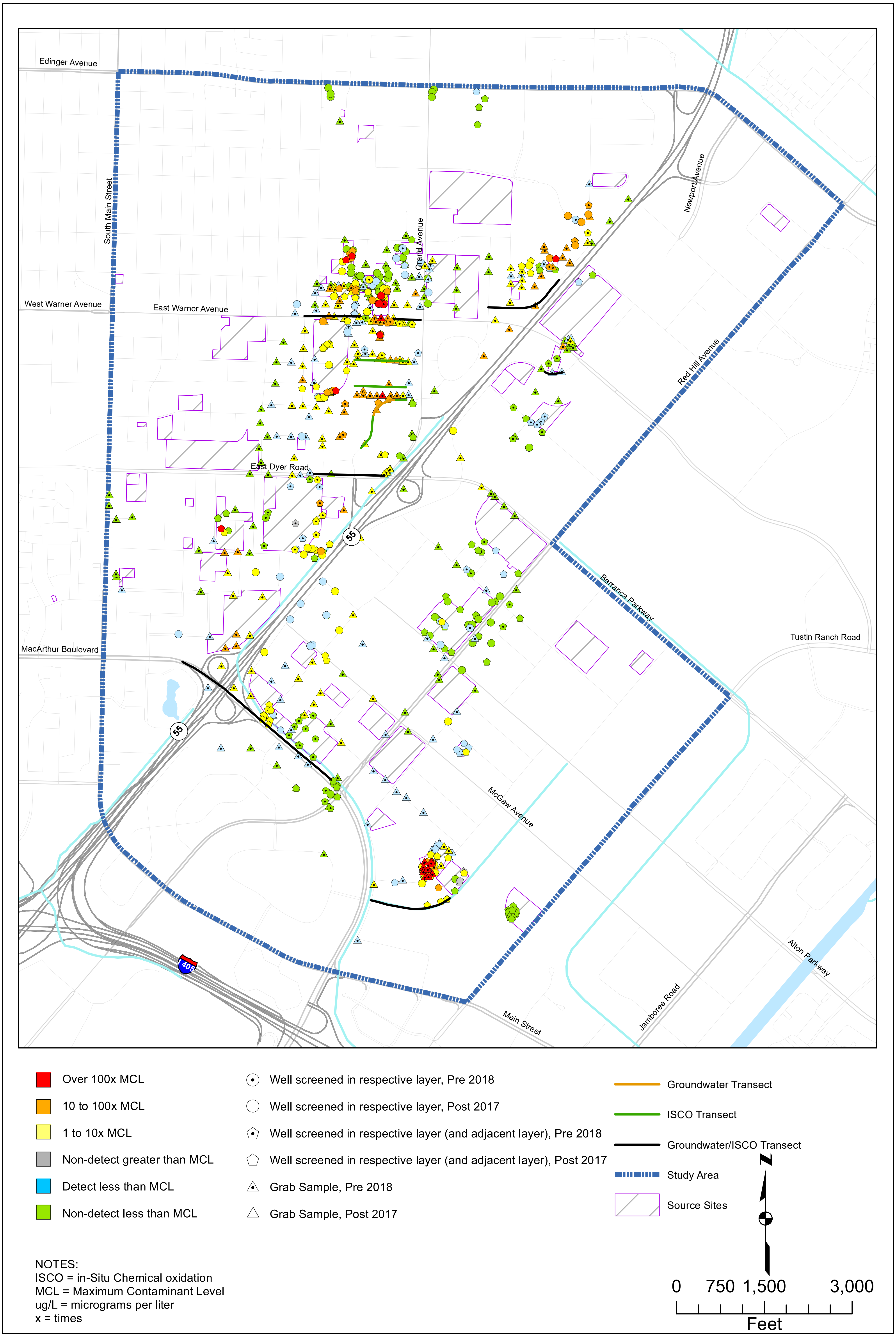
FIGURE 1-13: Tetrachloroethylene in Layer 4 Groundwater
Orange County Water District South Basin



NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

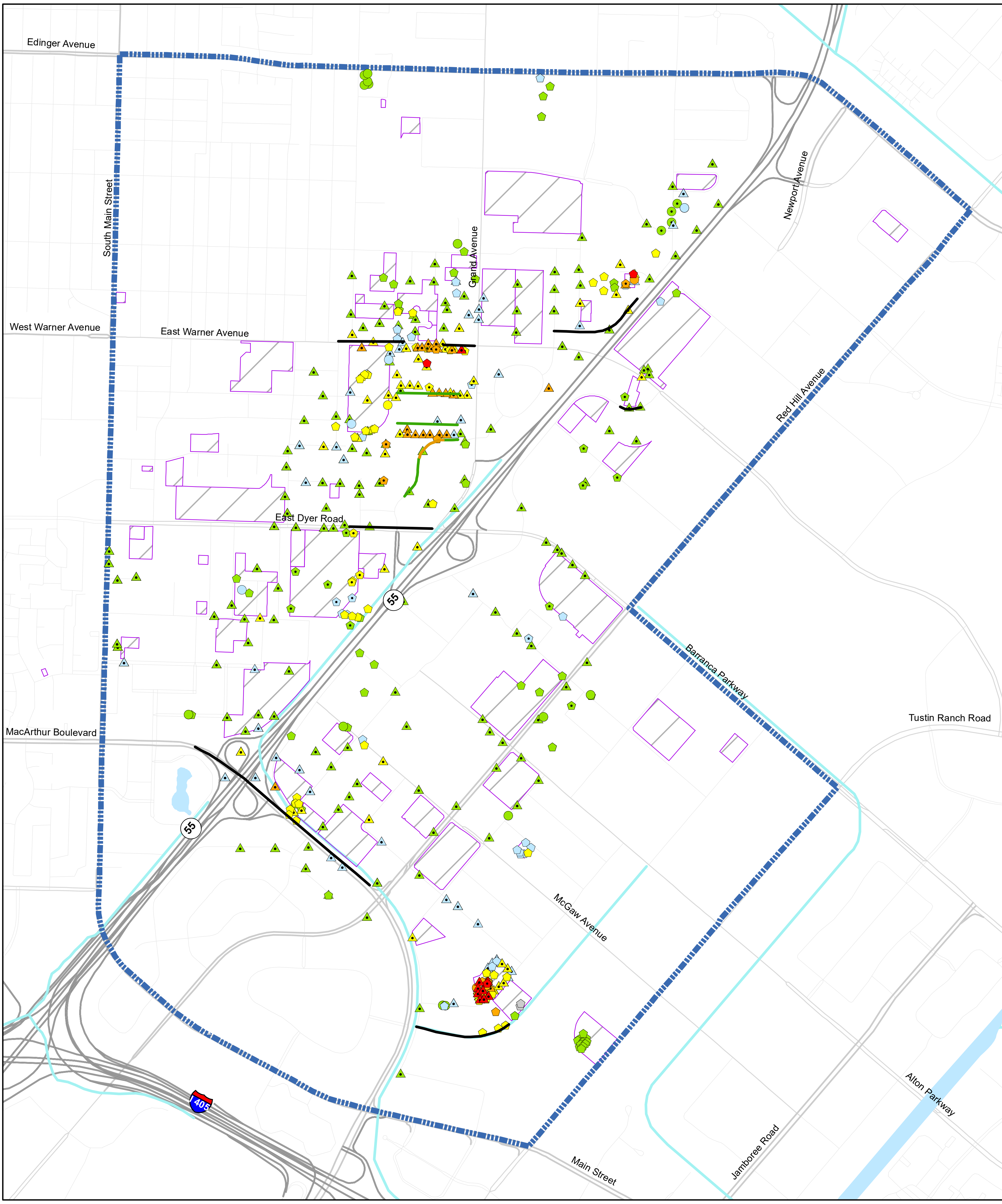
Engineering Analytics, Inc.

FIGURE 1-14: 1,1-Dichloroethylene in Layer 1 Groundwater
Orange County Water District South Basin



Engineering Analytics, Inc.

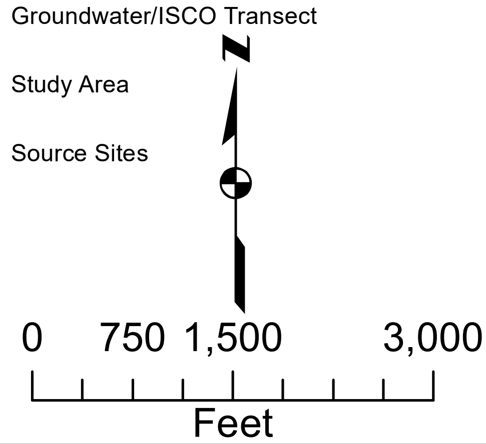
FIGURE 1-15: 1,1-Dichloroethylene in Layer 2 Groundwater
Orange County Water District South Basin



Over 100x MCL
10 to 100x MCL
1 to 10x MCL
Non-detect greater than MCL
Detect less than MCL
Non-detect less than MCL

Well screened in respective layer, Pre 2018
Well screened in respective layer, Post 2017
Well screened in respective layer (and adjacent layer), Pre 2018
Well screened in respective layer (and adjacent layer), Post 2017
Grab Sample, Pre 2018
Grab Sample, Post 2017

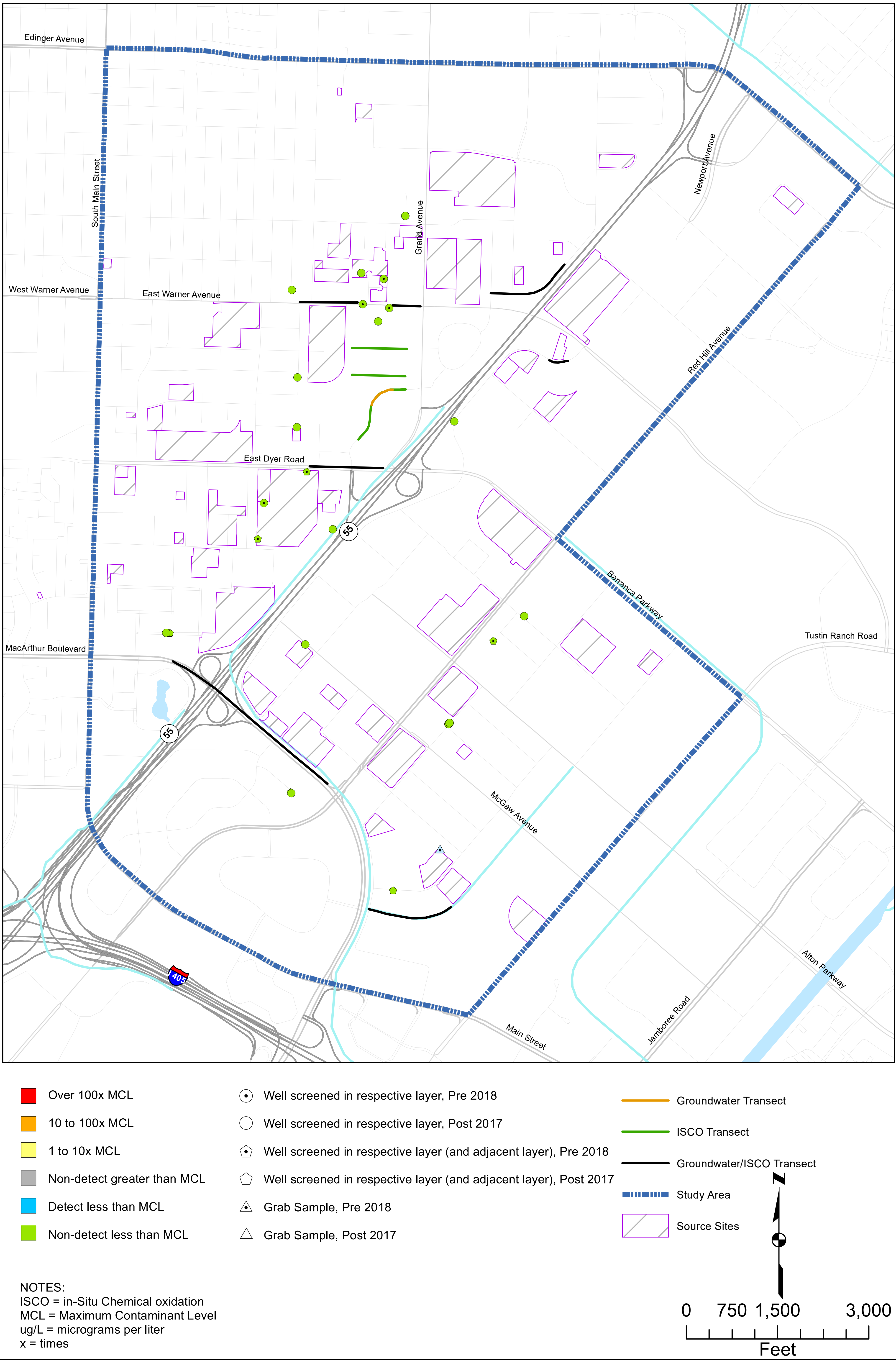
Groundwater Transect
ISCO Transect
Groundwater/ISCO Transect
Study Area
Source Sites



NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

Engineering Analytics, Inc.

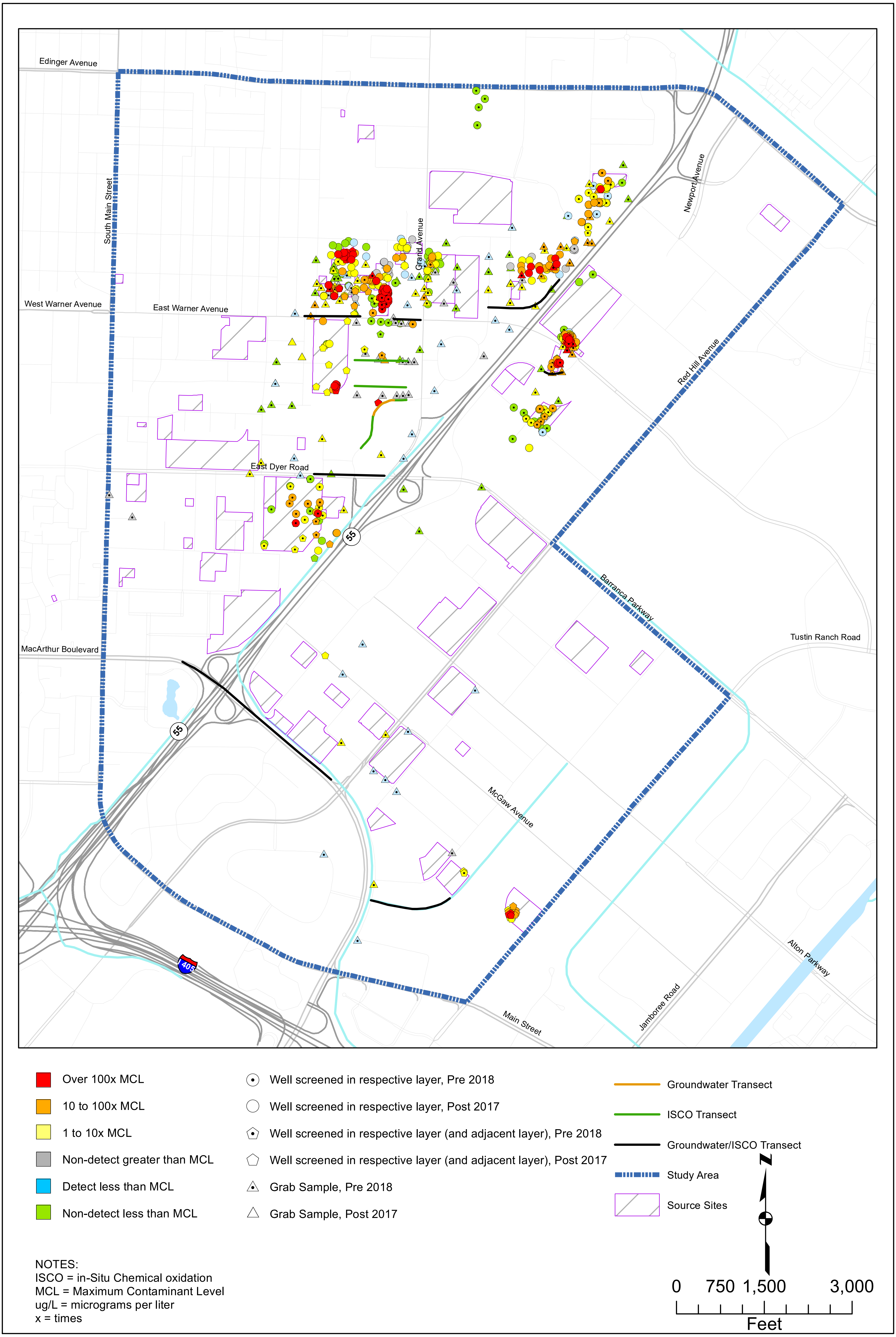
FIGURE 1-16: 1,1-Dichloroethylene in Layer 3 Groundwater
Orange County Water District South Basin



NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

Engineering Analytics, Inc.

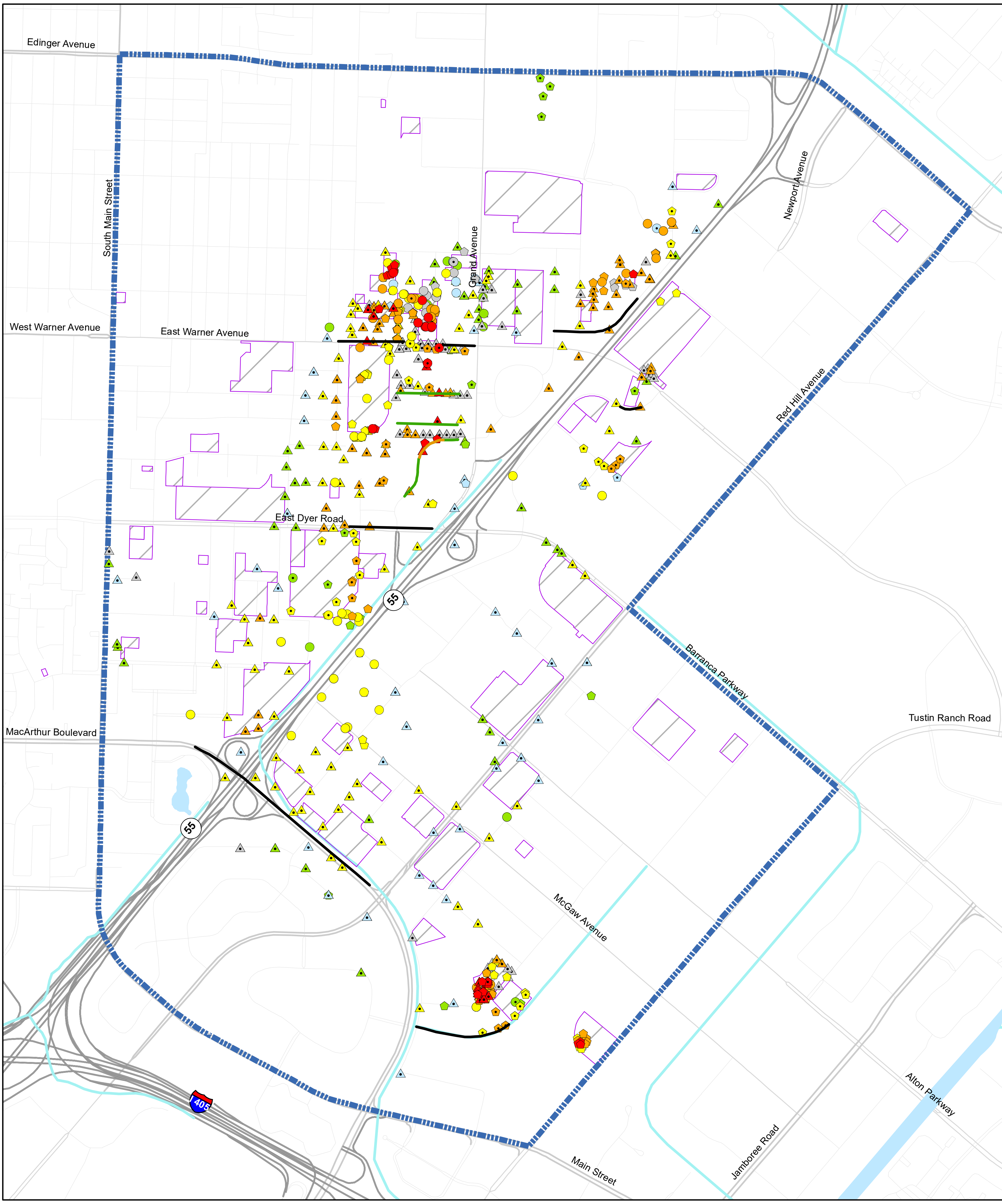
FIGURE 1-17: 1,1-Dichloroethylene in Layer 4 Groundwater
Orange County Water District South Basin



NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

Engineering Analytics, Inc.

FIGURE 1-18: 1,4-Dioxane in Layer 1 Groundwater
Orange County Water District South Basin



Over 100x MCL
10 to 100x MCL
1 to 10x MCL
Non-detect greater than MCL
Detect less than MCL
Non-detect less than MCL

Well screened in respective layer, Pre 2018
Well screened in respective layer, Post 2017
Well screened in respective layer (and adjacent layer), Pre 2018
Well screened in respective layer (and adjacent layer), Post 2017
Grab Sample, Pre 2018
Grab Sample, Post 2017

Groundwater Transect
ISCO Transect
Groundwater/ISCO Transect
Study Area
Source Sites

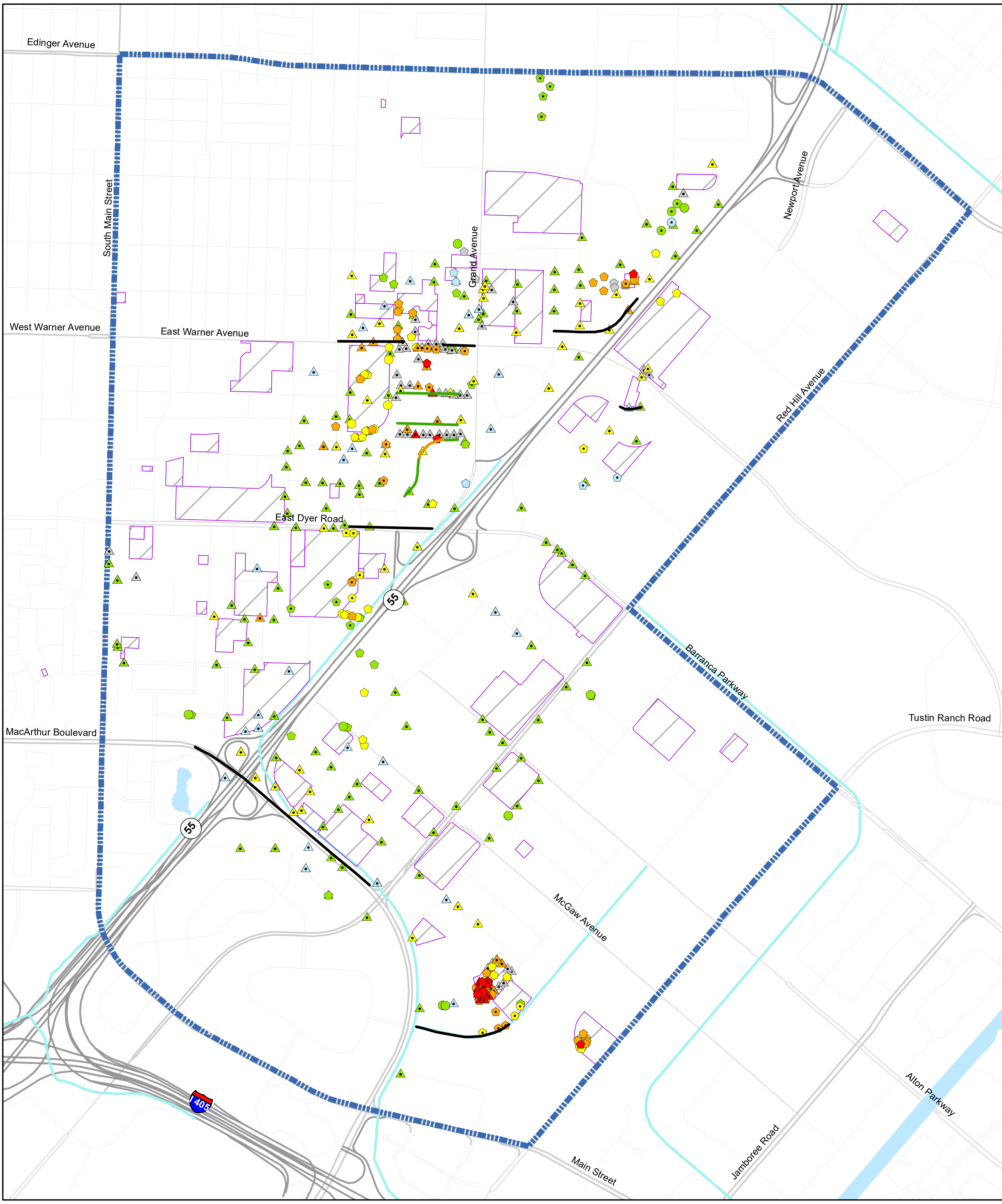
N

0 750 1,500 3,000
Feet

NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

Engineering Analytics, Inc.

FIGURE 1-19: 1,4-Dioxane in Layer 2 Groundwater
Orange County Water District South Basin



Over 100x MCL

10 to 100x MCL

1 to 10x MCL

Non-detect greater than MCL

Detect less than MCL

Non-detect less than MCL

Well screened in respective layer, Pre 2018

Well screened in respective layer, Post 2017

Well screened in respective layer (and adjacent layer), Pre 2018

Well screened in respective layer (and adjacent layer), Post 2017

Grab Sample, Pre 2018

Grab Sample, Post 2017

Groundwater Transect

ISCO Transect

Groundwater/ISCO Transect

Study Area

Source Sites

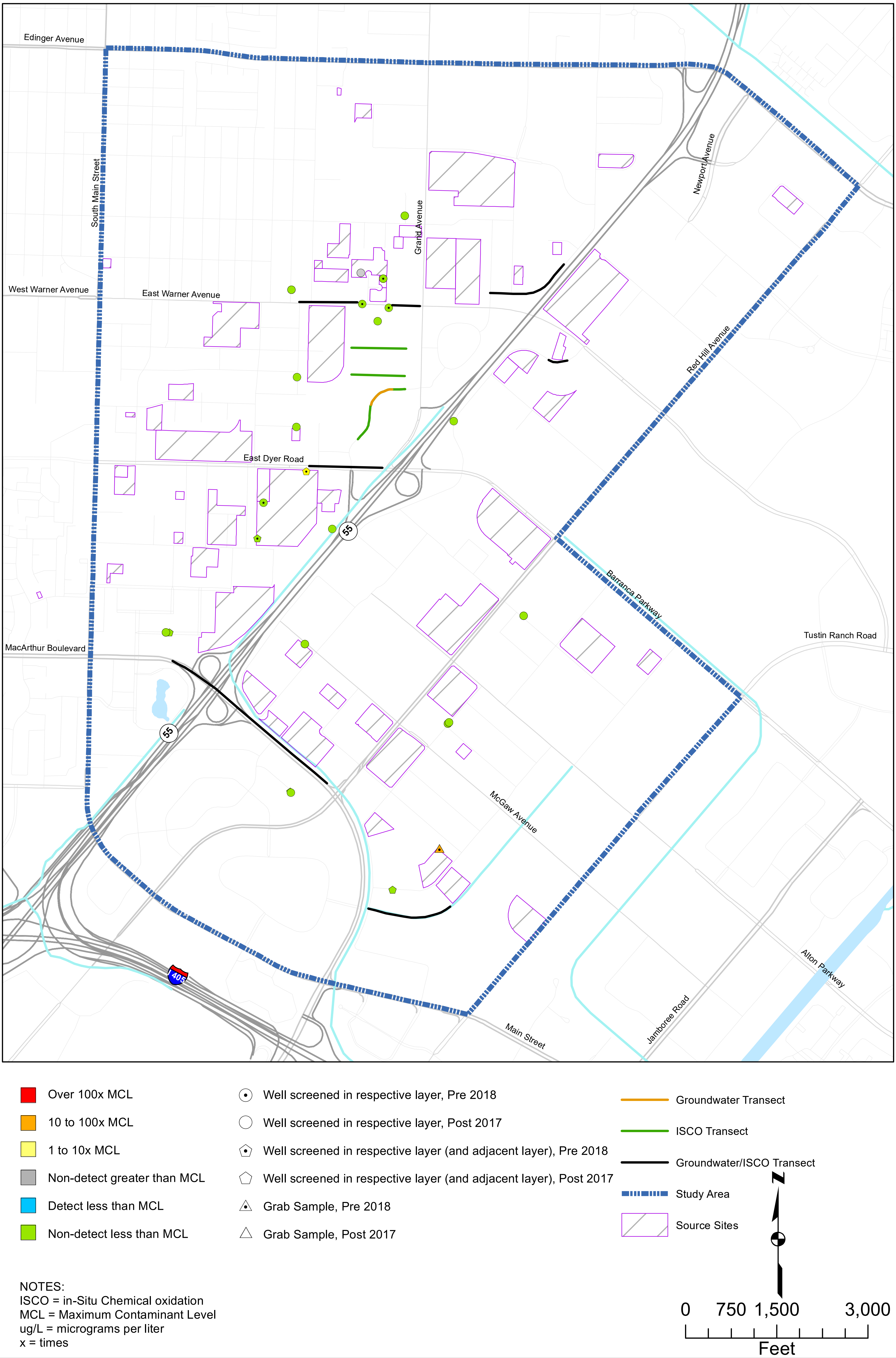
0 750 1,500 3,000

Feet

NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

Engineering Analytics, Inc.

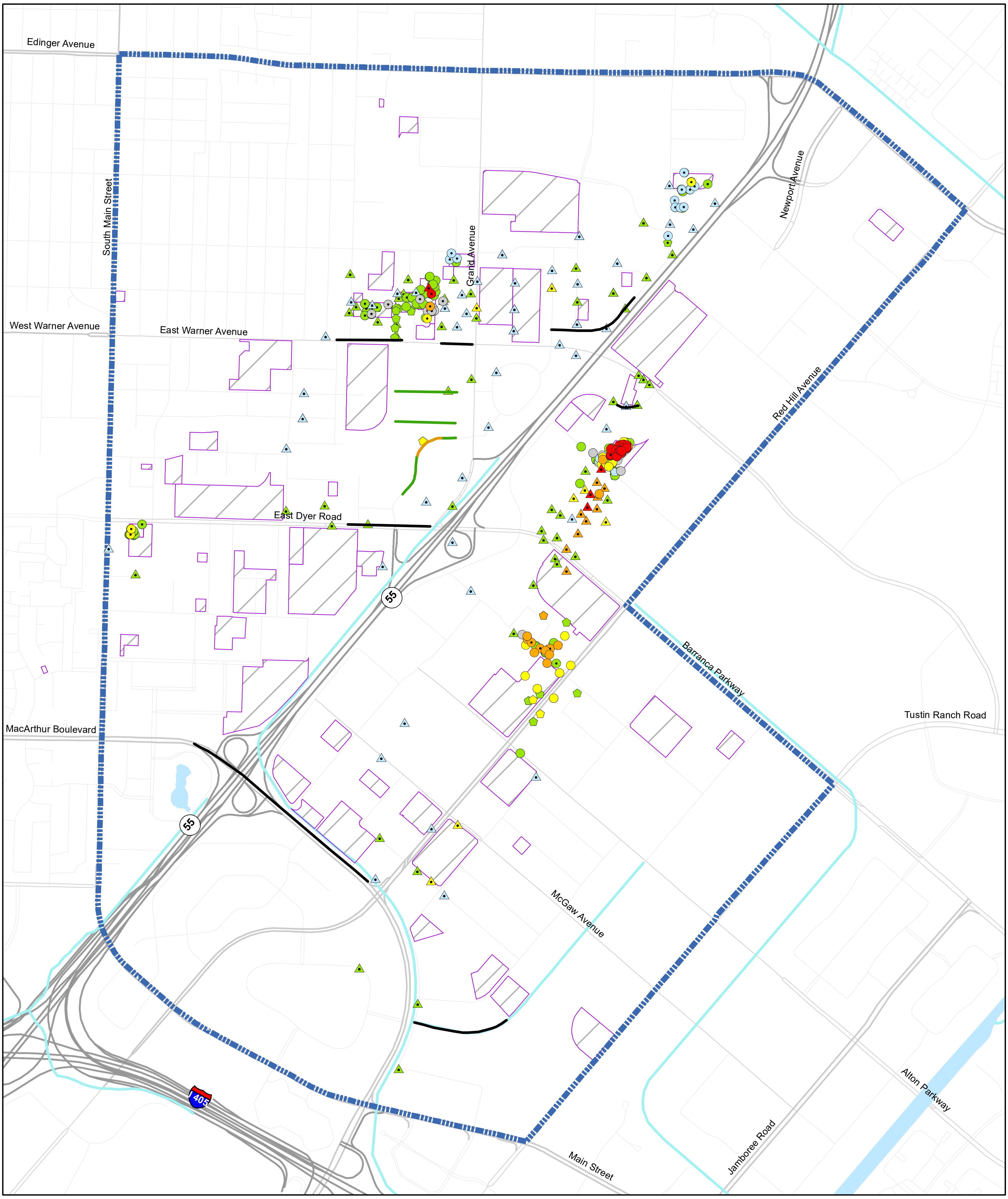
FIGURE 1-20: 1,4-Dioxane in Layer 3 Groundwater
Orange County Water District South Basin



NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

Engineering Analytics, Inc.

FIGURE 1-21: 1,4-Dioxane in Layer 4 Groundwater
Orange County Water District South Basin



Over 100x MCL
10 to 100x MCL
1 to 10x MCL
Non-detect greater than MCL
Detect less than MCL
Non-detect less than MCL

Well screened in respective layer, Pre 2018
Well screened in respective layer, Post 2017
Well screened in respective layer (and adjacent layer), Pre 2018
Well screened in respective layer (and adjacent layer), Post 2017
Grab Sample, Pre 2018
Grab Sample, Post 2017

Groundwater Transect
ISCO Transect
Groundwater/ISCO Transect
Study Area
Source Sites

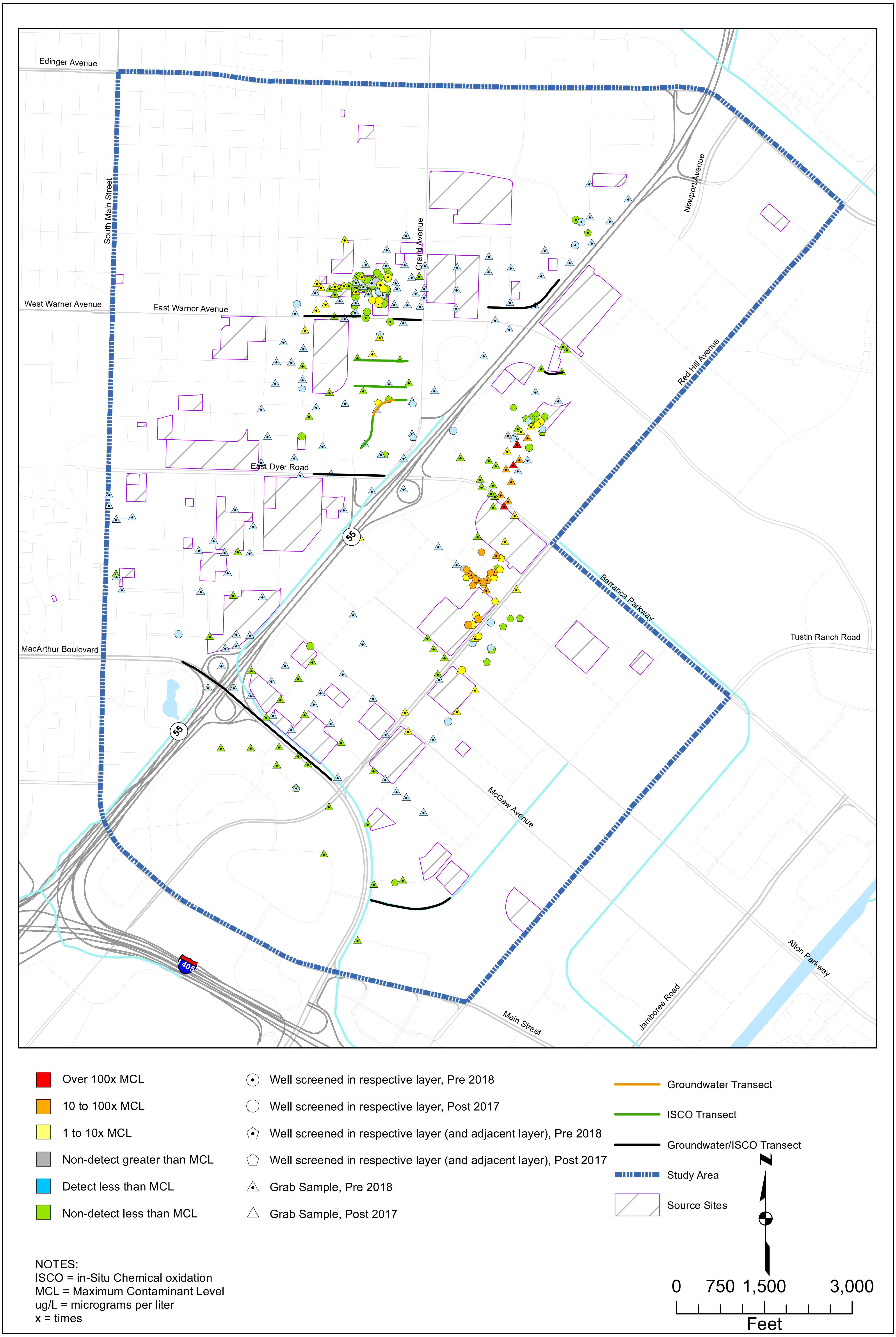
N

0 750 1,500 3,000
Feet

NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

Engineering Analytics, Inc.

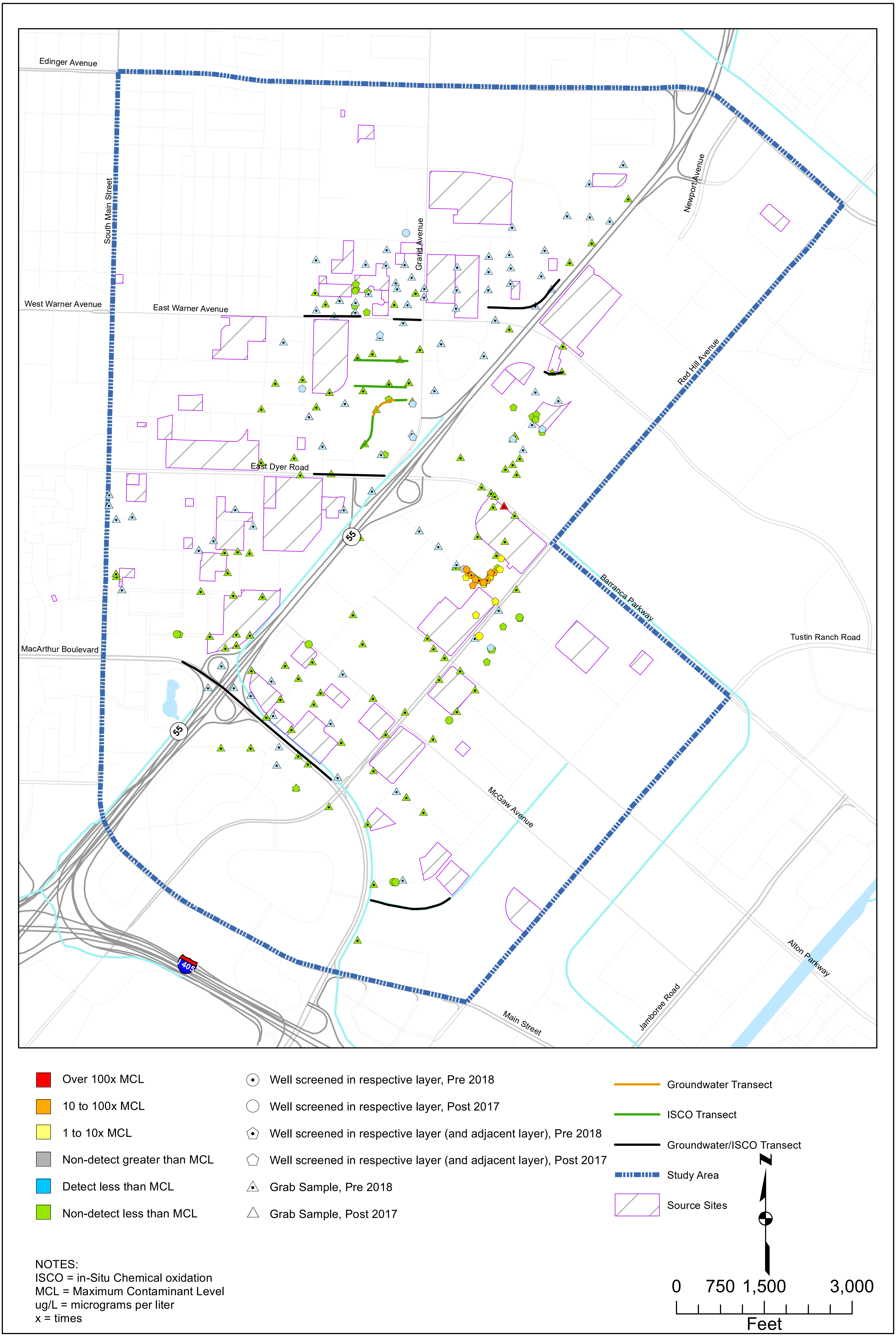
FIGURE 1-22: Perchlorate in Layer 1 Groundwater
Orange County Water District South Basin



NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

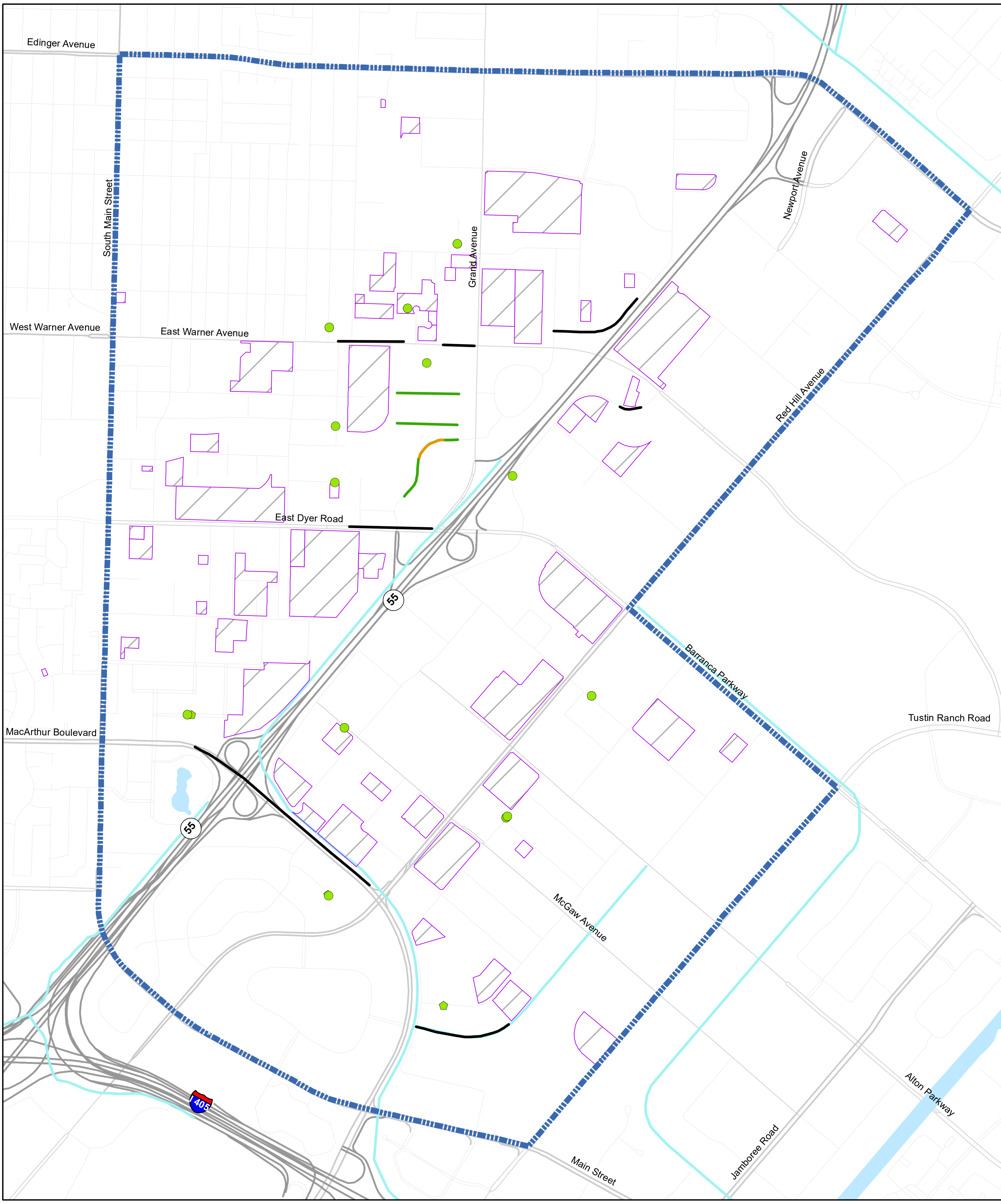
Engineering Analytics, Inc.

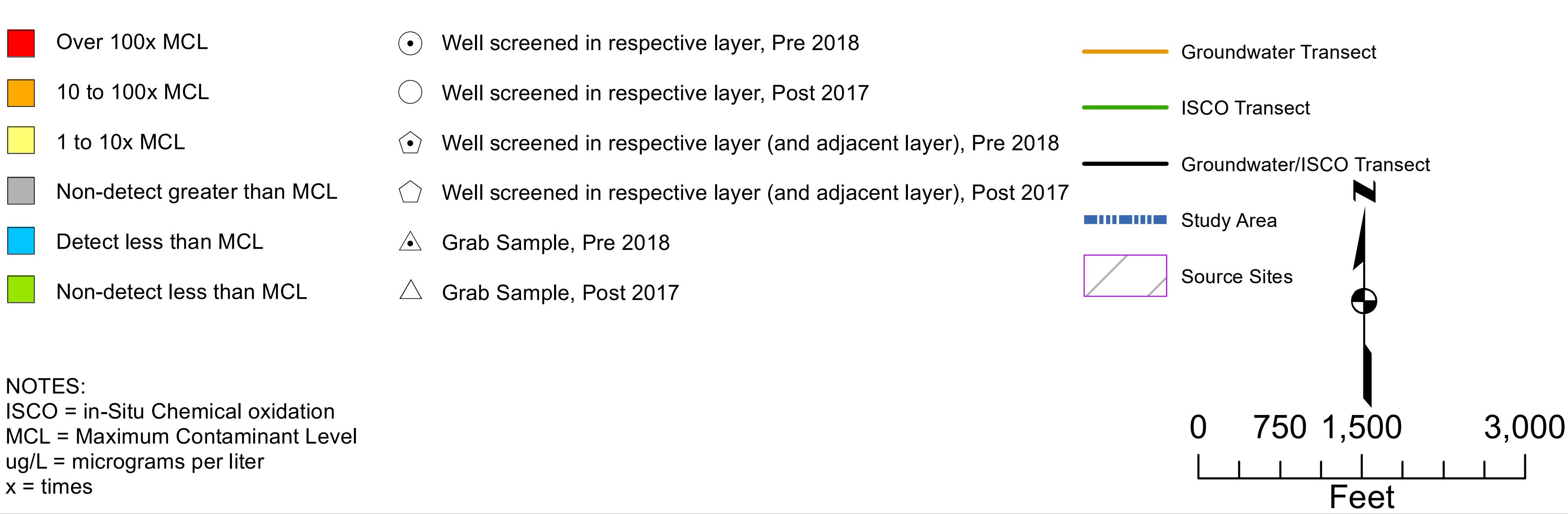
FIGURE 1-23: Perchlorate in Layer 2 Groundwater
Orange County Water District South Basin



Engineering Analytics, Inc.

FIGURE 1-24: Perchlorate in Layer 3 Groundwater
Orange County Water District South Basin

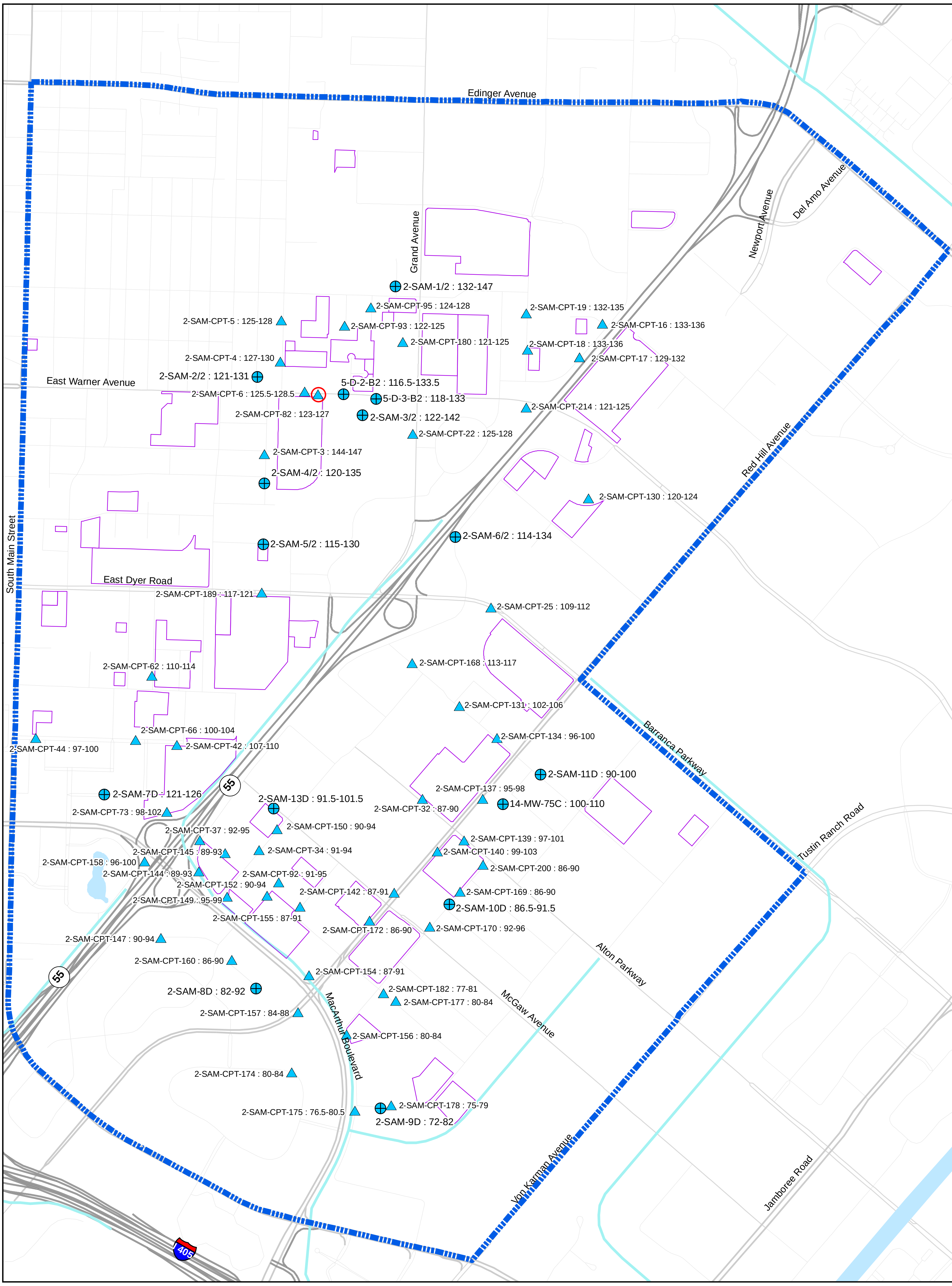




NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

Engineering Analytics, Inc.

FIGURE 1-25: Perchlorate in Layer 4 Groundwater
Orange County Water District South Basin



N

NOTES:

Principal Compounds of Potential Concern either not detected or detected below 1 microgram per liter (volatile organic compounds and 1,4-dioxane) or 6 micrograms per liter (perchlorate) except red circled location. The red circled location had a detection of 1,4-dioxane at 6.3 micrograms per liter. See appendix for additional information.

Sample identifiers include top and bottom of sampled interval (feet below land surface).

0 750 1,500 3,000
Feet

- Deep Sample Location - Grab Sample
- Deep Sample Location - Groundwater Monitor Well
- Study Area
- Source Sites
- Channels, Creeks, Washes

Document Path: C:\GIS\1170_OCWDSB_FD\Applications\1170_Fig5-12_Lower_Sample_Locations.mxd 4/22/2019 9:58:10 PM

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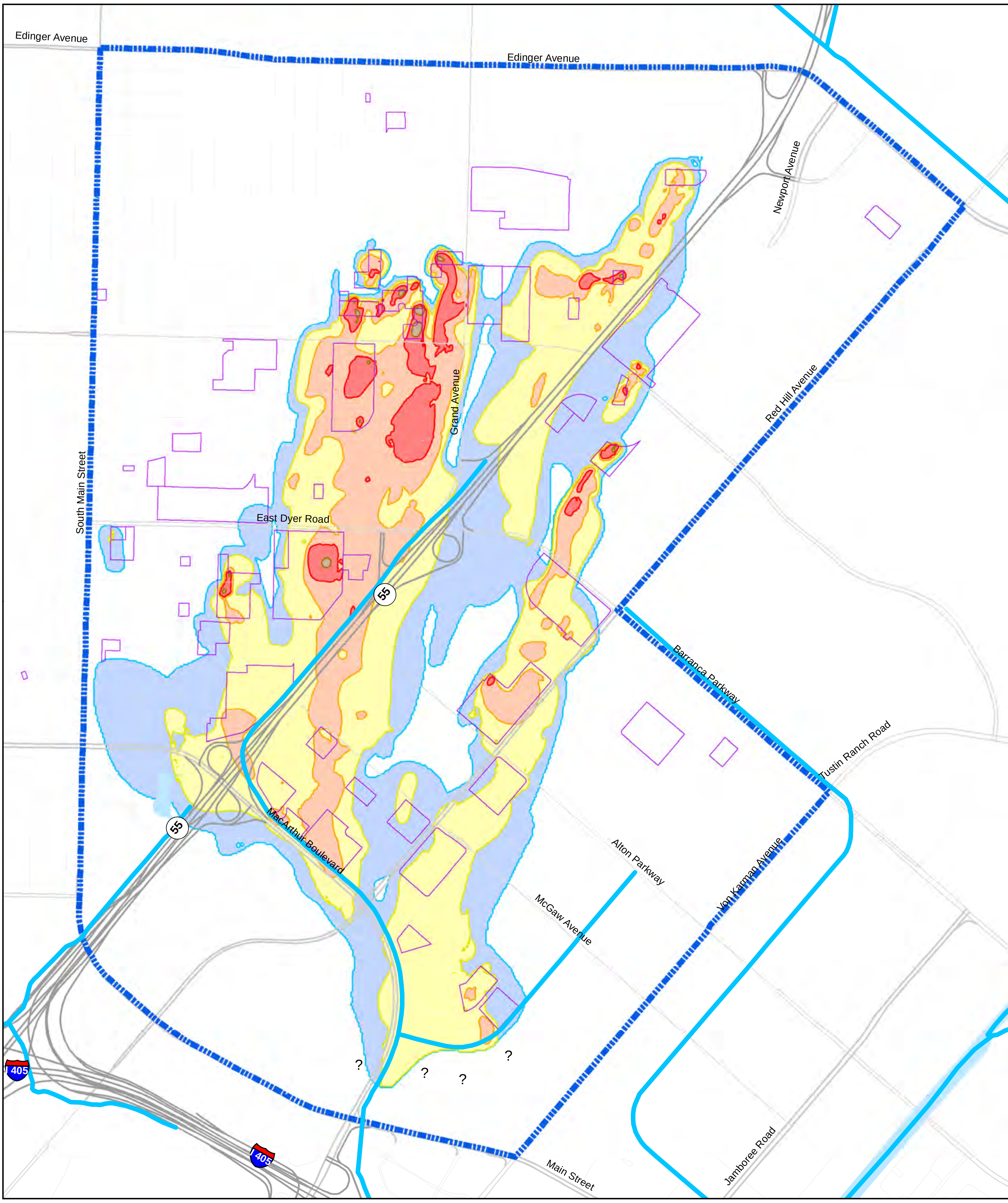
HYDROGEOLOGY • ENGINEERING

FIGURE 1-26. GROUNDWATER SAMPLE LOCATIONS NEAR/WITHIN LAYER 4 (BASAL SAND)



NOTES:

Approximate distribution based on maximum concentration of principal chemicals of potential concern (COPCs) (tetrachloroethylene, trichloroethylene, 1,1-dichloroethylene, perchlorate and 1,4-dioxane, micrograms per liter [ug/l]). See appendix for details.

Water level elevation based on upper shallow aquifer system water level measurements in first half of 2012 (see appendix), feet NAVD88 datum. Q1/Q2 2012 water level contours selected as the data set for this period was more extensive than other data sets.

Channels, unspecified
Study Area
Source Sites
Approximate Contour of Water Level Elevation, Upper Portion of Shallow Aquifer System (Q1/Q2 2012)

Approximate extent of principal COPCs

1 ug/l
10 ug/l
100 ug/l
1,000 ug/l
>10,000 ug/l

ug/l = micrograms per liter

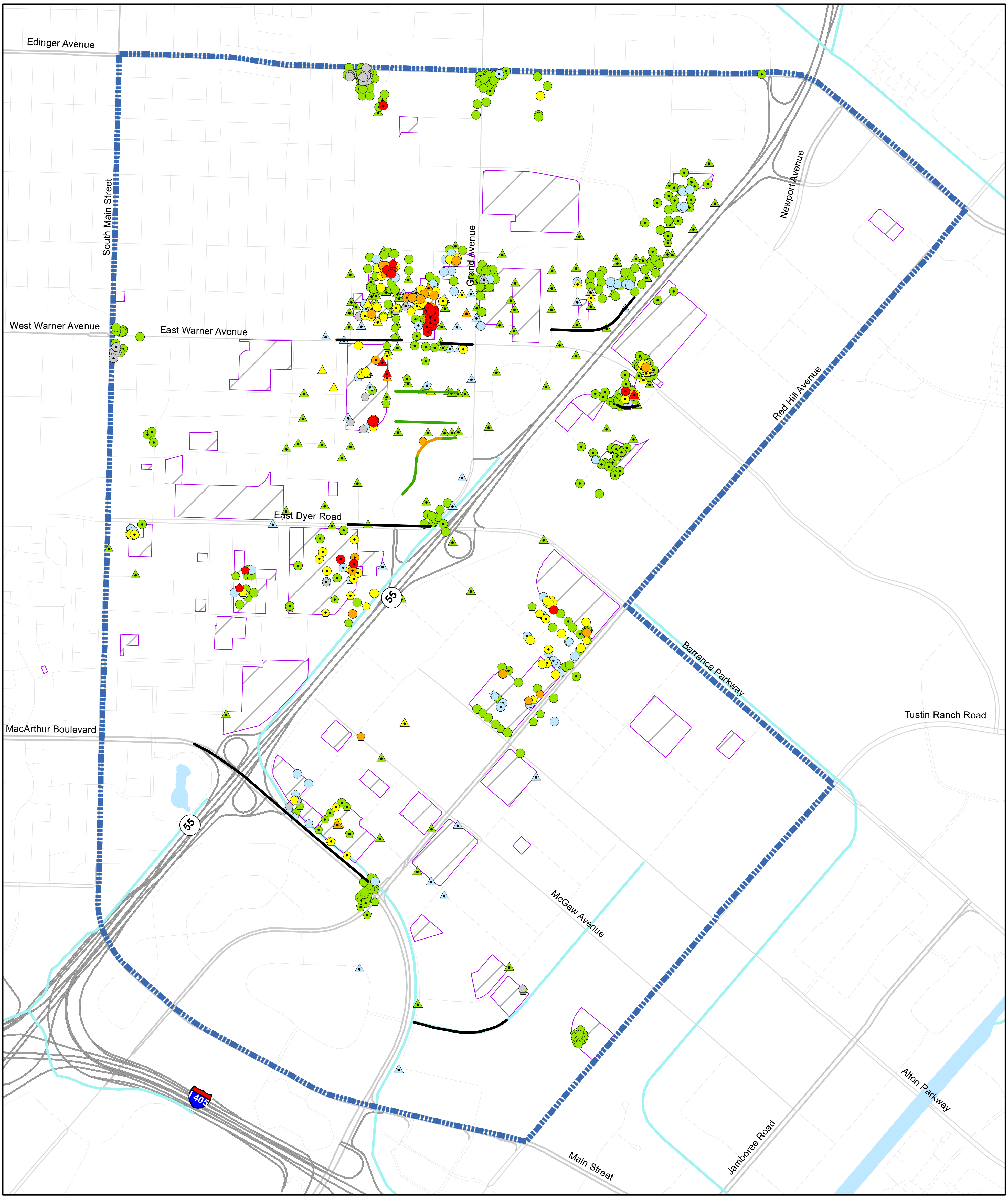
N

0 750 1,500 3,000
Feet

Document Path: C:\GIS\1170_OCWDSB_FD\Applications\1170_Fig-5-13_PRINCIPAL_COPCs.mxd 4/22/2019 10:09:23 PM

HARGIS + ASSOCIATES, INC.
HYDROGEOLOGY • ENGINEERING

FIGURE 1-27. OVERVIEW OF EXTENT OF PRINCIPAL COMPOUNDS OF POTENTIAL CONCERN IN SHALLOW AQUIFER SYSTEM



Over 100x MCL
10 to 100x MCL
1 to 10x MCL
Non-detect greater than MCL
Detect less than MCL
Non-detect less than MCL

Well screened in respective layer, Pre 2018
Well screened in respective layer, Post 2017
Well screened in respective layer (and adjacent layer), Pre 2018
Well screened in respective layer (and adjacent layer), Post 2017
Grab Sample, Pre 2018
Grab Sample, Post 2017

Groundwater Transect
ISCO Transect
Groundwater/ISCO Transect
Study Area
Source Sites

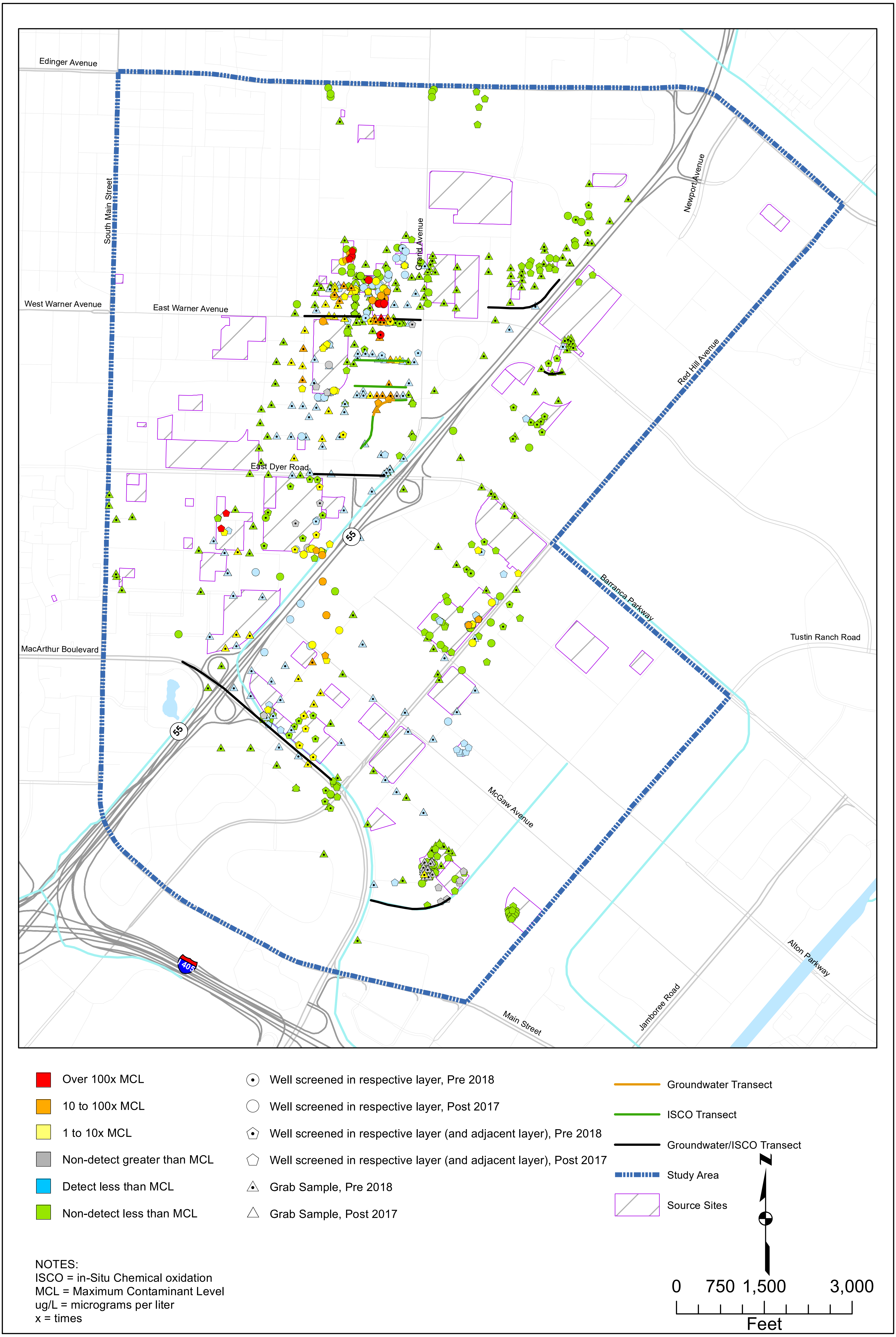
N

0 750 1,500 3,000
Feet

NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

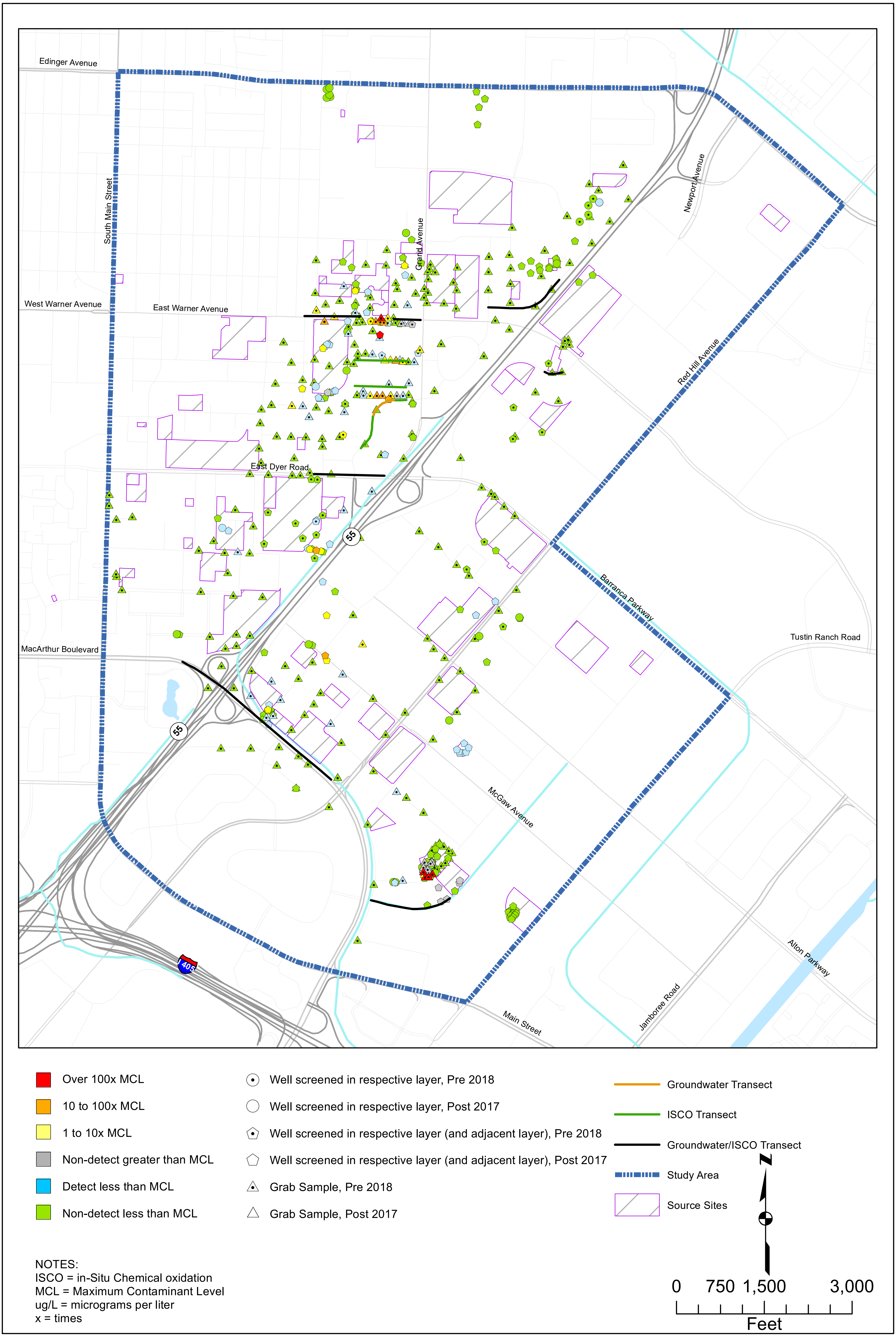
Engineering Analytics, Inc.

FIGURE 1-28: cis-1,2-Dichloroethylene in Layer 1 Groundwater
Orange County Water District South Basin



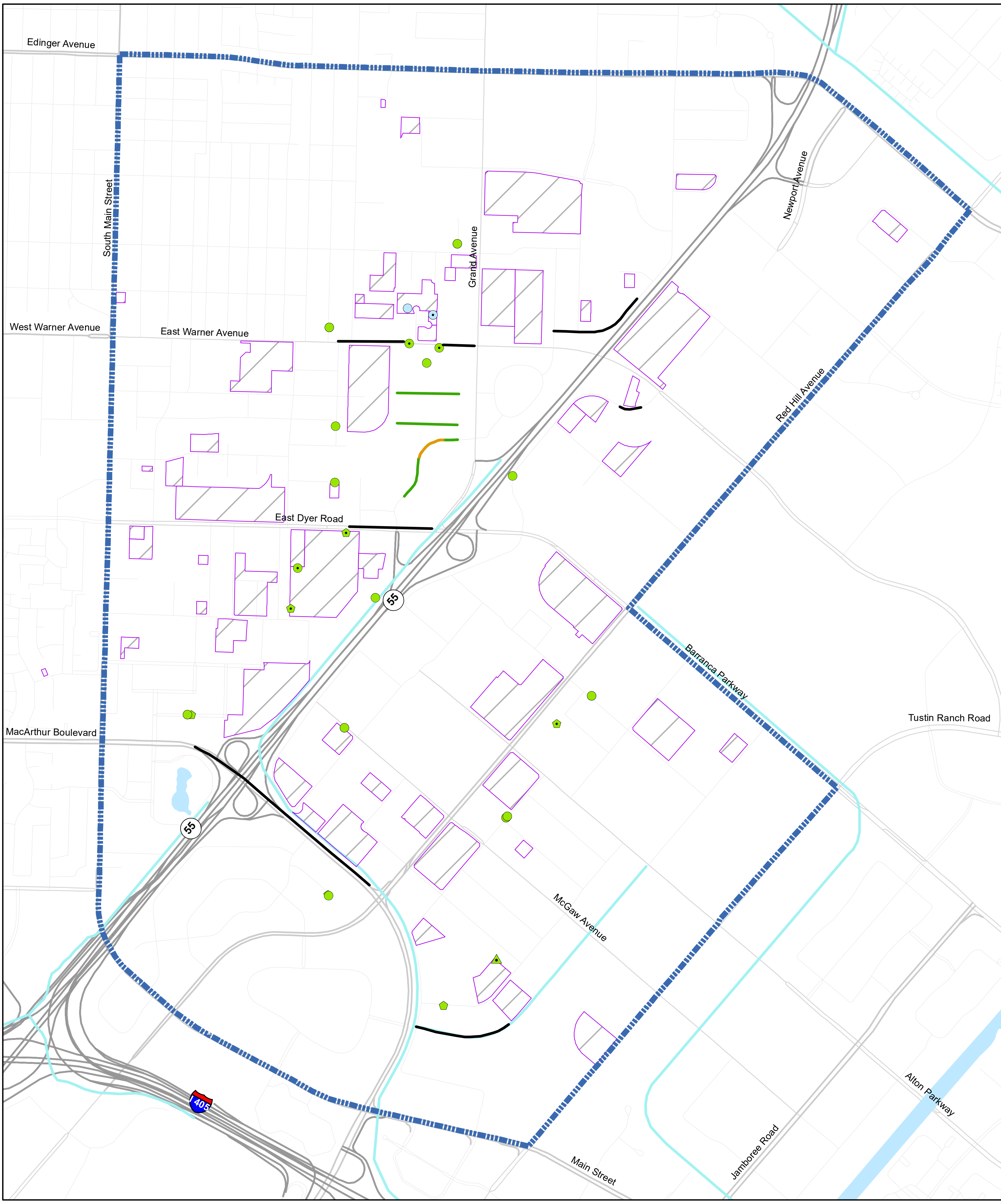
Engineering Analytics, Inc.

FIGURE 1-29: cis-1,2-Dichloroethylene in Layer 2 Groundwater
Orange County Water District South Basin



Engineering Analytics, Inc.

FIGURE 1-30: cis-1,2-Dichloroethylene in Layer 3 Groundwater
Orange County Water District South Basin



- Over 100x MCL
- 10 to 100x MCL
- 1 to 10x MCL
- Non-detect greater than MCL
- Detect less than MCL
- Non-detect less than MCL

- Well screened in respective layer, Pre 2018
- Well screened in respective layer, Post 2017
- Well screened in respective layer (and adjacent layer), Pre 2018
- Well screened in respective layer (and adjacent layer), Post 2017
- Grab Sample, Pre 2018
- Grab Sample, Post 2017

- Groundwater Transect
- ISCO Transect
- Groundwater/ISCO Transect
- Study Area
- Source Sites

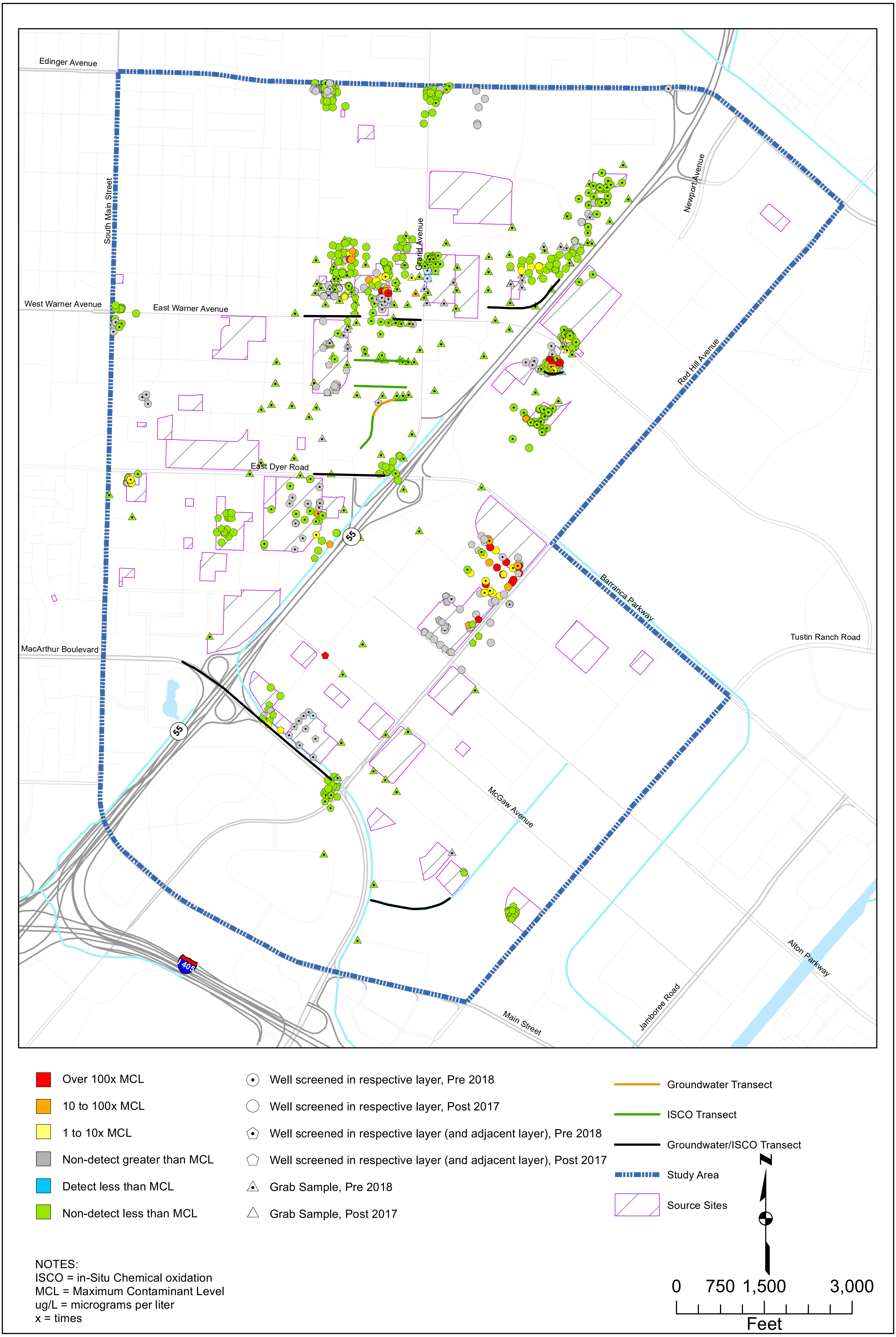
N

0 750 1,500 3,000
Feet

NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

Engineering Analytics, Inc.

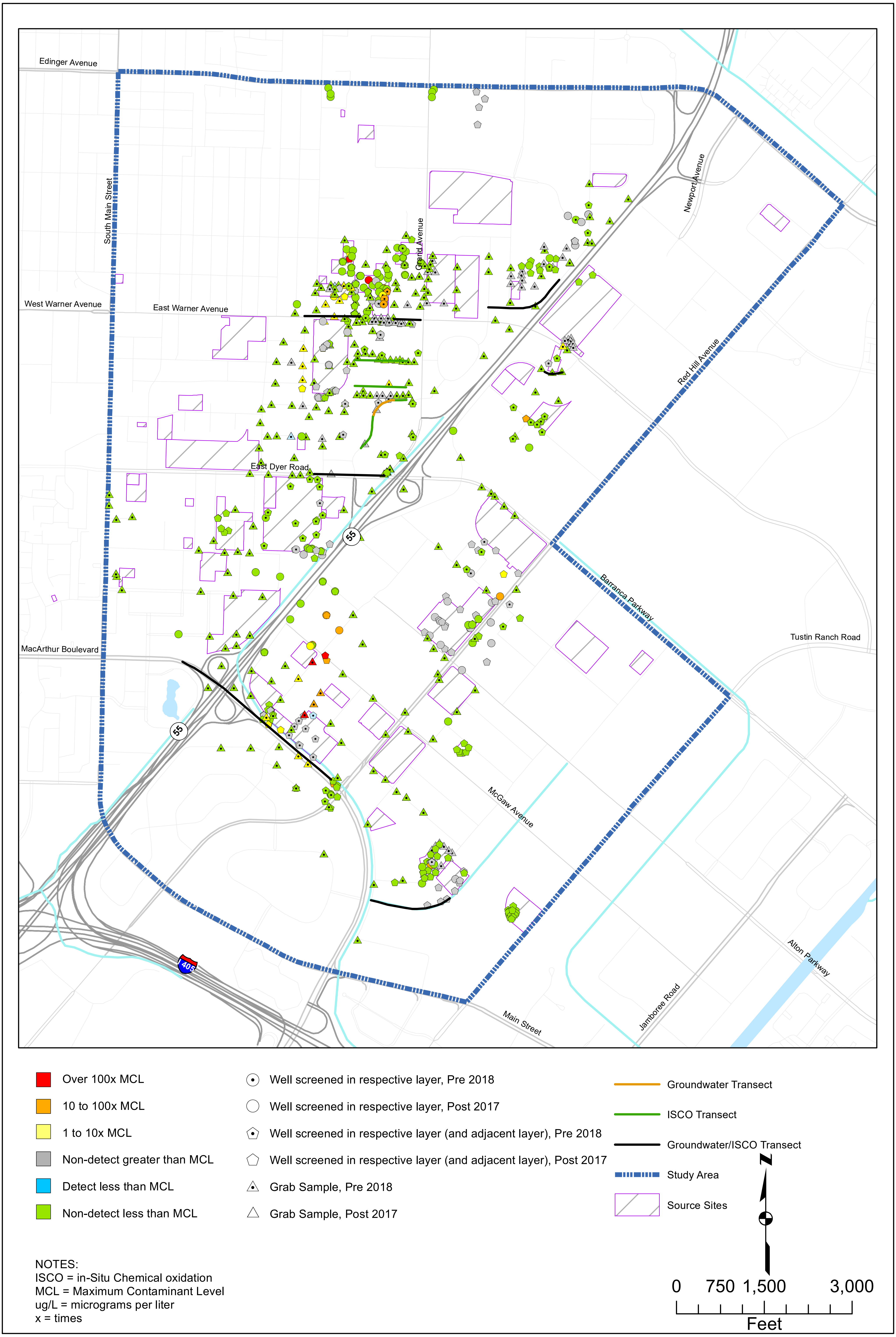
FIGURE 1-31: cis-1,2-Dichloroethylene in Layer 4 Groundwater
Orange County Water District South Basin



NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

Engineering Analytics, Inc.

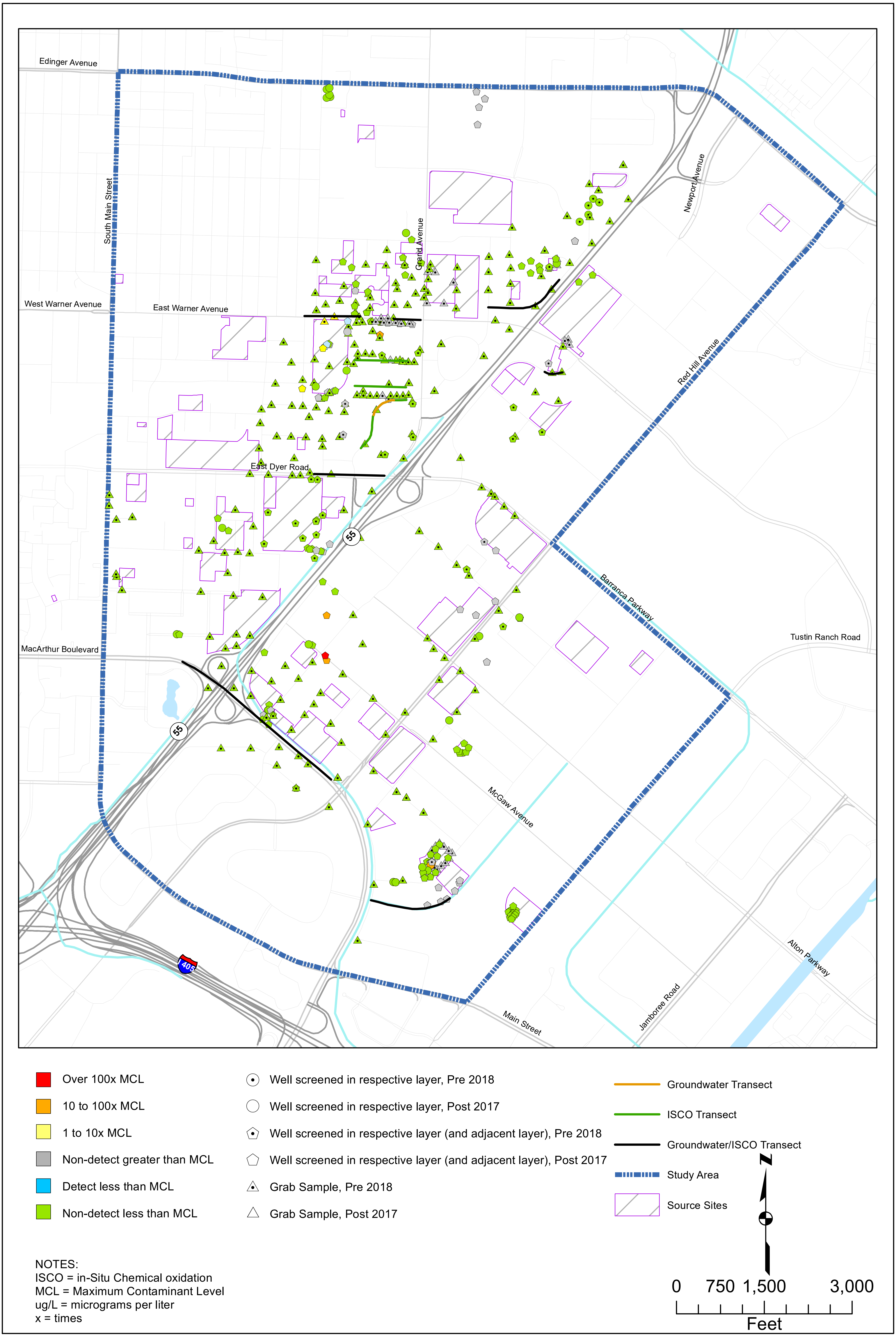
FIGURE 1-32: Vinyl Chloride in Layer 1 Groundwater
Orange County Water District South Basin



NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

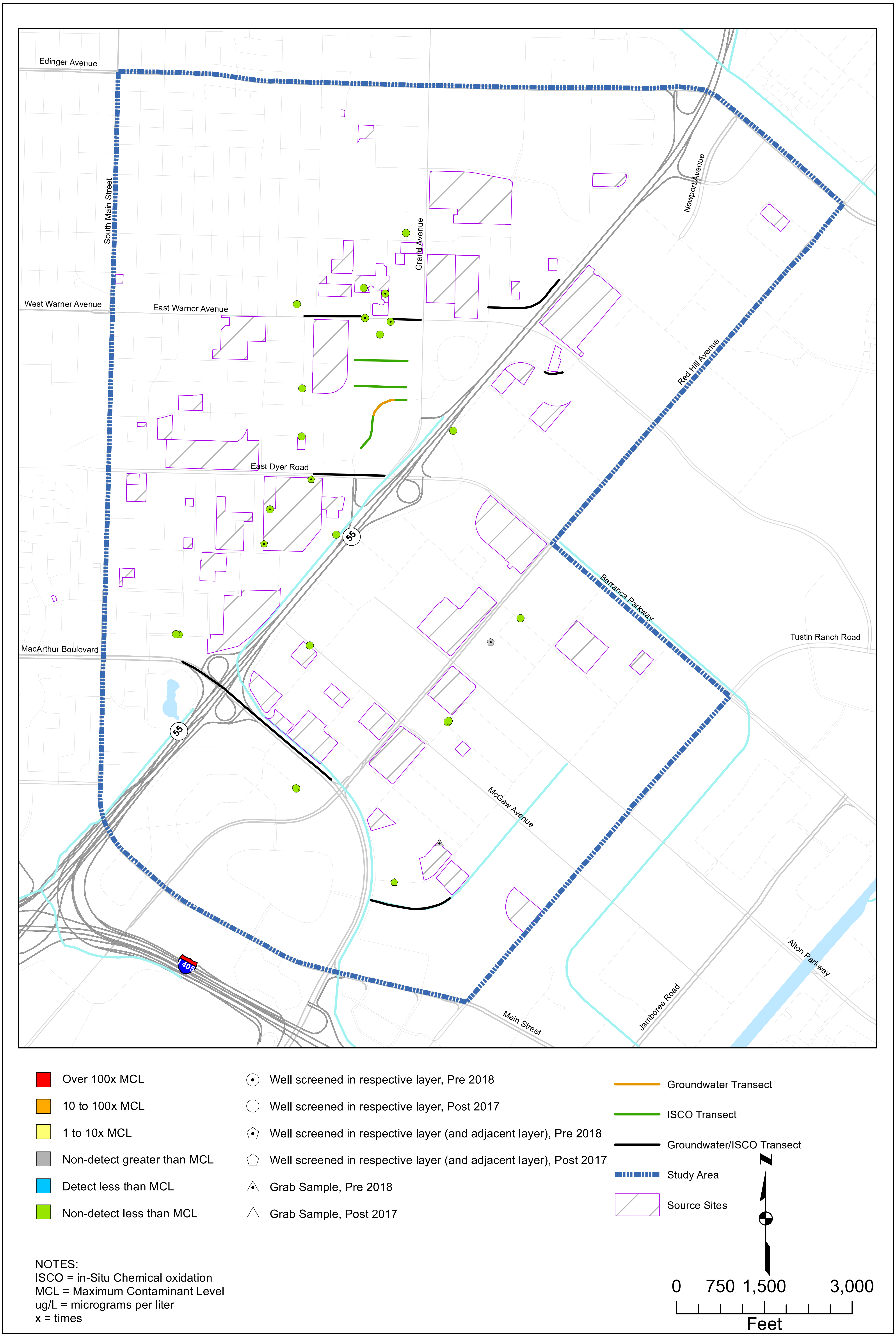
Engineering Analytics, Inc.

FIGURE 1-33: Vinyl Chloride in Layer 2 Groundwater
Orange County Water District South Basin



Engineering Analytics, Inc.

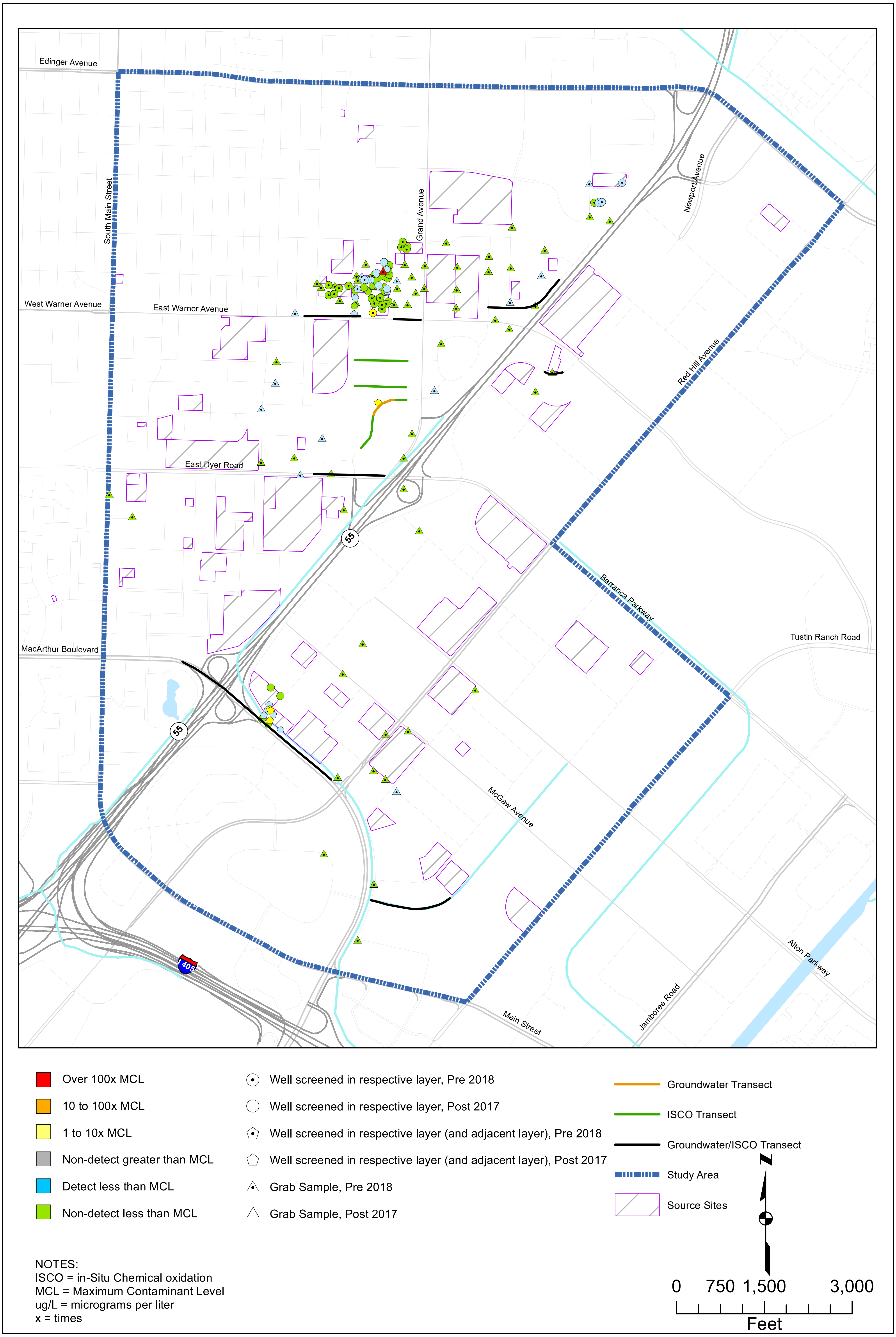
FIGURE 1-34: Vinyl Chloride in Layer 3 Groundwater
Orange County Water District South Basin



NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

Engineering Analytics, Inc.

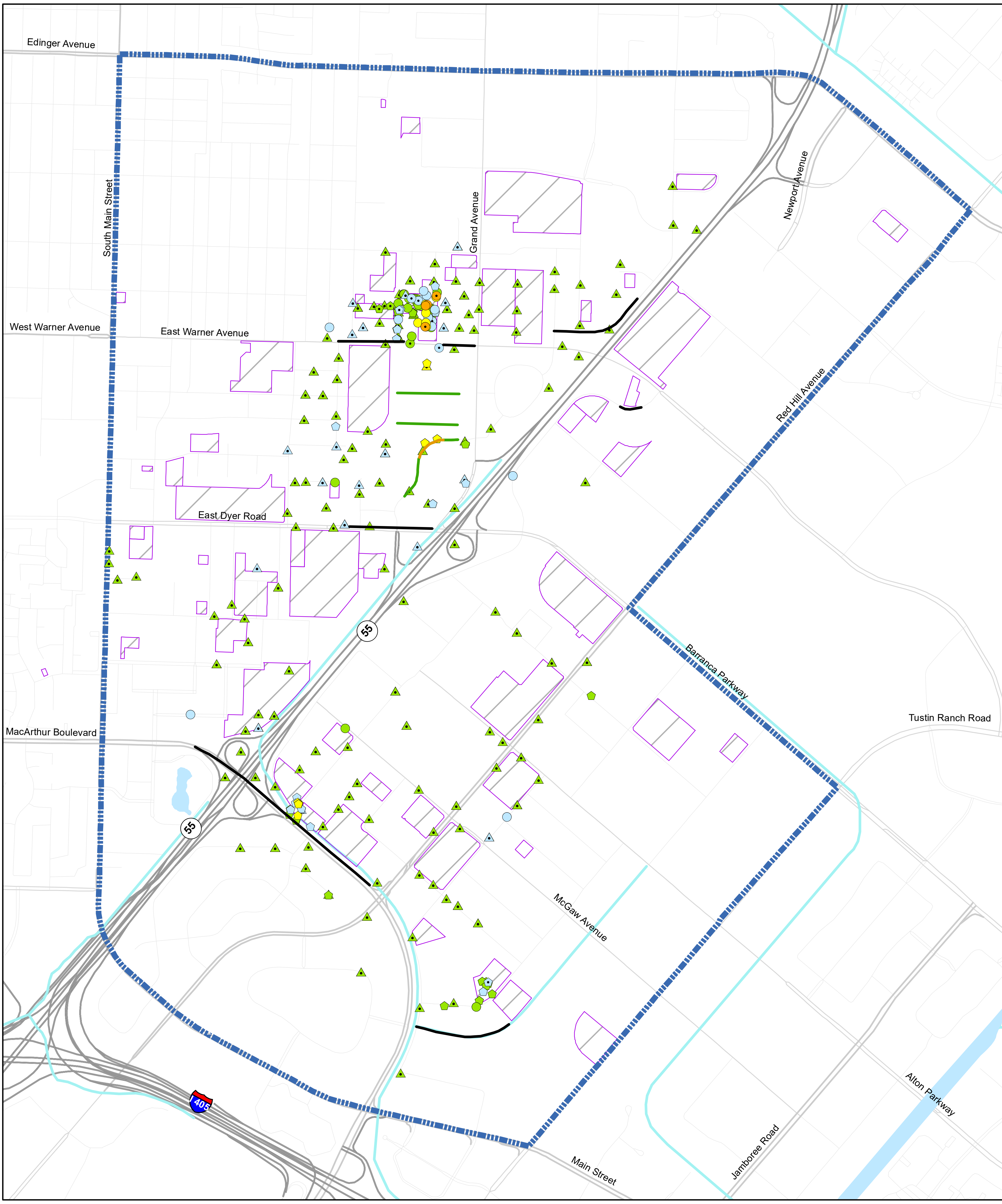
FIGURE 1-35: Vinyl Chloride in Layer 4 Groundwater
Orange County Water District South Basin



NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

Engineering Analytics, Inc.

FIGURE 1-36: Hexavalent Chromium in Layer 1 Groundwater
Orange County Water District South Basin



Over 100x MCL
10 to 100x MCL
1 to 10x MCL
Non-detect greater than MCL
Detect less than MCL
Non-detect less than MCL

Well screened in respective layer, Pre 2018
Well screened in respective layer, Post 2017
Well screened in respective layer (and adjacent layer), Pre 2018
Well screened in respective layer (and adjacent layer), Post 2017
Grab Sample, Pre 2018
Grab Sample, Post 2017

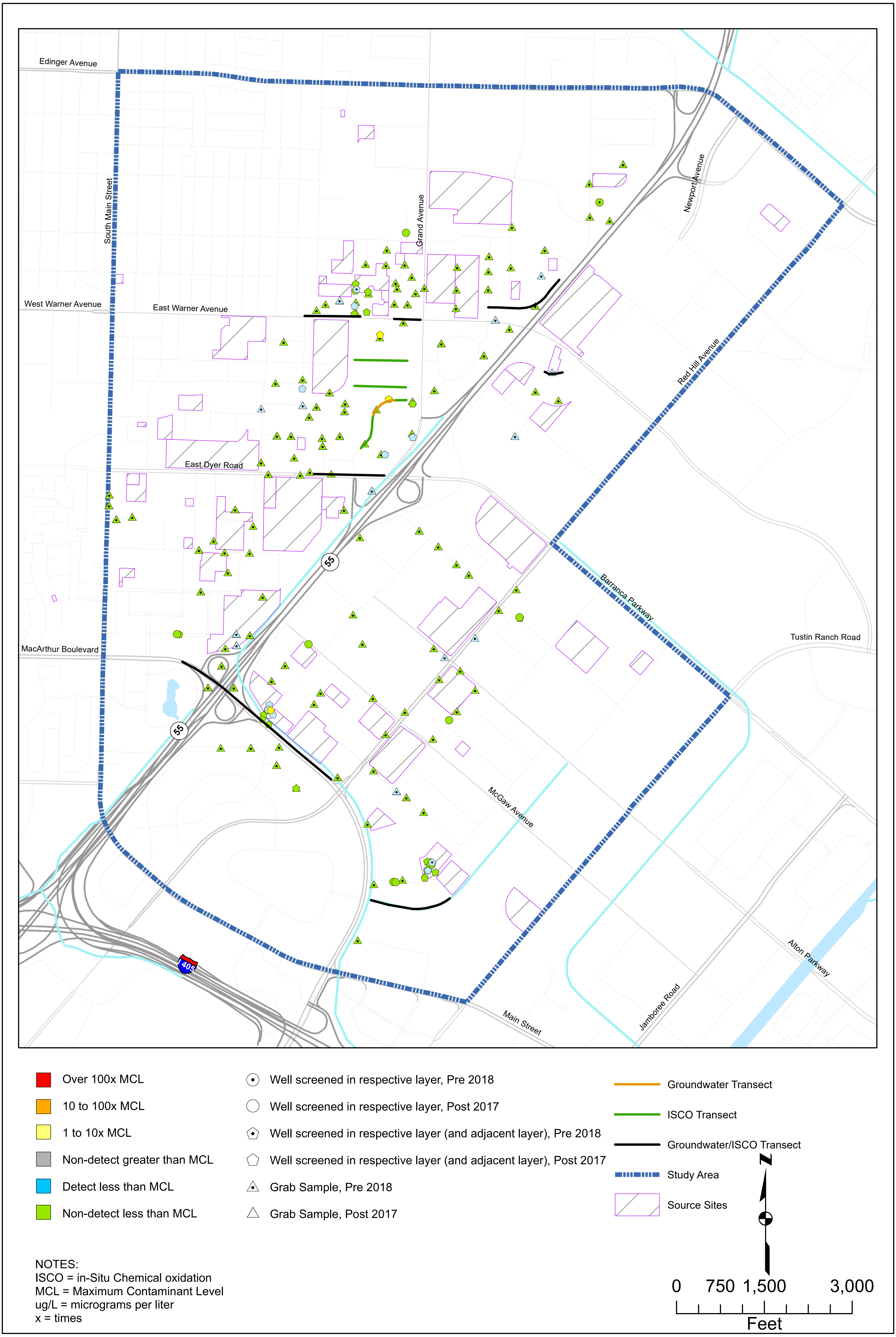
Groundwater Transect
ISCO Transect
Groundwater/ISCO Transect
Study Area
Source Sites

0 750 1,500 3,000
Feet

NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

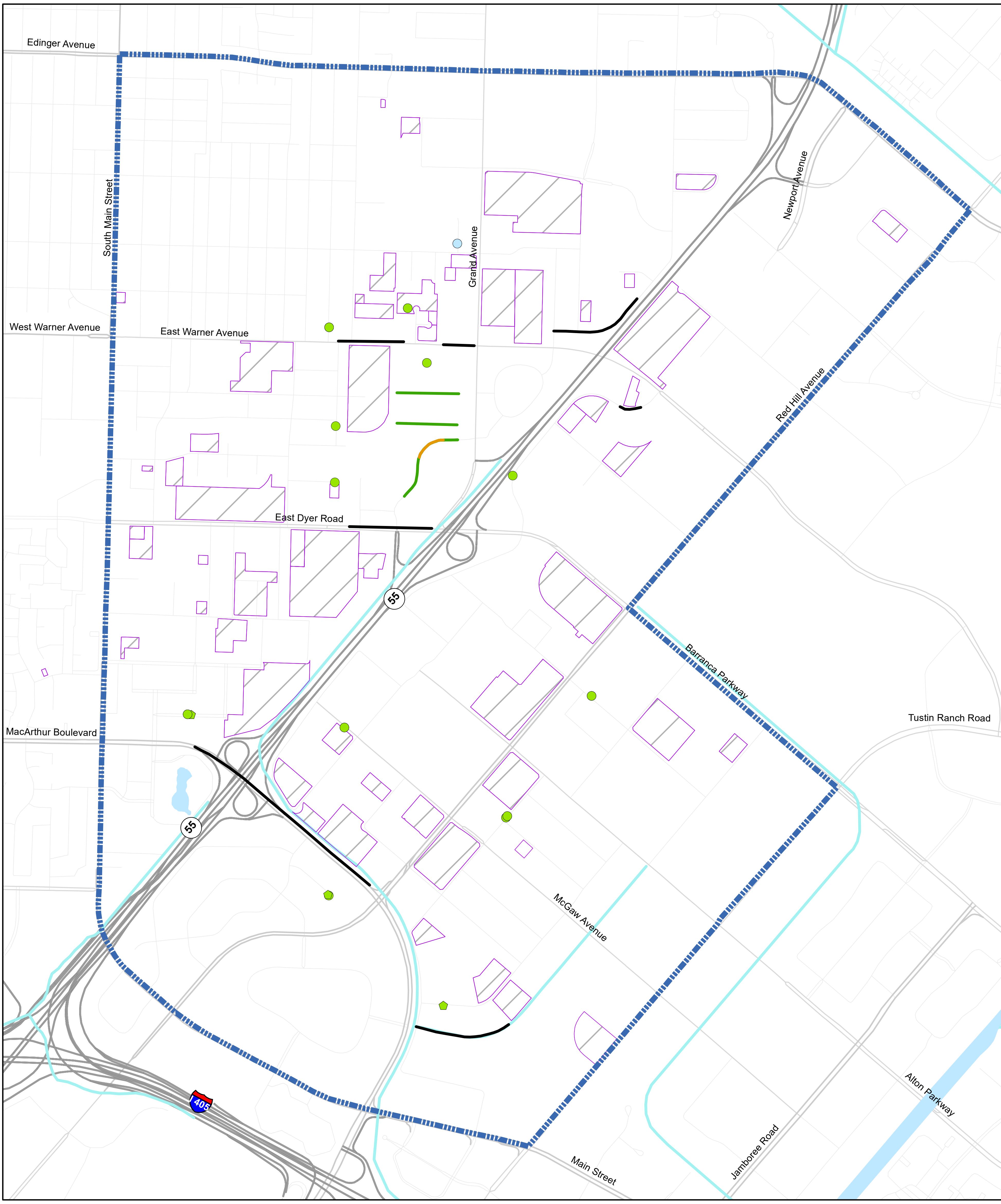
Engineering Analytics, Inc.

FIGURE 1-37: Hexavalent Chromium in Layer 2 Groundwater
Orange County Water District South Basin



Engineering Analytics, Inc.

FIGURE 1-38: Hexavalent Chromium in Layer 3 Groundwater
Orange County Water District South Basin



Over 100x MCL
10 to 100x MCL
1 to 10x MCL
Non-detect greater than MCL
Detect less than MCL
Non-detect less than MCL

Well screened in respective layer, Pre 2018
Well screened in respective layer, Post 2017
Well screened in respective layer (and adjacent layer), Pre 2018
Well screened in respective layer (and adjacent layer), Post 2017
Grab Sample, Pre 2018
Grab Sample, Post 2017

Groundwater Transect
ISCO Transect
Groundwater/ISCO Transect
Study Area
Source Sites

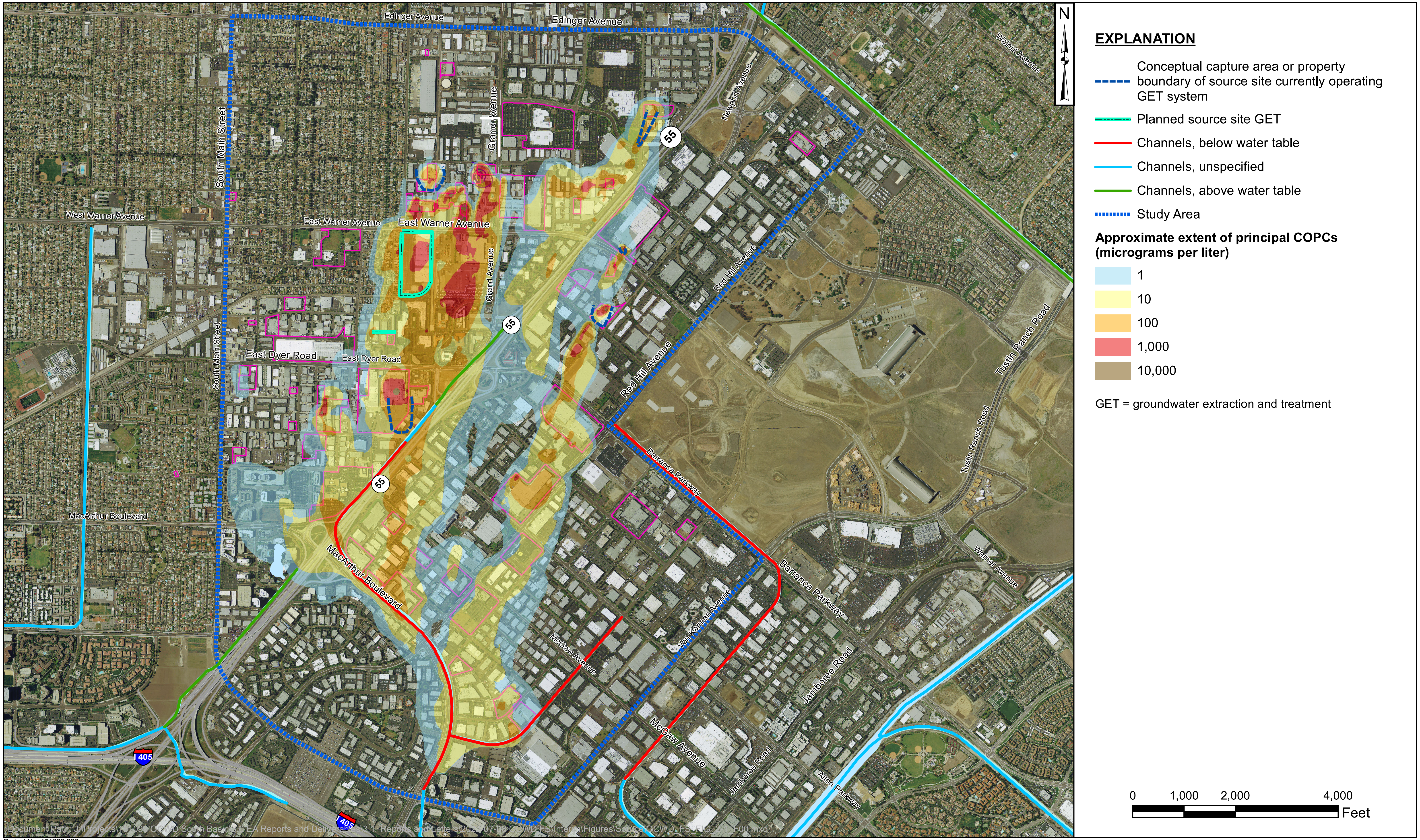
N

0 750 1,500 3,000
Feet

NOTES:
ISCO = in-Situ Chemical oxidation
MCL = Maximum Contaminant Level
ug/L = micrograms per liter
x = times

Engineering Analytics, Inc.

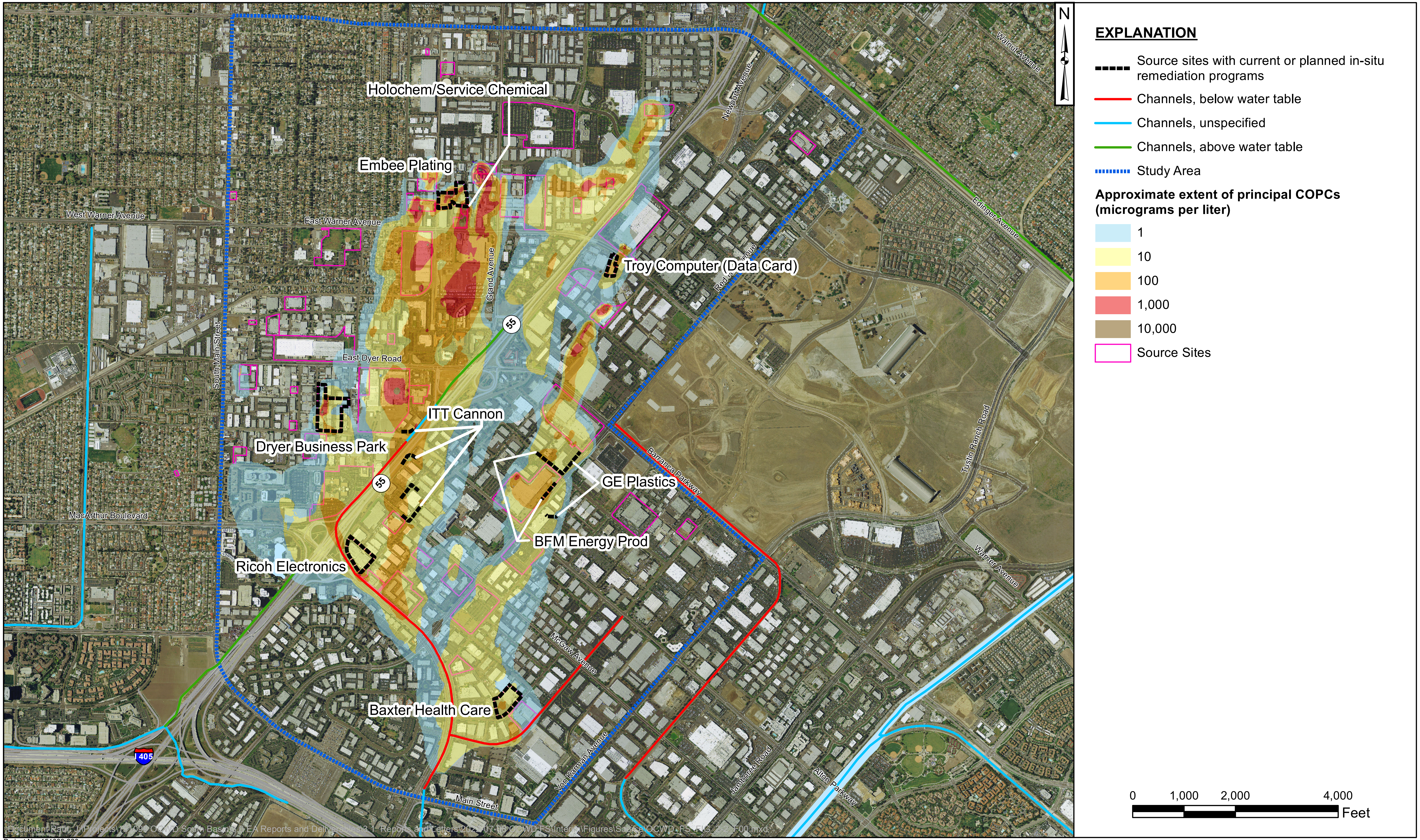
FIGURE 1-39: Hexavalent Chromium in Layer 4 Groundwater
Orange County Water District South Basin



Project No. 151099.220

Engineering Analytics, Inc.

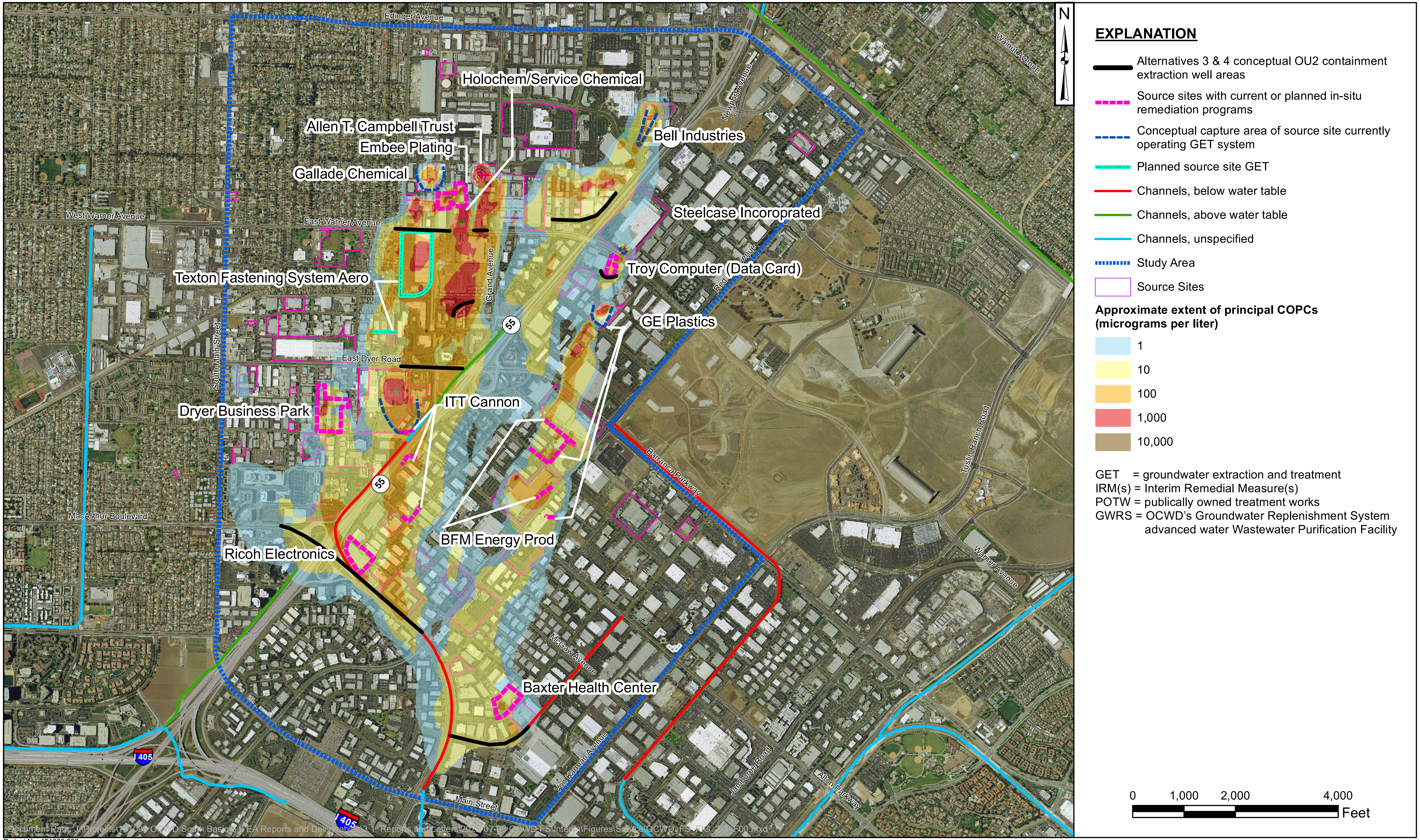
FIGURE 2-1
SOURCE SITES WITH CURRENTLY OPERATING OR PLANNED GROUNDWATER EXTRACTION AND TREATMENT (GET) SYSTEMS
ORANGE COUNTY WATER DISTRICT SOUTH BASIN



Project No. 151099.220

Engineering Analytics, Inc.

FIGURE 2-2
SOURCE SITES WITH CURRENT OR PLANNED IN-SITU REMEDIATION PROGRAMS
ORANGE COUNTY WATER DISTRICT SOUTH BASIN



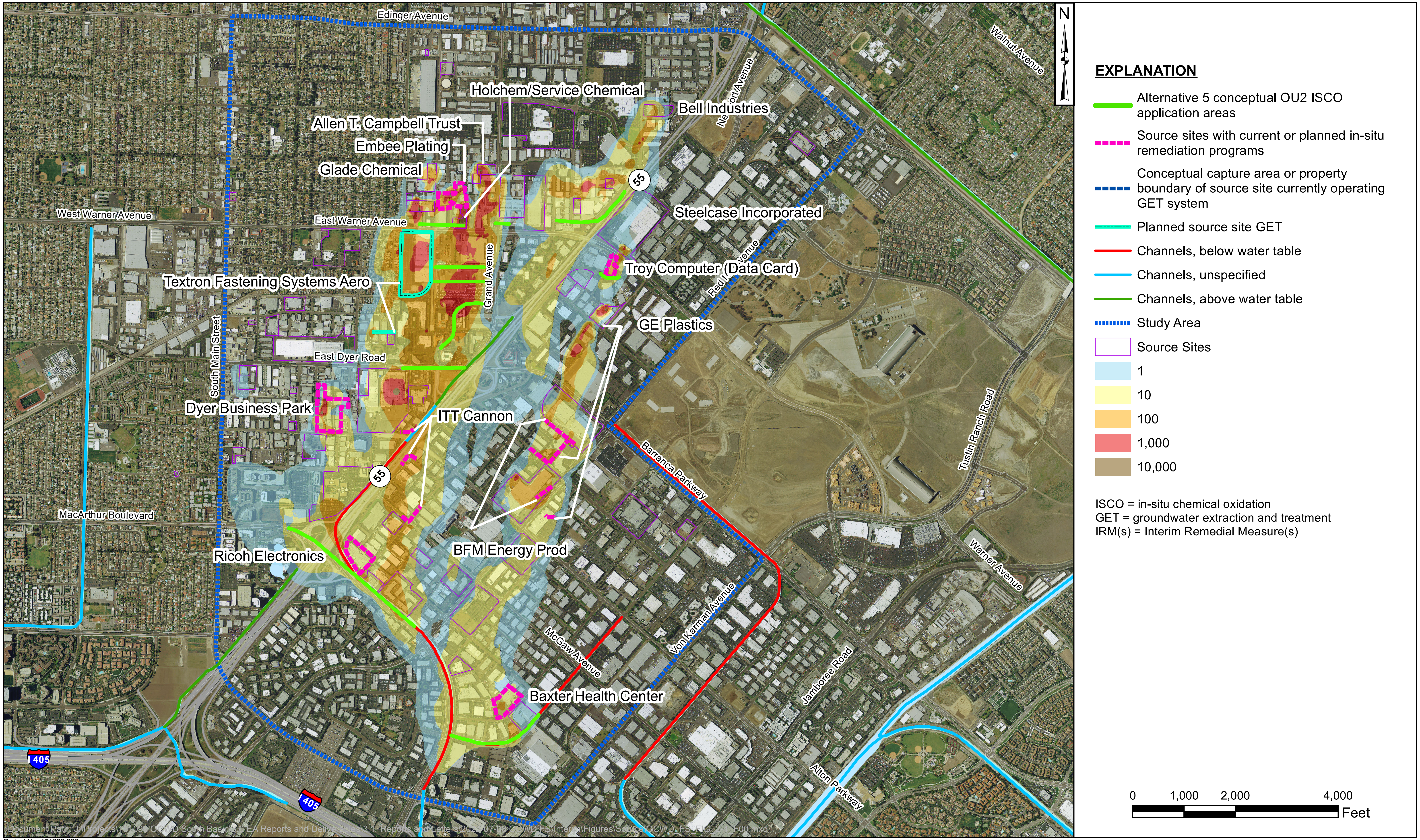
Project No. 151099.220

Engineering Analytics, Inc.

FIGURE 2-3

APPROXIMATE AREAS OF OU2 TARGETED FOR IRMs - ALTERNATIVES 3 AND 4: CONTAINMENT AND TREATMENT OF RELATIVELY HIGH CONCENTRATION AND LEADING-EDGE AREAS USING GROUNDWATER AND TREATMENT WITH DISCHARGE TO POTW/GWRS OR REINJECTION

ORANGE COUNTY WATER DISTRICT SOUTH BASIN



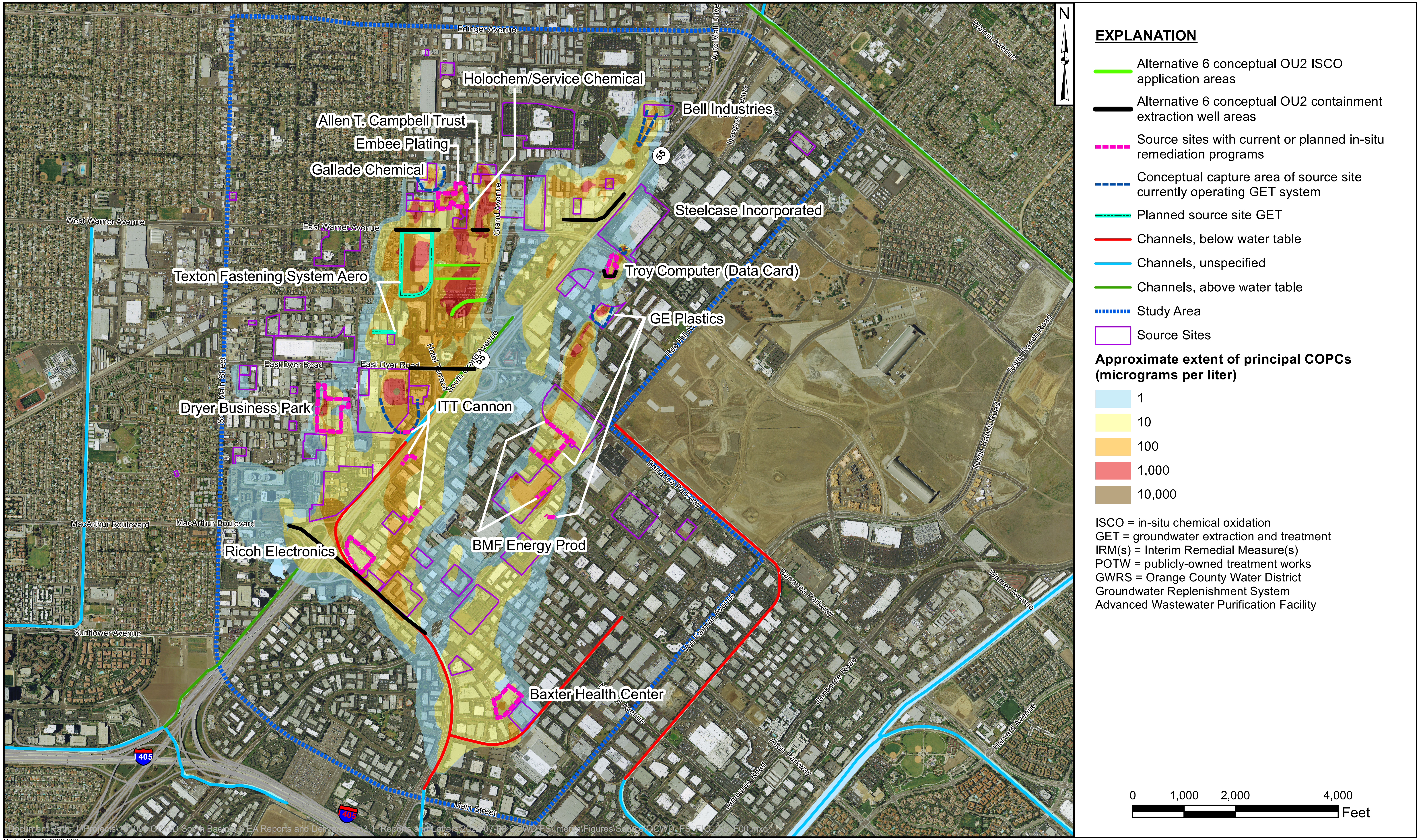
Project No. 151099.220

Engineering Analytics, Inc.

FIGURE 2-4

APPROXIMATE AREAS OF OU2 TARGETED FOR IRMs - ALTERNATIVE 5: IN-SITU TREATMENT OF RELATIVELY HIGH CONCENTRATION AND LEADING-EDGE AREAS USING CHEMICAL OXIDATION

ORANGE COUNTY WATER DISTRICT SOUTH BASIN



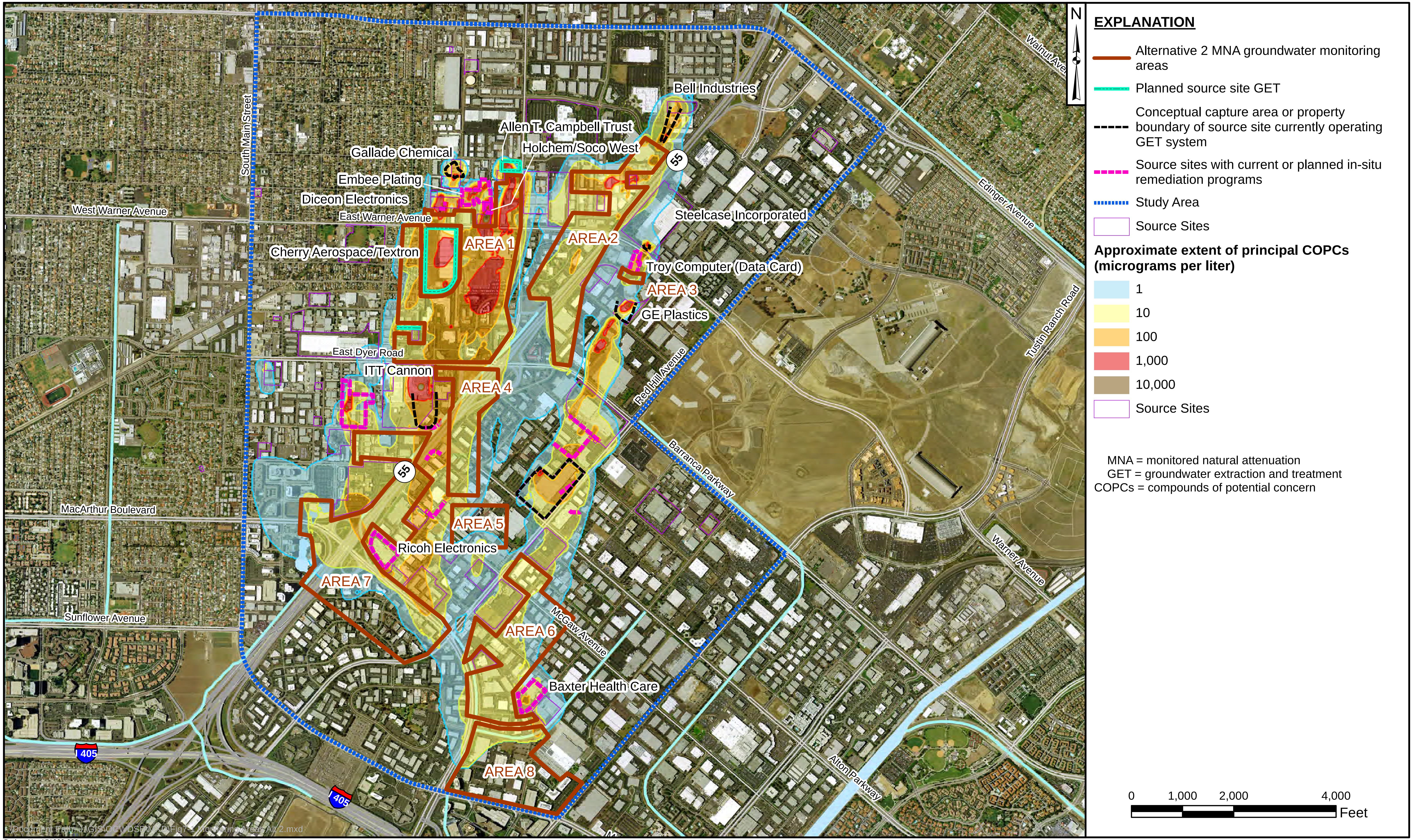
Project No. 151099.220

Engineering Analytics, Inc.

FIGURE 2-5

APPROXIMATE AREAS OF OU2 TARGETED FOR IRMS - ALTERNATIVE 6: IN-SITU TREATMENT OF RELATIVELY HIGH CONCENTRATION AND LEADING-EDGE AREAS USING CHEMICAL OXIDATION COMBINED WITH GROUNDWATER EXTRACTION AND TREATMENT WITH DISCHARGE TO POTW AND GRWS

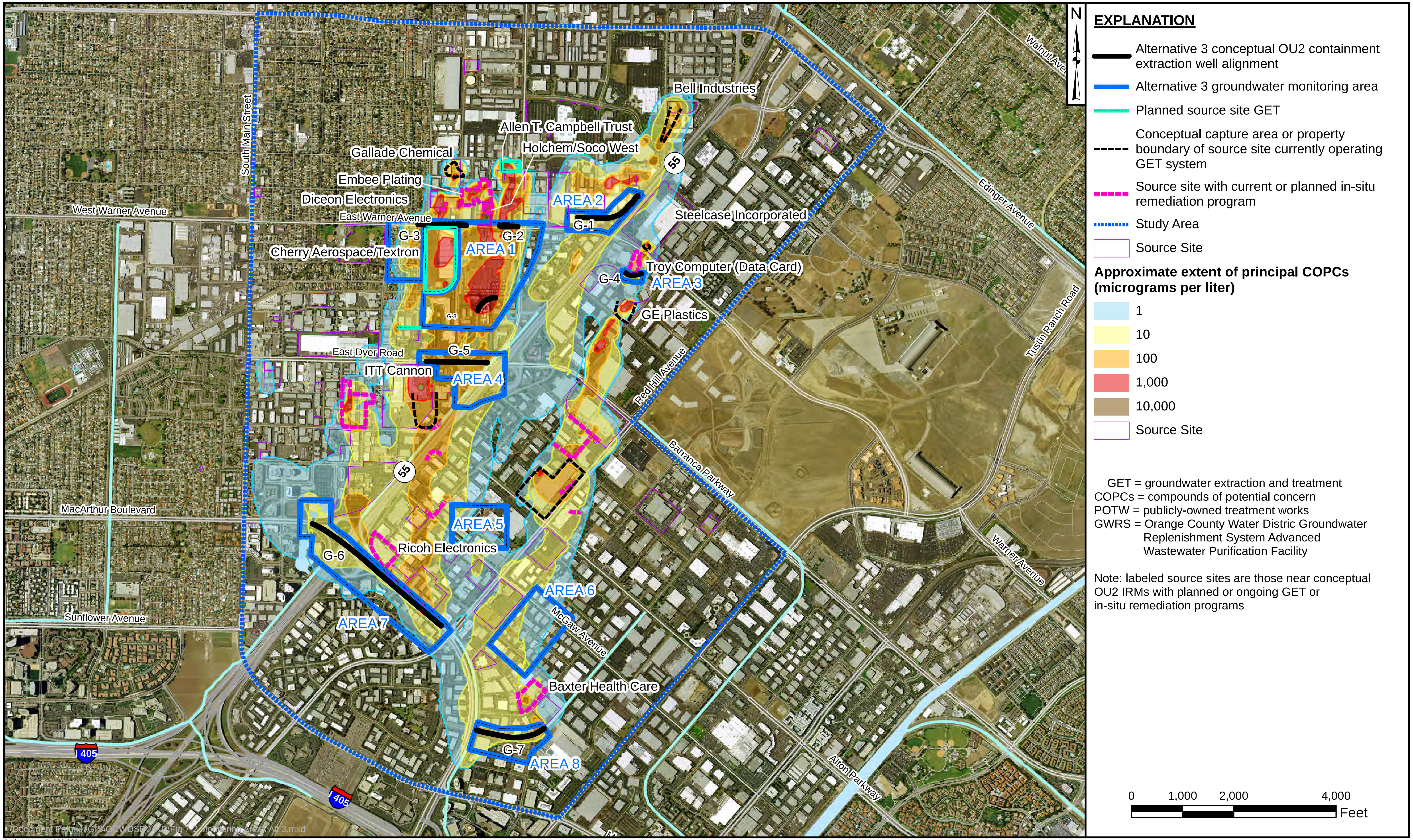
ORANGE COUNTY WATER DISTRICT SOUTH BASIN



Project No. 151099.220

Engineering Analytics, Inc.

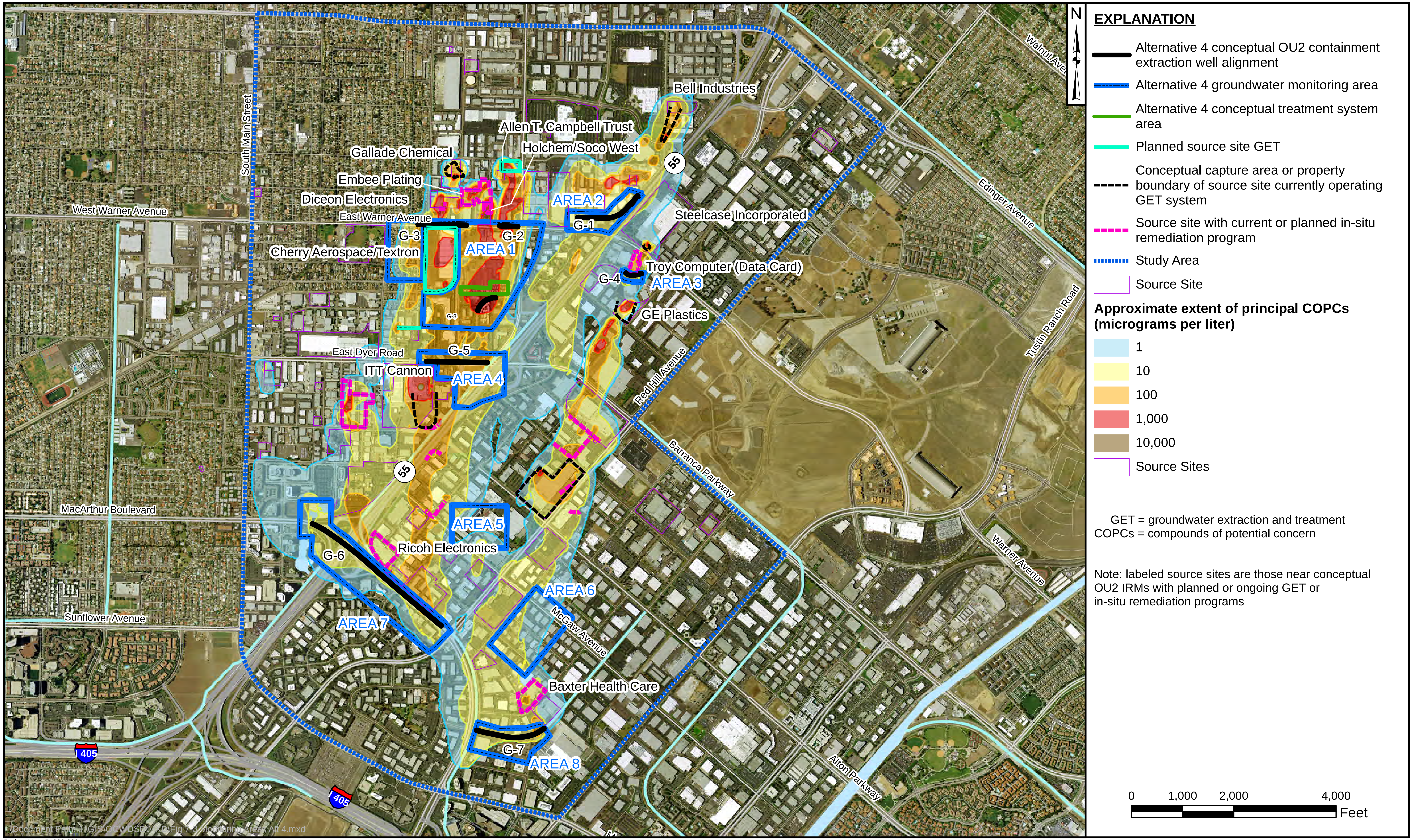
FIGURE 7-1
GROUNDWATER MONITORING AREAS: ALTERNATIVE 2 - MONITORED NATURAL ATTENUATION
ORANGE COUNTY WATER DISTRICT SOUTH BASIN



Project No. 151099.230

Engineering Analytics, Inc.

FIGURE 7-2
GROUNDWATER MONITORING AREAS - ALTERNATIVE 3: CONTAINMENT AND TREATMENT OF RELATIVELY HIGH CONCENTRATION AND LEADING-EDGE AREAS USING GROUNDWATER EXTRACTION AND TREATMENT WITH DISCHARGE TO POTW AND GWRS
ORANGE COUNTY WATER DISTRICT SOUTH BASIN



Project No. 151099.230

Engineering Analytics, Inc.

FIGURE 7-3
GROUNDWATER MONITORING AREAS - ALTERNATIVE 4: CONTAINMENT AND TREATMENT OF RELATIVELY HIGH CONCENTRATION AND LEADING-EDGE AREAS USING GROUNDWATER EXTRACTION AND TREATMENT WITH INJECTION TO BASAL SAND
ORANGE COUNTY WATER DISTRICT SOUTH BASIN

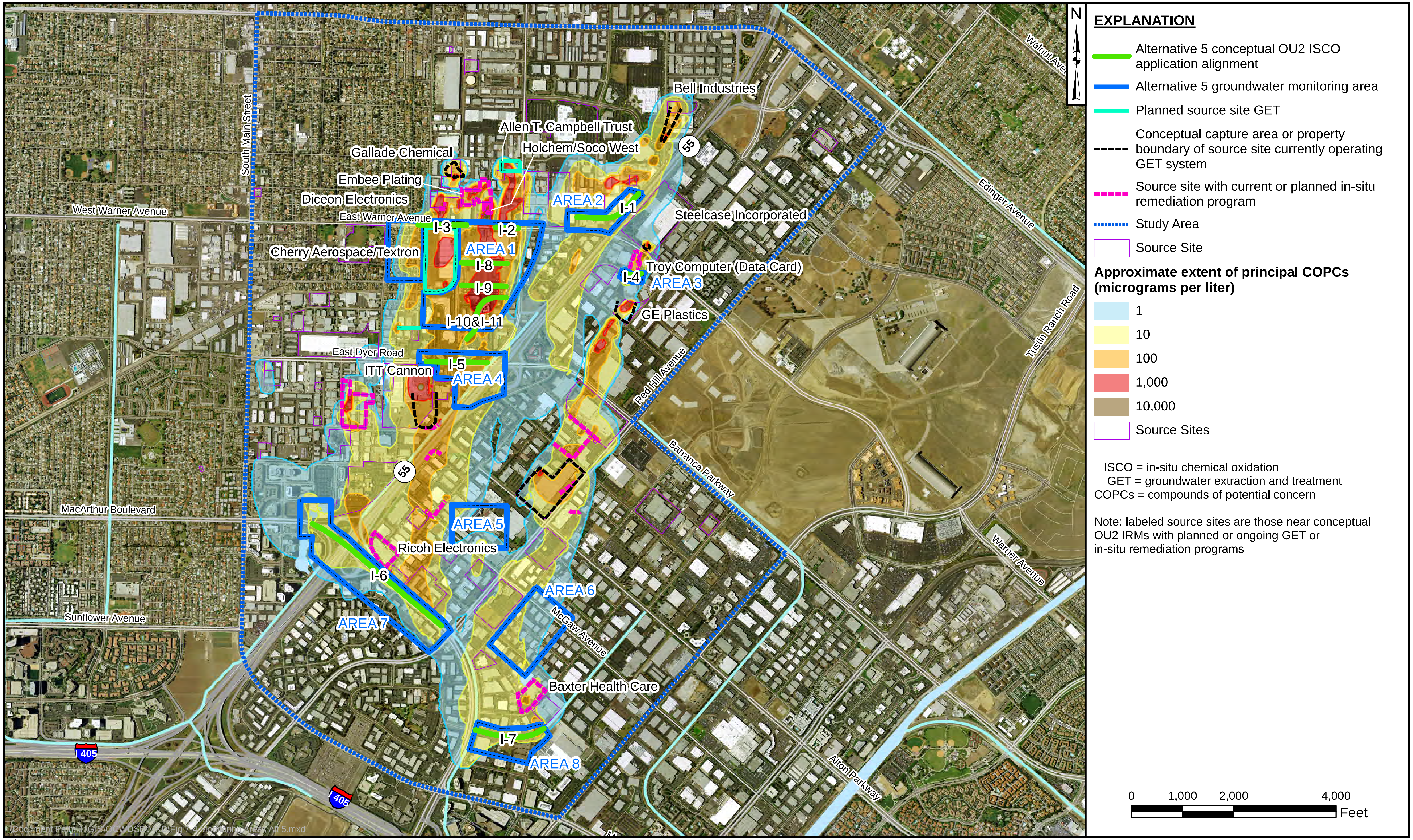


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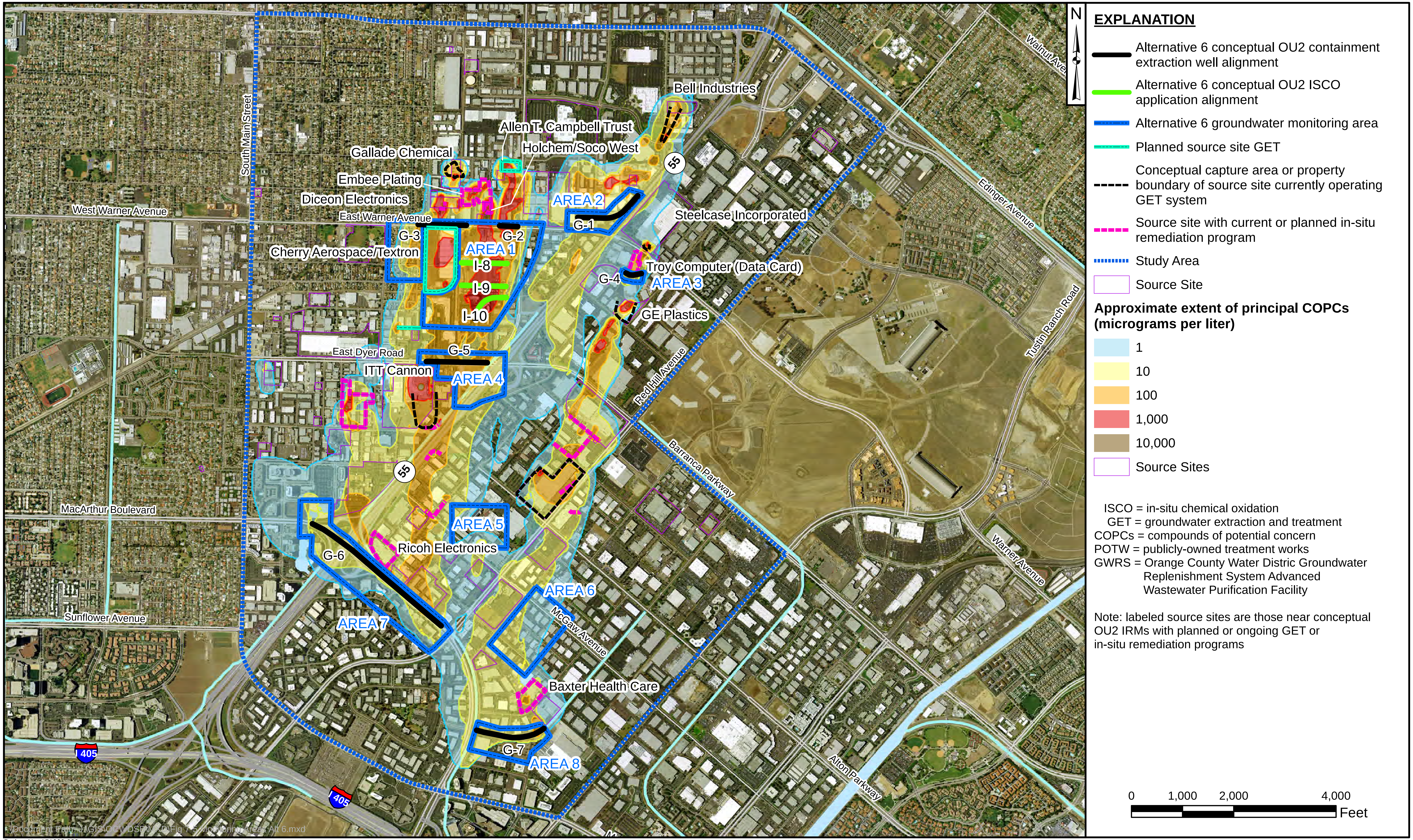
FIGURE 7-4
GROUNDWATER MONITORING AREAS - ALTERNATIVE 5: IN-SITU TREATMENT OF RELATIVELY HIGH CONCENTRATION AND LEADING-EDGE AREAS USING CHEMICAL OXIDATION
ORANGE COUNTY WATER DISTRICT SOUTH BASIN



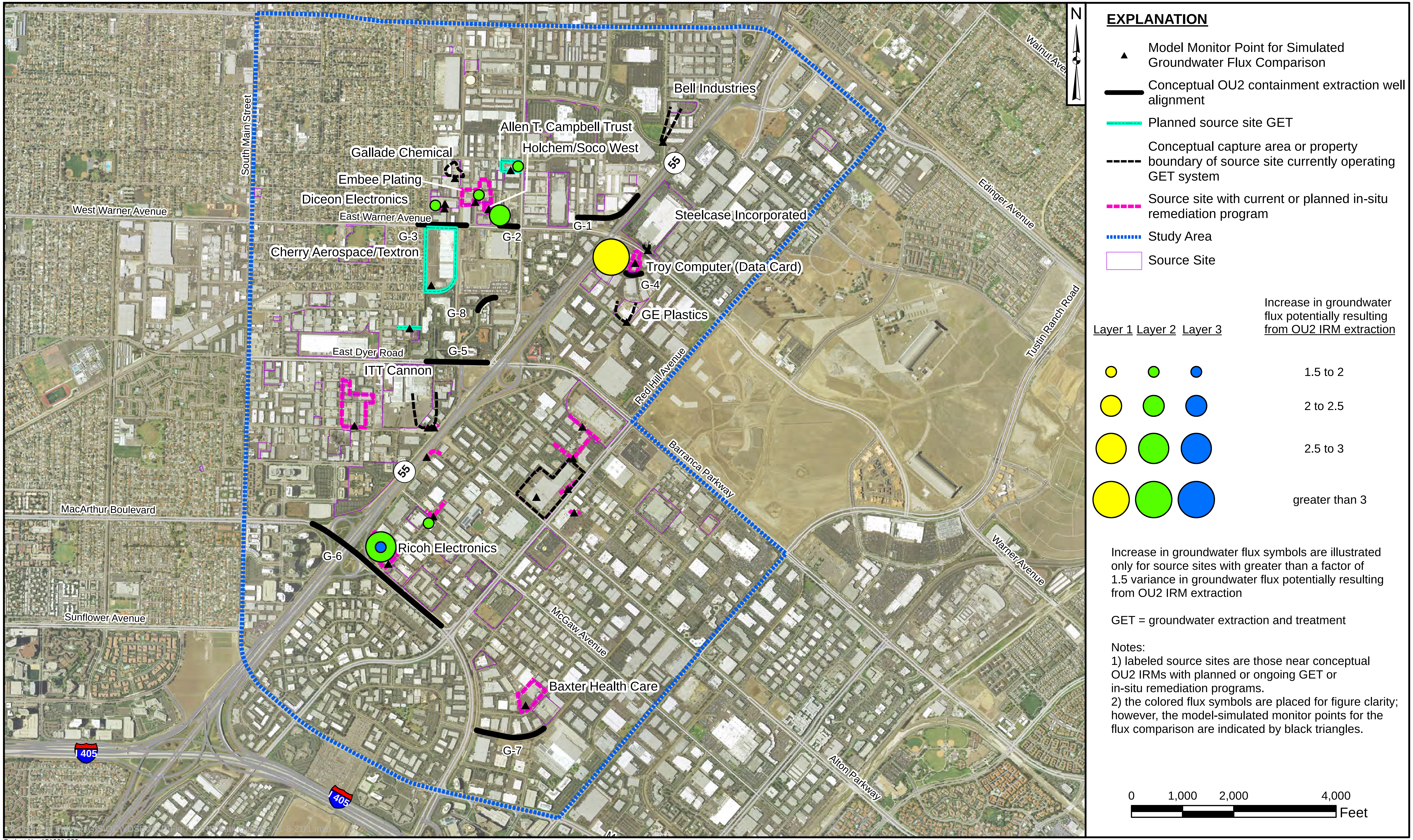
Project No. 151099.220

Engineering Analytics, Inc.

FIGURE 7-5

GROUNDWATER MONITORING AREAS - ALTERNATIVE 6: CONTAINMENT AND IN-SITU TREATMENT OF RELATIVELY HIGH CONCENTRATION AND LEADING-EDGE AREAS USING CHEMICAL OXIDATION COMBINED WITH GROUNDWATER EXTRACTION AND TREATMENT WITH DISCHARGE TO POTW AND GWRS

ORANGE COUNTY WATER DISTRICT SOUTH BASIN



Project No. 151099.230

Engineering Analytics, Inc.

FIGURE 7-6
MODEL SIMULATED CHANGES IN GROUNDWATER FLUX VALUES RESULTING FROM OU2 IRM EXTRACTION
ORANGE COUNTY WATER DISTRICT SOUTH BASIN

EXPLANATION

- IRM GET Alignment G-3 Model Simulated Groundwater Particle Track
- IRM GET Alignment G-2 Model Simulated Groundwater Particle Track
- Conceptual OU2 Containment Extraction Well Alignment
- Source Sites
- Allen T. Campbell Trust

IRM = OU2 Interim Remedial Measures
GET = Groundwater Extraction and Treatment

NOTE: Groundwater elevation contours from Bowyer Environmental Consulting, 2021. 2021 First Half Groundwater Monitoring and Remedial Progress Report, May 4, 2021.

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Engineering Analytics, Inc.

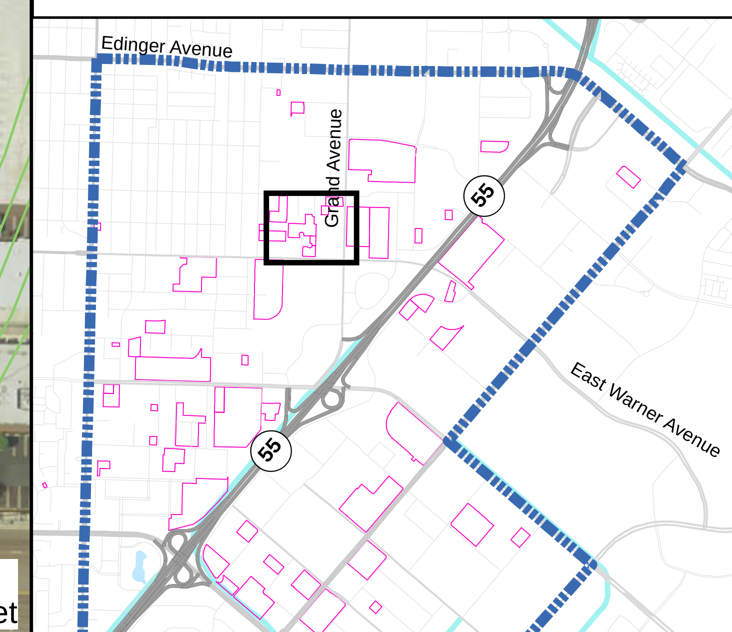
FIGURE 7-7A
COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED A-ZONE GROUNDWATER ELEVATION CONTOURS, ALLAN T. CAMPBELL TRUST SOURCE SITE
ORANGE COUNTY WATER DISTRICT SOUTH BASIN

EXPLANATION

- IRM GET Alignment G-3 Model Simulated Groundwater Particle Track
- IRM GET Alignment G-2 Model Simulated Groundwater Particle Track
- Conceptual OU2 Containment Extraction Well Alignment
- Source Sites
- Allen T. Campbell Trust

IRM = OU2 Interim Remedial Measures
GET = Groundwater Extraction and Treatment

NOTE: Groundwater elevation contours from Bowyer Environmental Consulting, 2021. 2021 First Half Groundwater Monitoring and Remedial Progress Report, May 4, 2021.



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Engineering Analytics, Inc.

FIGURE 7-7B

COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED B1(50)-ZONE GROUNDWATER ELEVATION CONTOURS, ALLAN T. CAMPBELL TRUST SOURCE SITE

ORANGE COUNTY WATER DISTRICT SOUTH BASIN

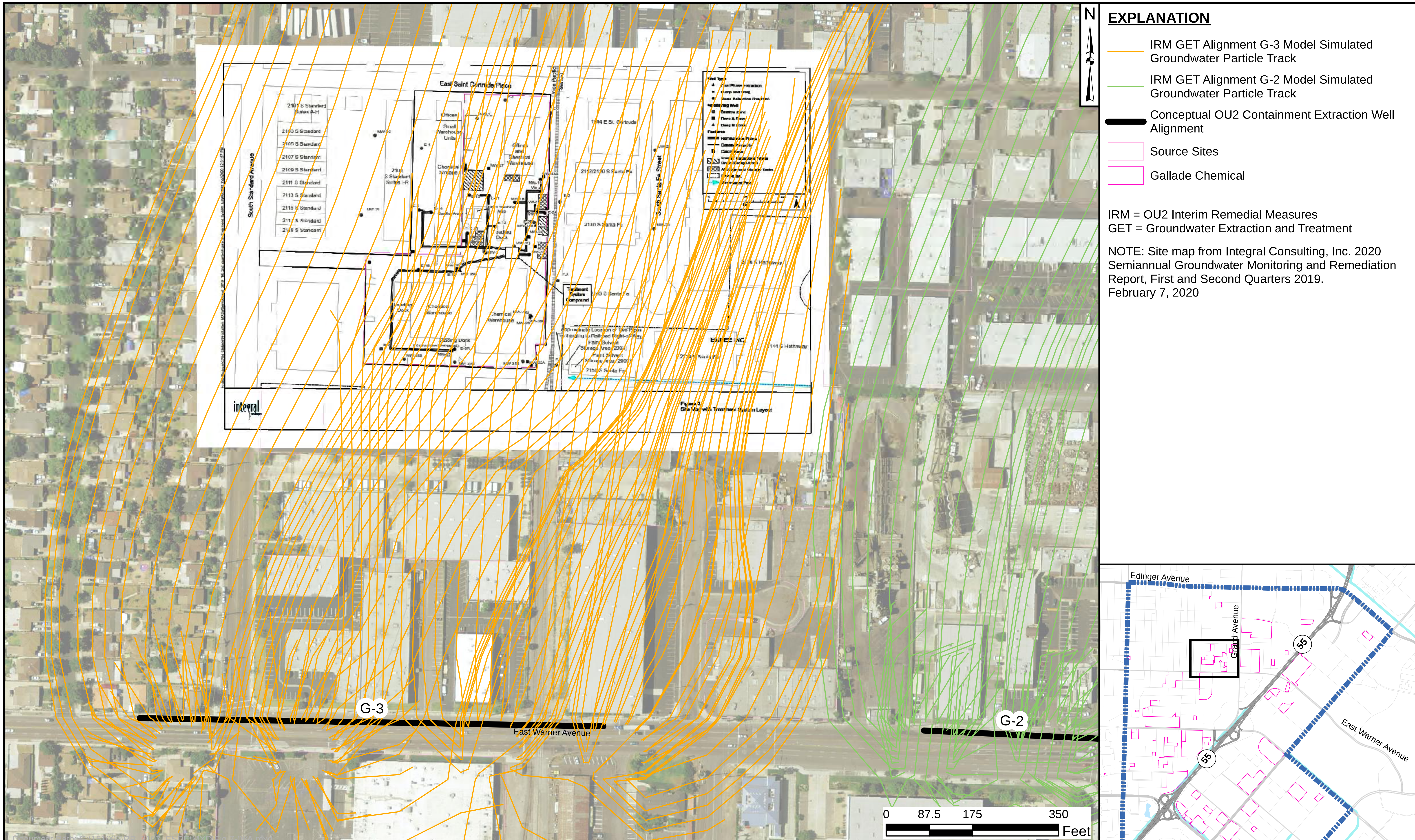
Project No. 151099.220

Engineering Analytics, Inc.

FIGURE 7-7C

COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED B1(60)-ZONE GROUNDWATER ELEVATION CONTOURS, ALLAN T. CAMPBELL TRUST SOURCE SITE

ORANGE COUNTY WATER DISTRICT SOUTH BASIN



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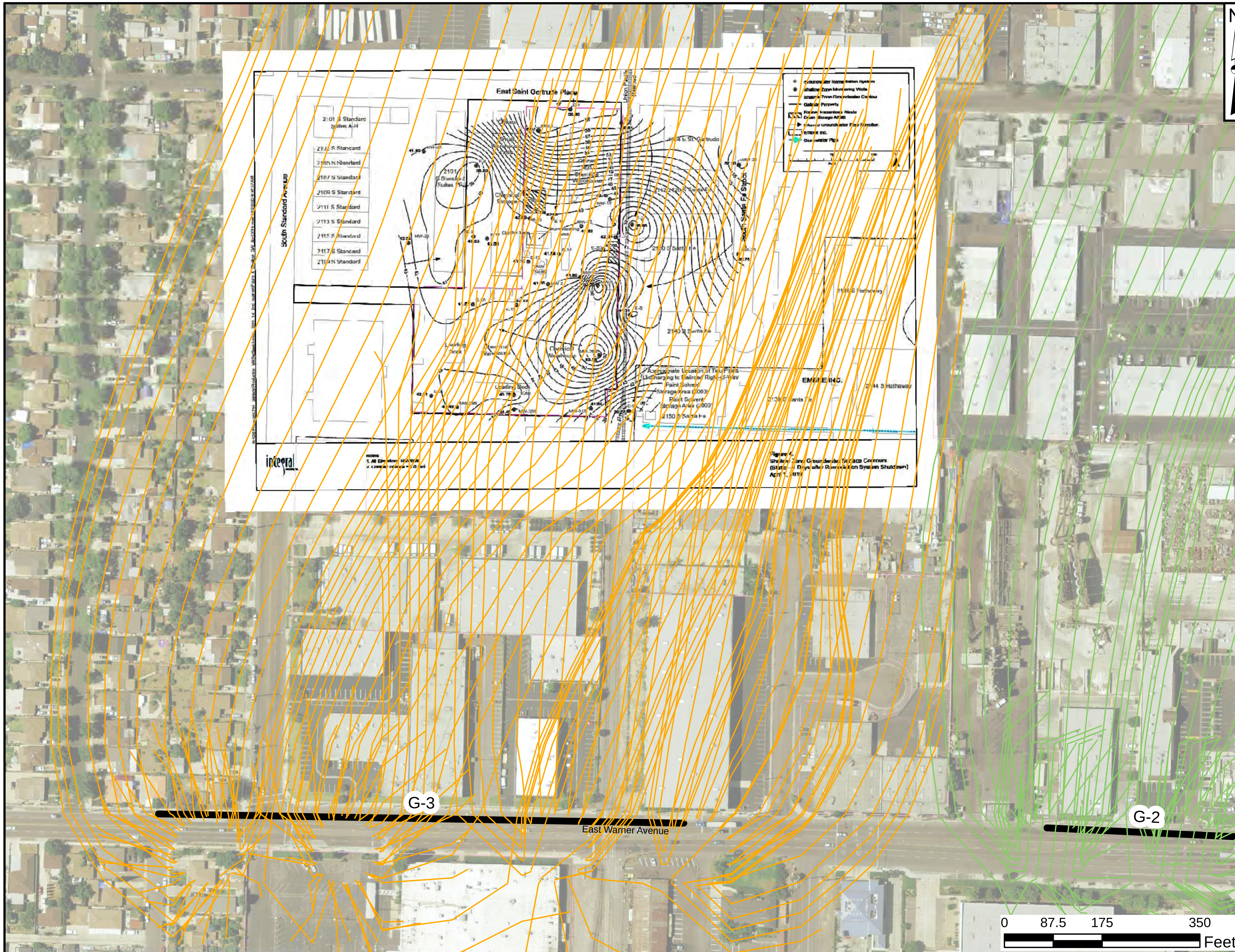
Engineering Analytics, Inc.

FIGURE 7-8A

GALLADE CHEMICAL SITE MAP WITH MODEL SIMULATED GROUNDWATER PARTICLE TRACKS

ORANGE COUNTY WATER DISTRICT SOUTH BASIN



EXPLANATION

IRM GET Alignment G-3 Model Simulated Groundwater Particle Track

IRM GET Alignment G-2 Model Simulated Groundwater Particle Track

Conceptual OU2 Containment Extraction Well Alignment

Source Sites

Gallade Chemical

IRM = OU2 Interim Remedial Measures
GET = Groundwater Extraction and Treatment

NOTE: Site map from Integral Consulting, Inc. 2020 Semiannual Groundwater Monitoring and Remediation Report, First and Second Quarters 2019. February 7, 2020

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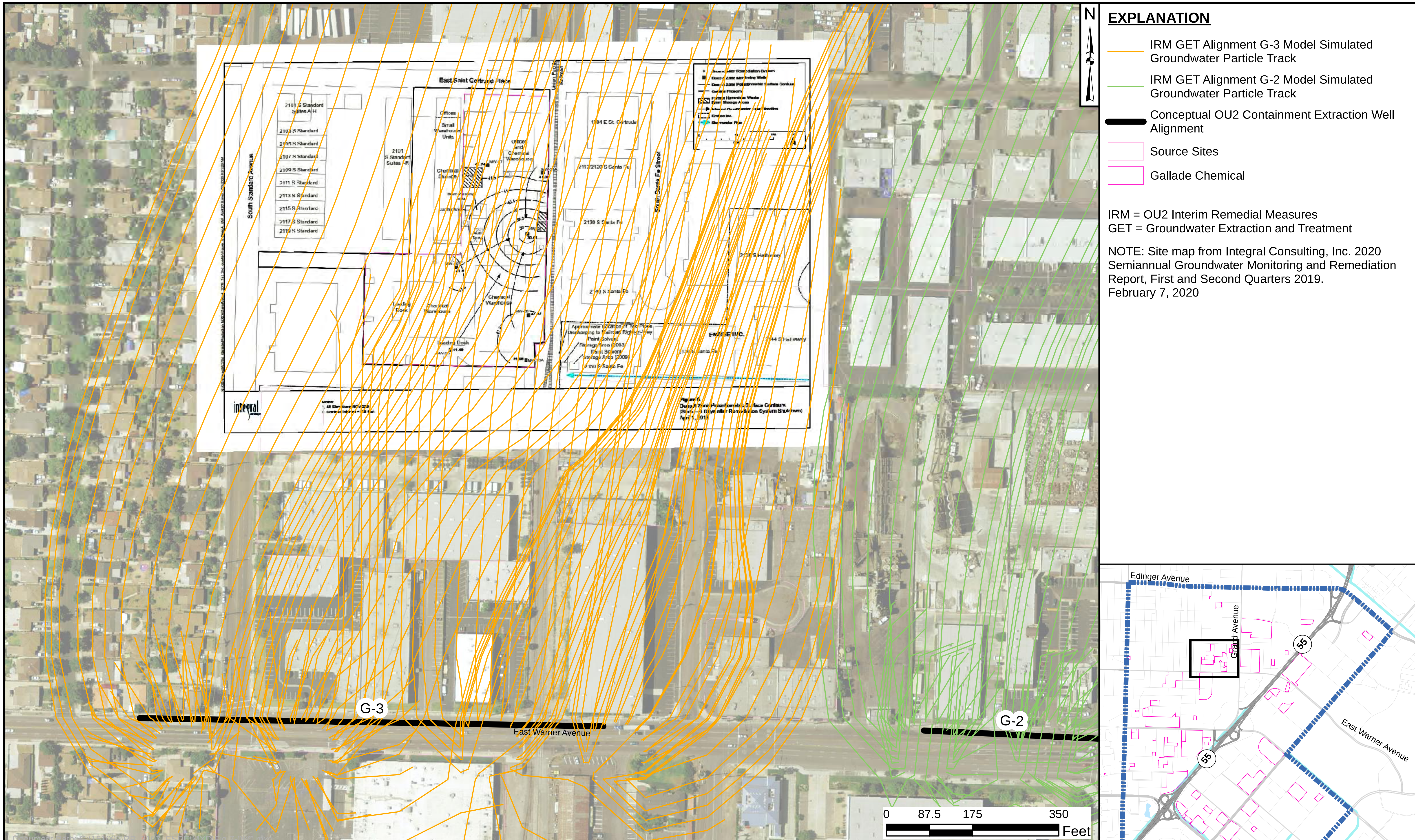
FIGURE 7-8B
COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED SHALLOW ZONE GROUNDWATER ELEVATION CONTOURS, GALLADE CHEMICAL
ORANGE COUNTY WATER DISTRICT SOUTH BASIN



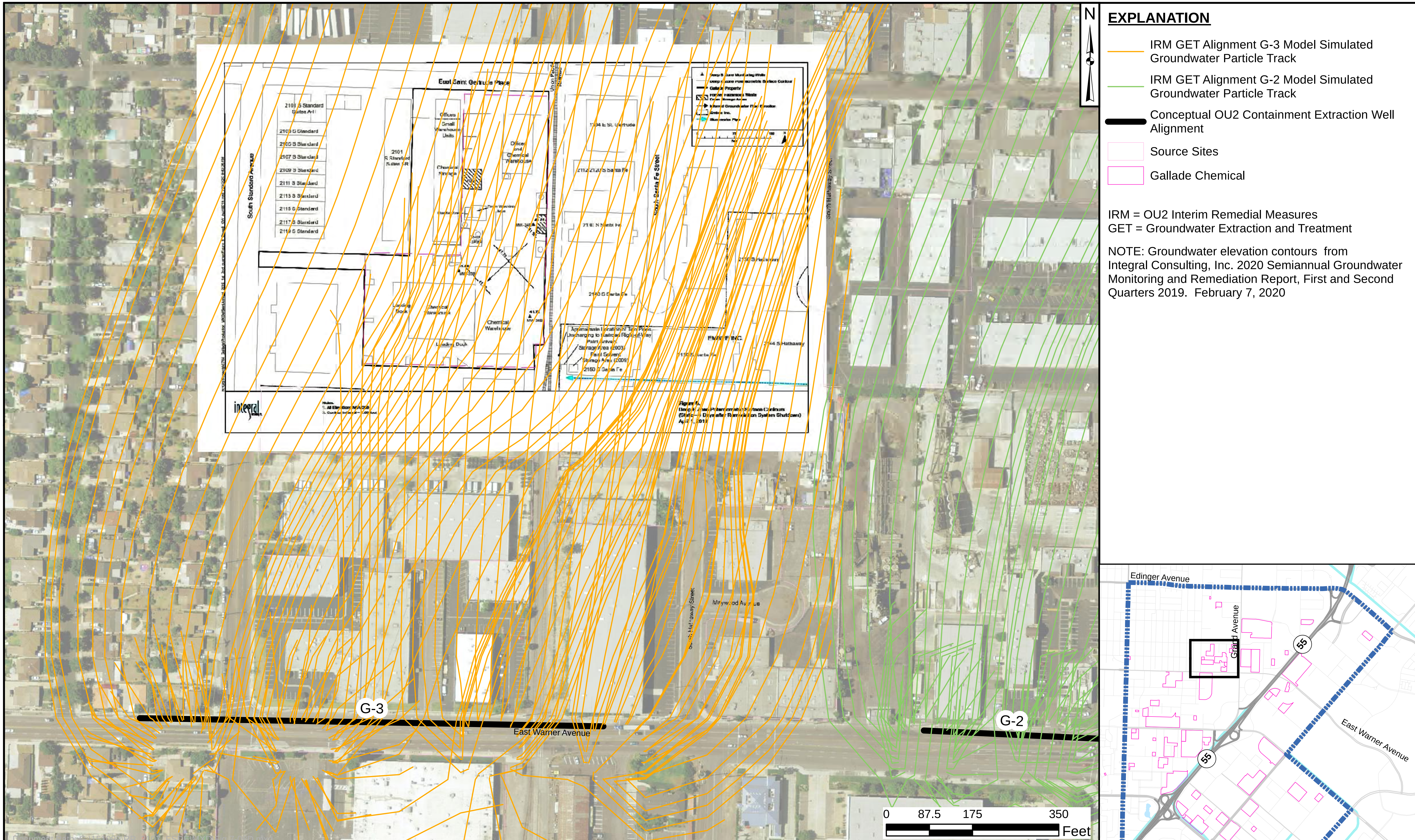
Project No. 151099.220

Engineering Analytics, Inc.

FIGURE 7-8C

COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED DEEP A ZONE GROUNDWATER ELEVATION CONTOURS, GALLADE CHEMICAL

ORANGE COUNTY WATER DISTRICT SOUTH BASIN



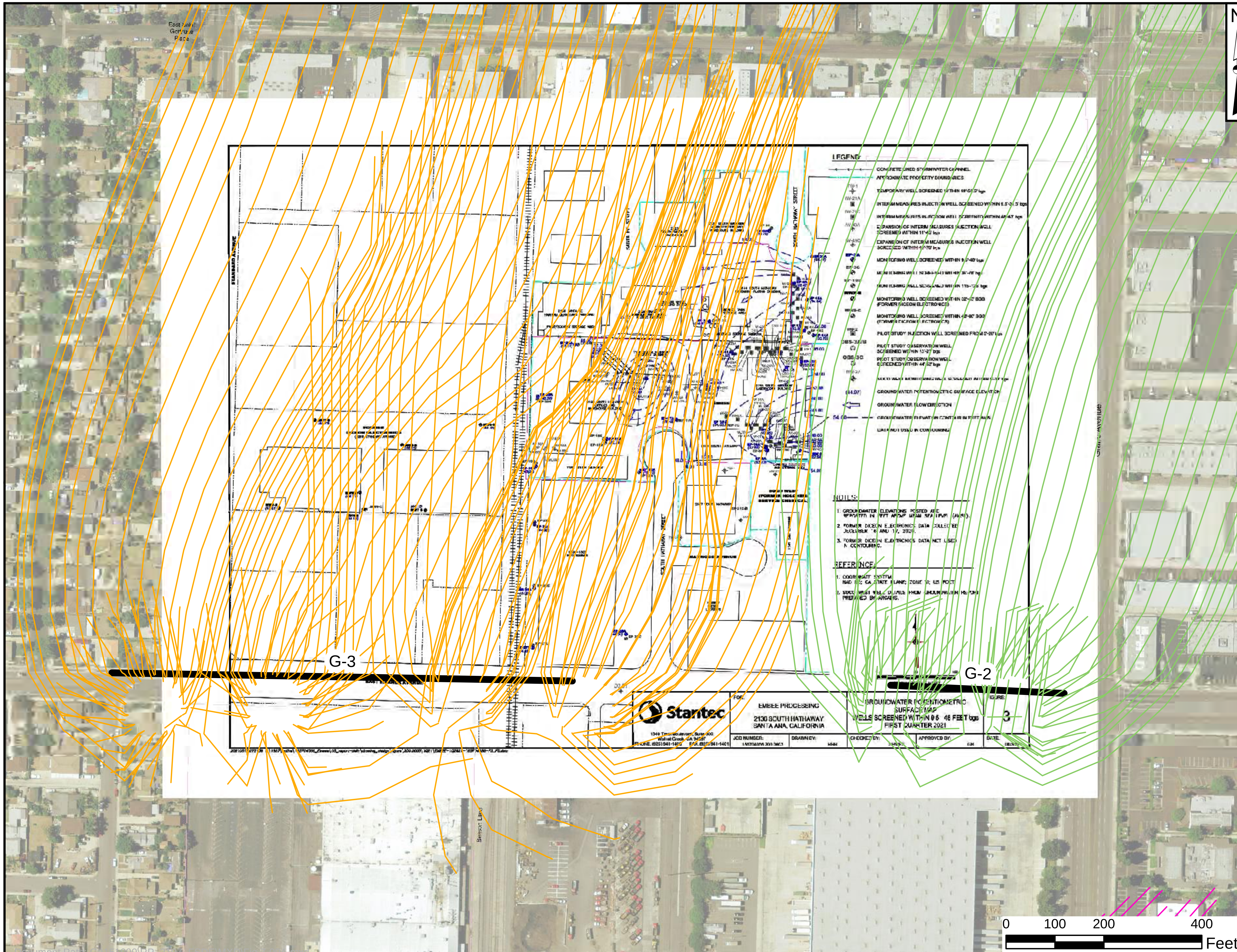
Project No. 151099.220

Engineering Analytics, Inc.

FIGURE 7-8D

COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED DEEP B ZONE GROUNDWATER ELEVATION CONTOURS, GALLADE CHEMICAL

ORANGE COUNTY WATER DISTRICT SOUTH BASIN



EXPLANATION

- IRM GET Alignment G-8 Model Simulated Groundwater Particle Track
- IRM GET Alignment G-3 Model Simulated Groundwater Particle Track
- IRM GET Alignment G-2 Model Simulated Groundwater Particle Track
- Conceptual OU2 Containment Extraction Well Alignment
- Source Sites
- Embee Plating

IRM = OU2 Interim Remedial Measures
GET = Groundwater Extraction and Treatment

NOTE: Groundwater elevation contours from Stantec, 2021. First Quarter 2021 Status Report Embee Processing, May 14, 2021.

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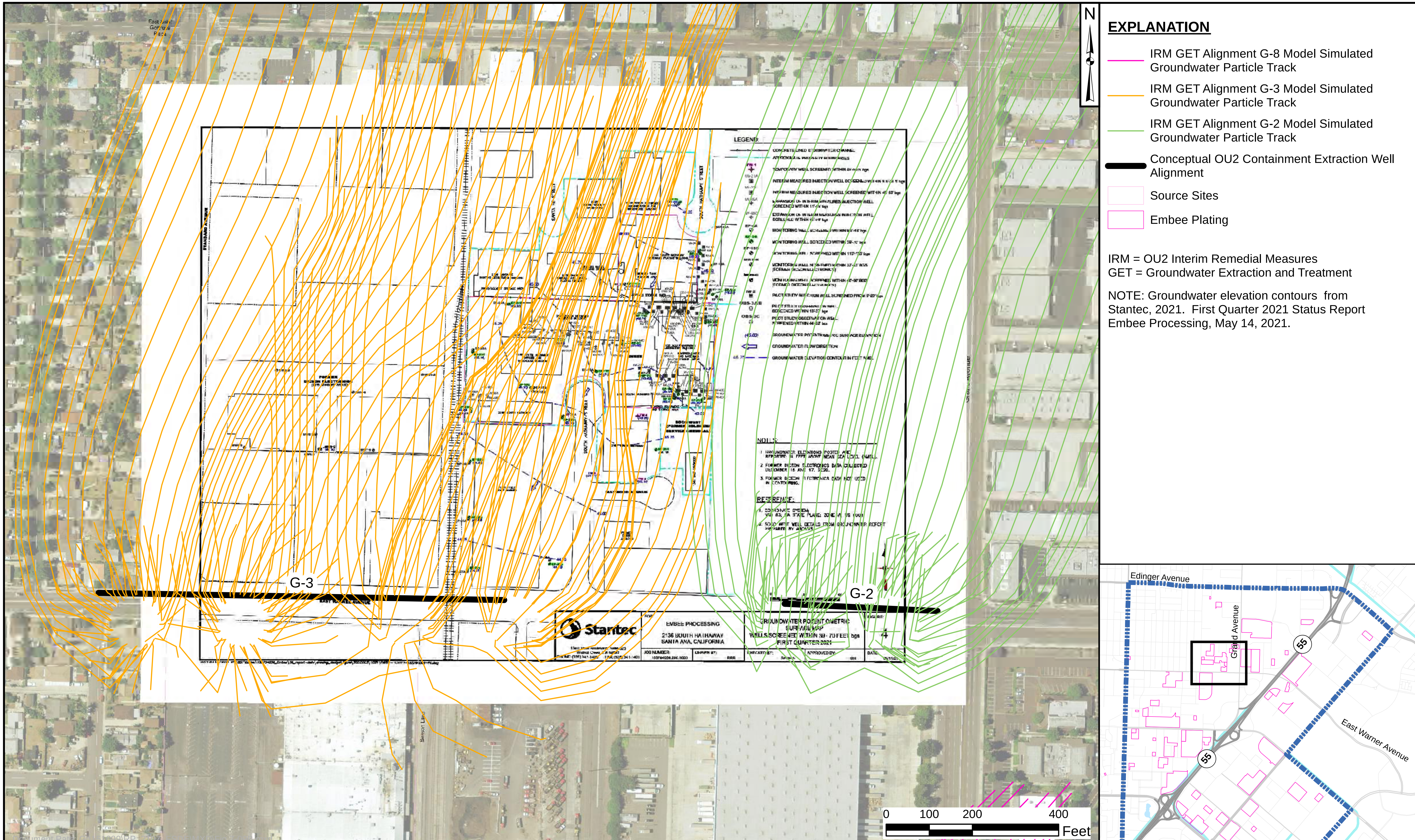
FIGURE 7-9A
COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED A-ZONE GROUNDWATER ELEVATION CONTOURS, EMBEE PLATING
ORANGE COUNTY WATER DISTRICT SOUTH BASIN



Project No. 151099.220

Engineering Analytics, Inc.

FIGURE 7-9B
COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED C-ZONE GROUNDWATER ELEVATION CONTOURS, EMBEE PLATING
ORANGE COUNTY WATER DISTRICT SOUTH BASIN

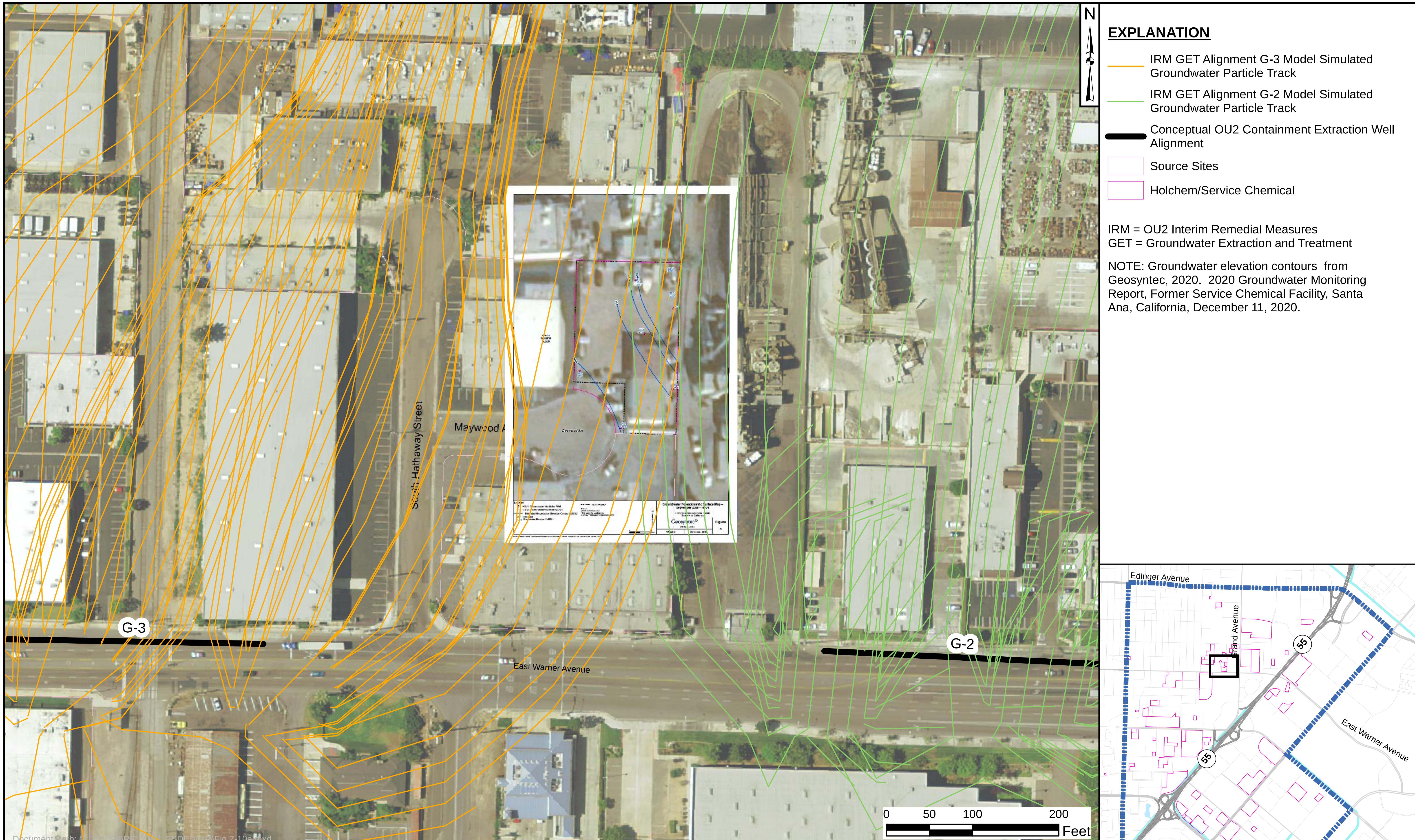


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FIGURE 7-10A

COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED HSU 1 GROUNDWATER ELEVATION CONTOURS, SOCO WEST, INC., FORMER SERVICES CHEMICAL

ORANGE COUNTY WATER DISTRICT SOUTH BASIN

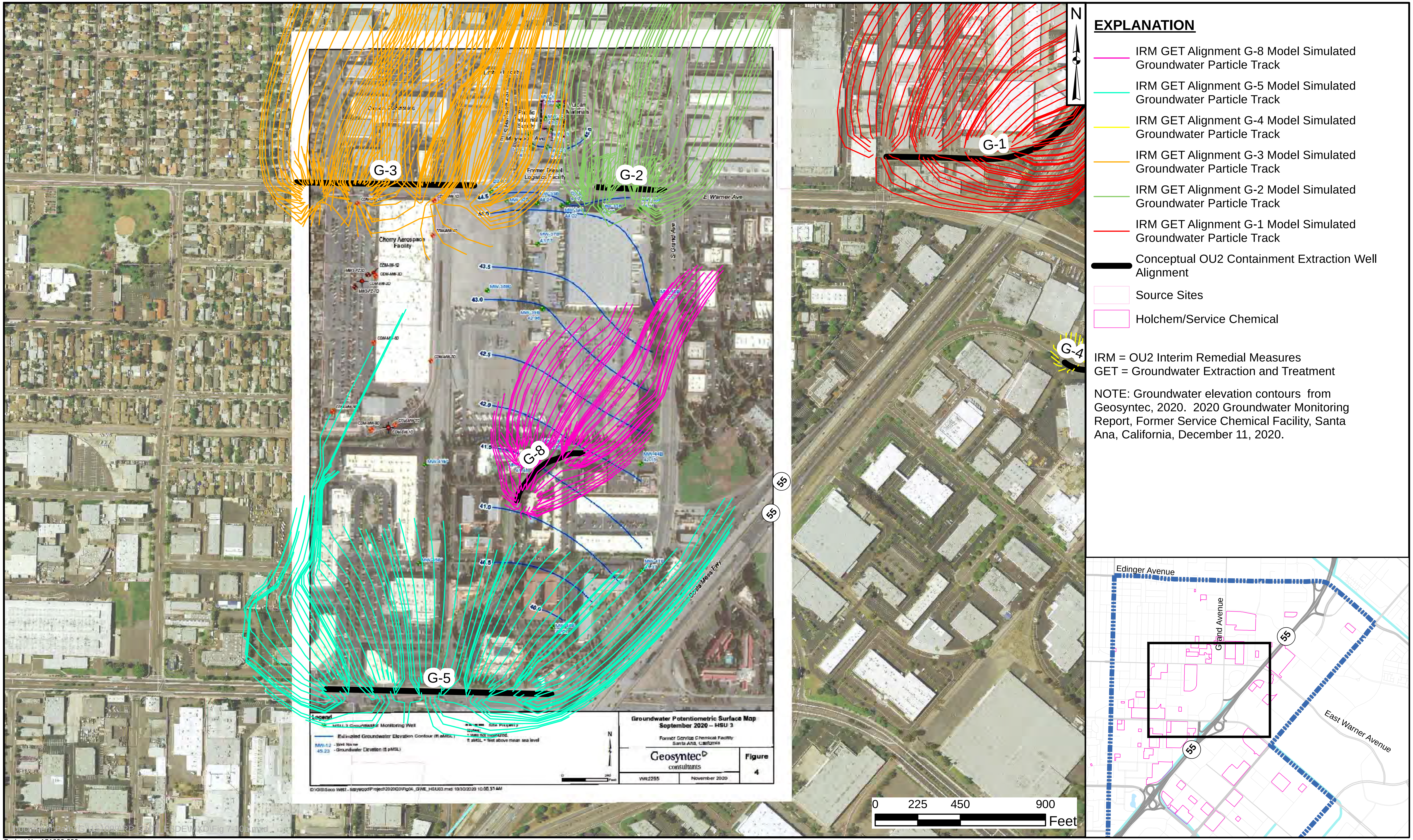

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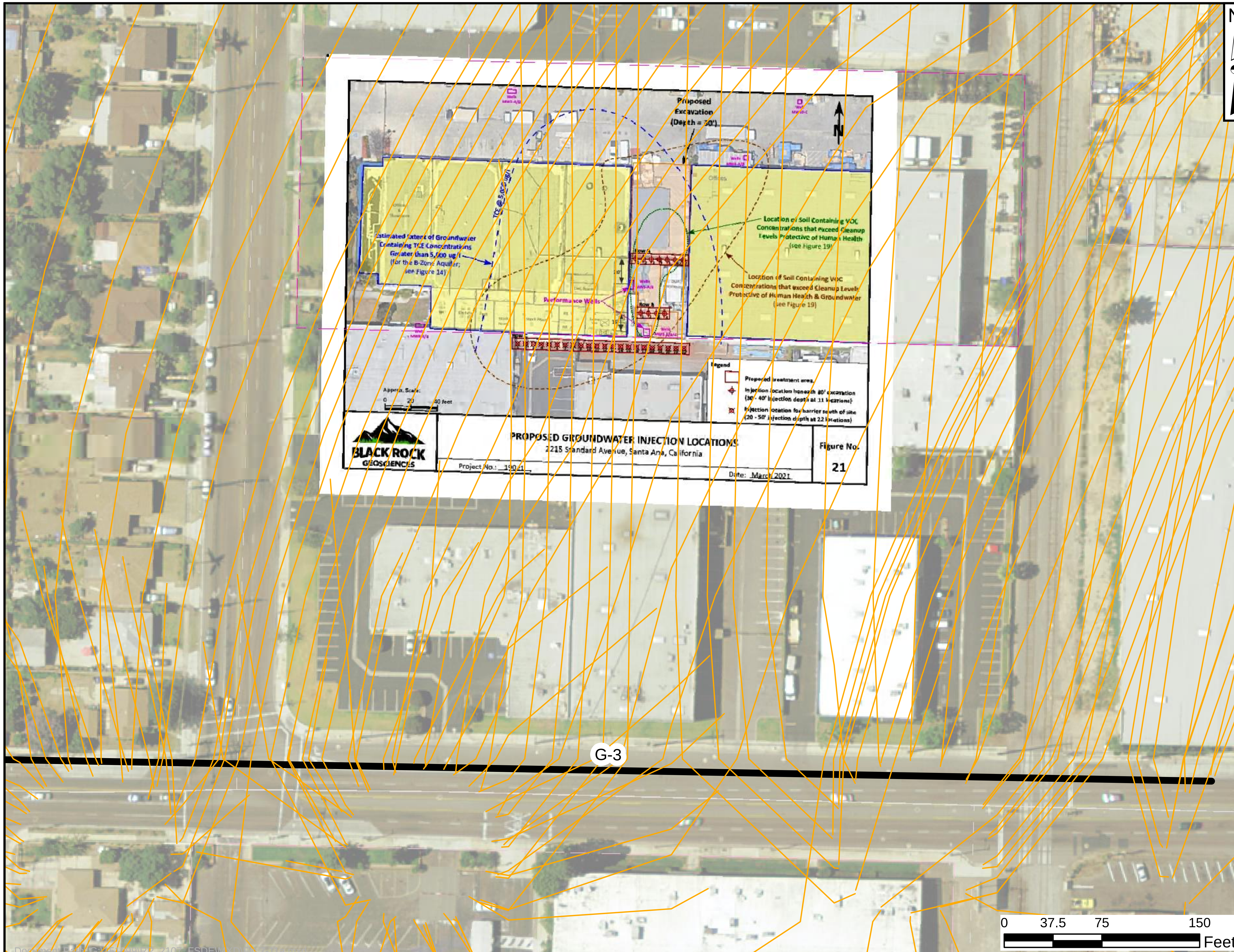
FIGURE 7-10B

COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED HSU 3 GROUNDWATER ELEVATION CONTOURS, SOCO WEST, INC., FORMER SERVICES CHEMICAL ORANGE COUNTY WATER DISTRICT SOUTH BASIN



EXPLANATION

IRM GET Alignment G-3 Model Simulated Groundwater Particle Track

Conceptual OU2 Containment Extraction Well Alignment

Source Sites

Diceon Electronics

IRM = OU2 Interim Remedial Measures
GET = Groundwater Extraction and Treatment

NOTE: Proposed Groundwater Injection Locations from: Black Rock Geosciences, 2021. First Quarter 2021 Groundwater Monitoring Report - Former Diceon Electronics Facility, 2215 South Standard Avenue, Santa Ana, California, April 9, 2021.

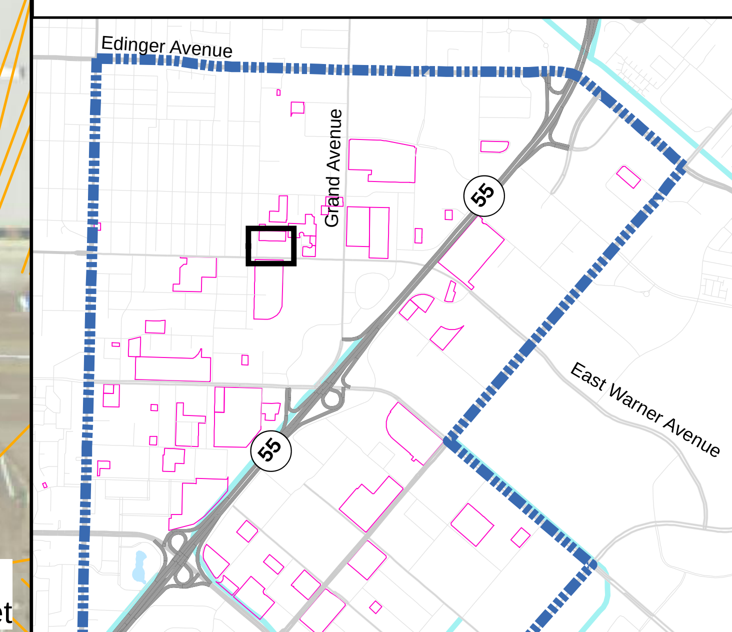


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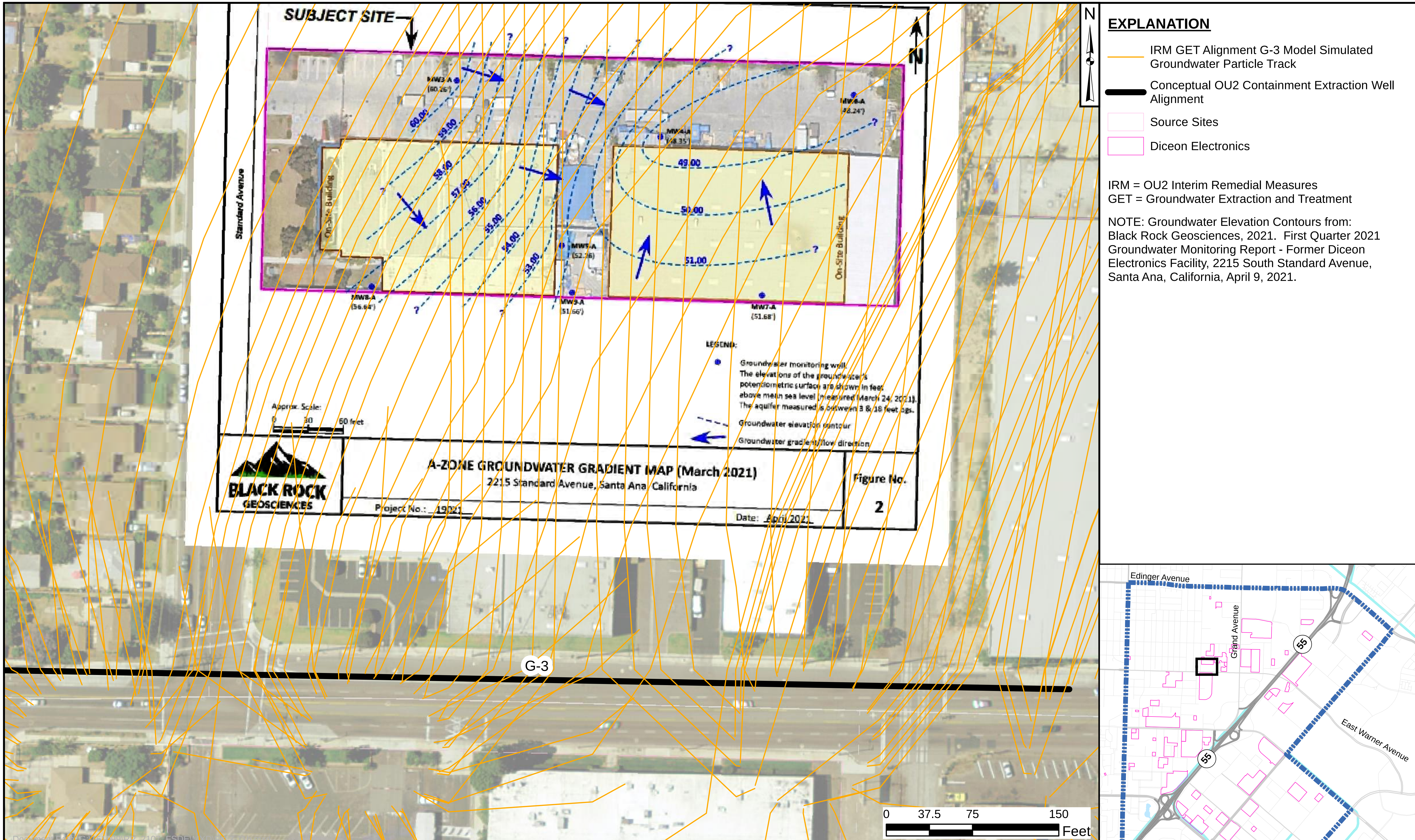
FIGURE 7-11A
FORMER DICEON ELECTRONICS PROPOSED GROUNDWATER INJECTION LOCATIONS AND MODEL SIMULATED GROUNDWATER PARTICLE TRACKS
ORANGE COUNTY WATER DISTRICT SOUTH BASIN



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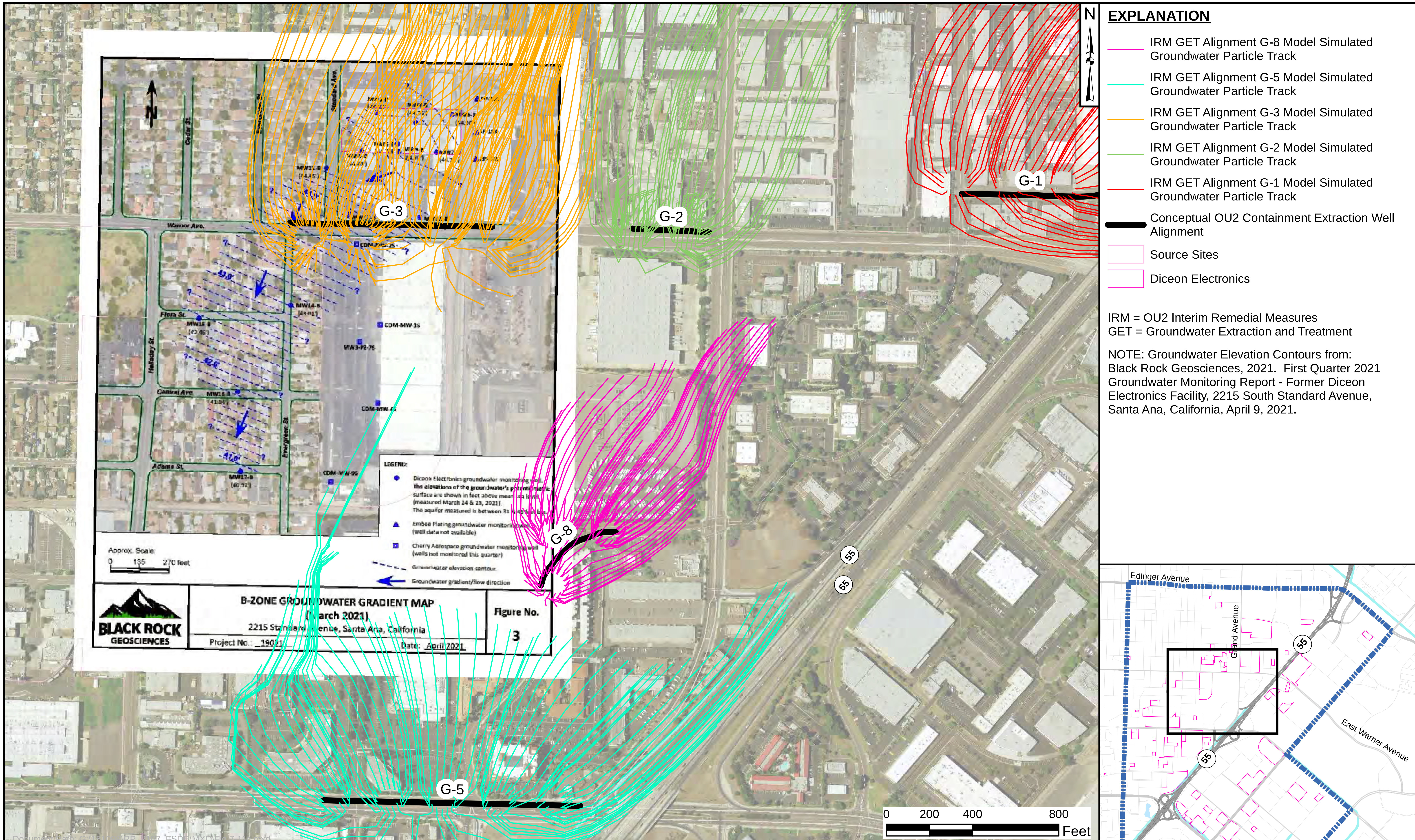
Engineering Analytics, Inc.

FIGURE 7-11B
COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED A-ZONE GROUNDWATER ELEVATION CONTOURS, FORMER DICEON ELECTRONICS FACILITY
ORANGE COUNTY WATER DISTRICT SOUTH BASIN



EXPLANATION

- IRM GET Alignment G-8 Model Simulated Groundwater Particle Track
- IRM GET Alignment G-5 Model Simulated Groundwater Particle Track
- IRM GET Alignment G-3 Model Simulated Groundwater Particle Track
- IRM GET Alignment G-2 Model Simulated Groundwater Particle Track
- IRM GET Alignment G-1 Model Simulated Groundwater Particle Track
- Conceptual OU2 Containment Extraction Well Alignment
- Source Sites
- Diceon Electronics

IRM = OU2 Interim Remedial Measures
GET = Groundwater Extraction and Treatment

NOTE: Groundwater Elevation Contours from: Black Rock Geosciences, 2021. First Quarter 2021 Groundwater Monitoring Report - Former Diceon Electronics Facility, 2215 South Standard Avenue, Santa Ana, California, April 9, 2021.

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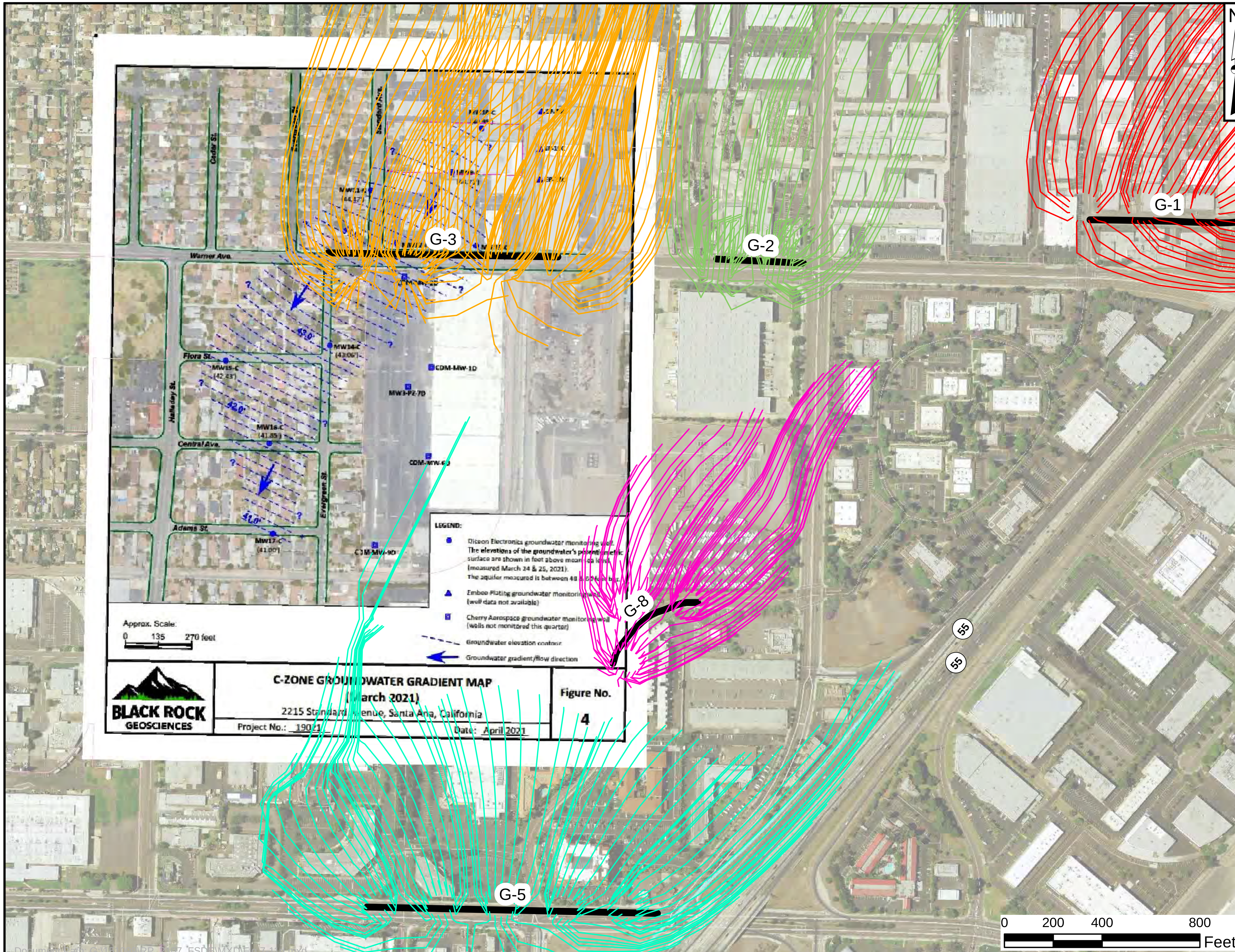
FIGURE 7-11C
COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED B-ZONE GROUNDWATER ELEVATION CONTOURS, FORMER DICEON ELECTRONICS FACILITY
ORANGE COUNTY WATER DISTRICT SOUTH BASIN



EXPLANATION

- IRM GET Alignment G-8 Model Simulated Groundwater Particle Track
- IRM GET Alignment G-5 Model Simulated Groundwater Particle Track
- IRM GET Alignment G-3 Model Simulated Groundwater Particle Track
- IRM GET Alignment G-2 Model Simulated Groundwater Particle Track
- IRM GET Alignment G-1 Model Simulated Groundwater Particle Track
- Conceptual OU2 Containment Extraction Well Alignment
- Source Sites
- Diceon Electronics

IRM = OU2 Interim Remedial Measures
GET = Groundwater Extraction and Treatment

NOTE: Groundwater Elevation Contours from: Black Rock Geosciences, 2021. First Quarter 2021 Groundwater Monitoring Report - Former Diceon Electronics Facility, 2215 South Standard Avenue, Santa Ana, California, April 9, 2021.

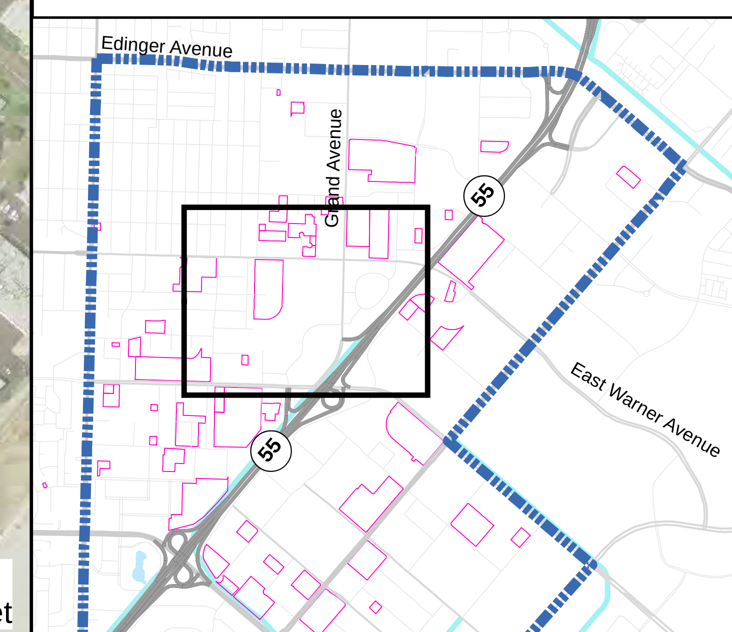


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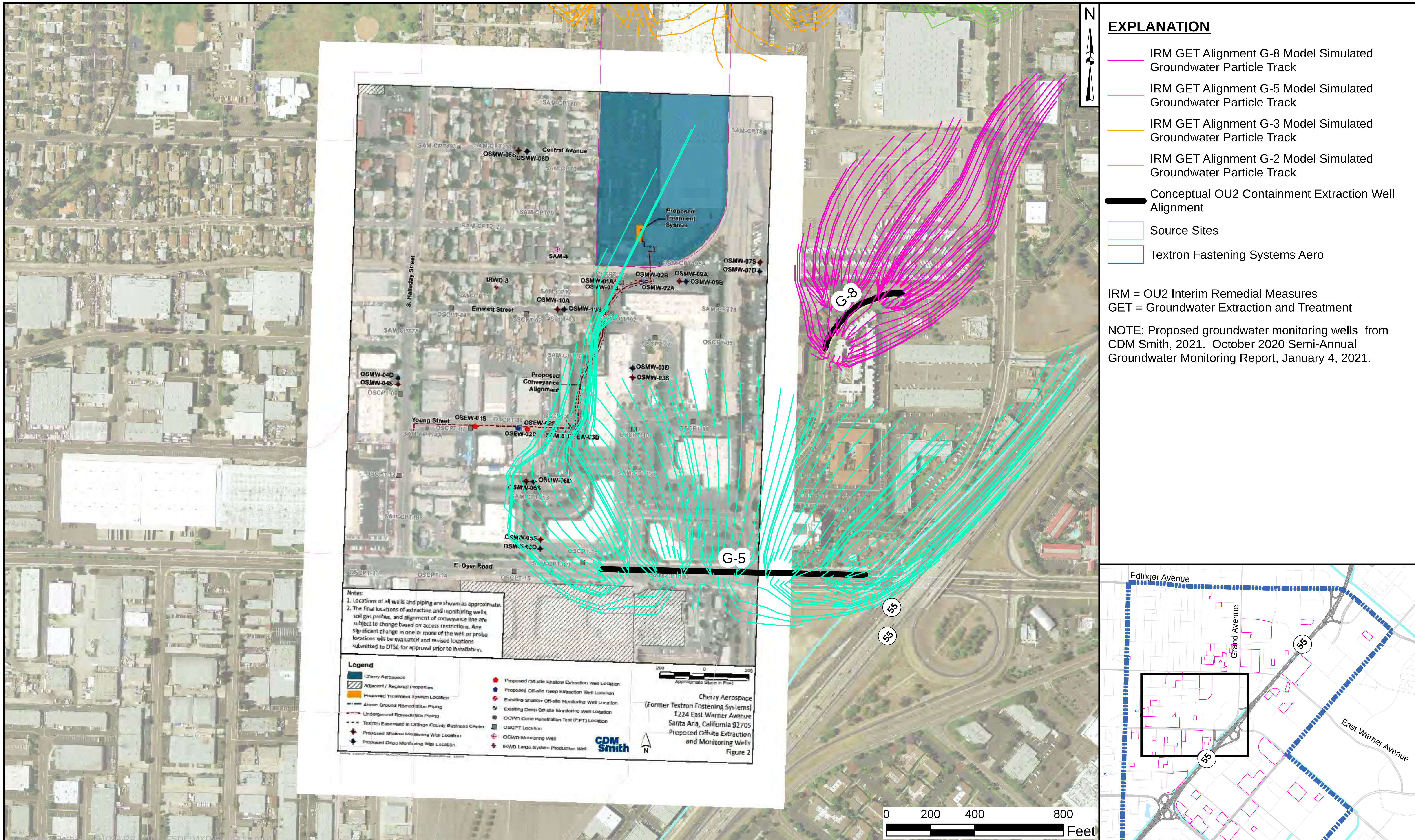
FIGURE 7-11D
COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED C-ZONE GROUNDWATER ELEVATION CONTOURS, FORMER DICEON ELECTRONICS FACILITY
ORANGE COUNTY WATER DISTRICT SOUTH BASIN



Project No. 151099.220

Engineering Analytics, Inc.

FIGURE 7-12A

CHERRY AEROSPACE PROPOSED OFF-SITE MONITORING AND EXTRACTION WELLS AND OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS

ORANGE COUNTY WATER DISTRICT SOUTH BASIN

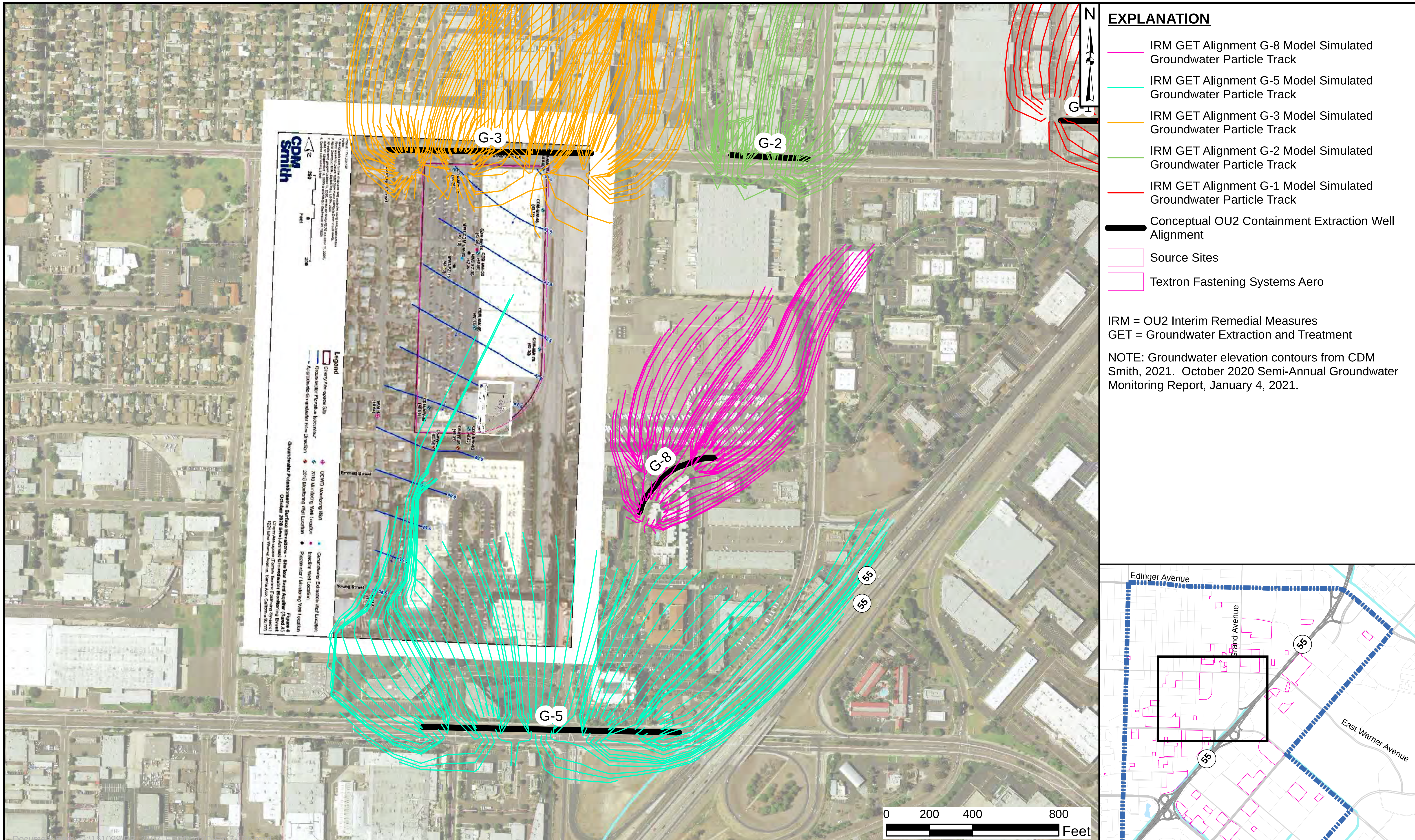


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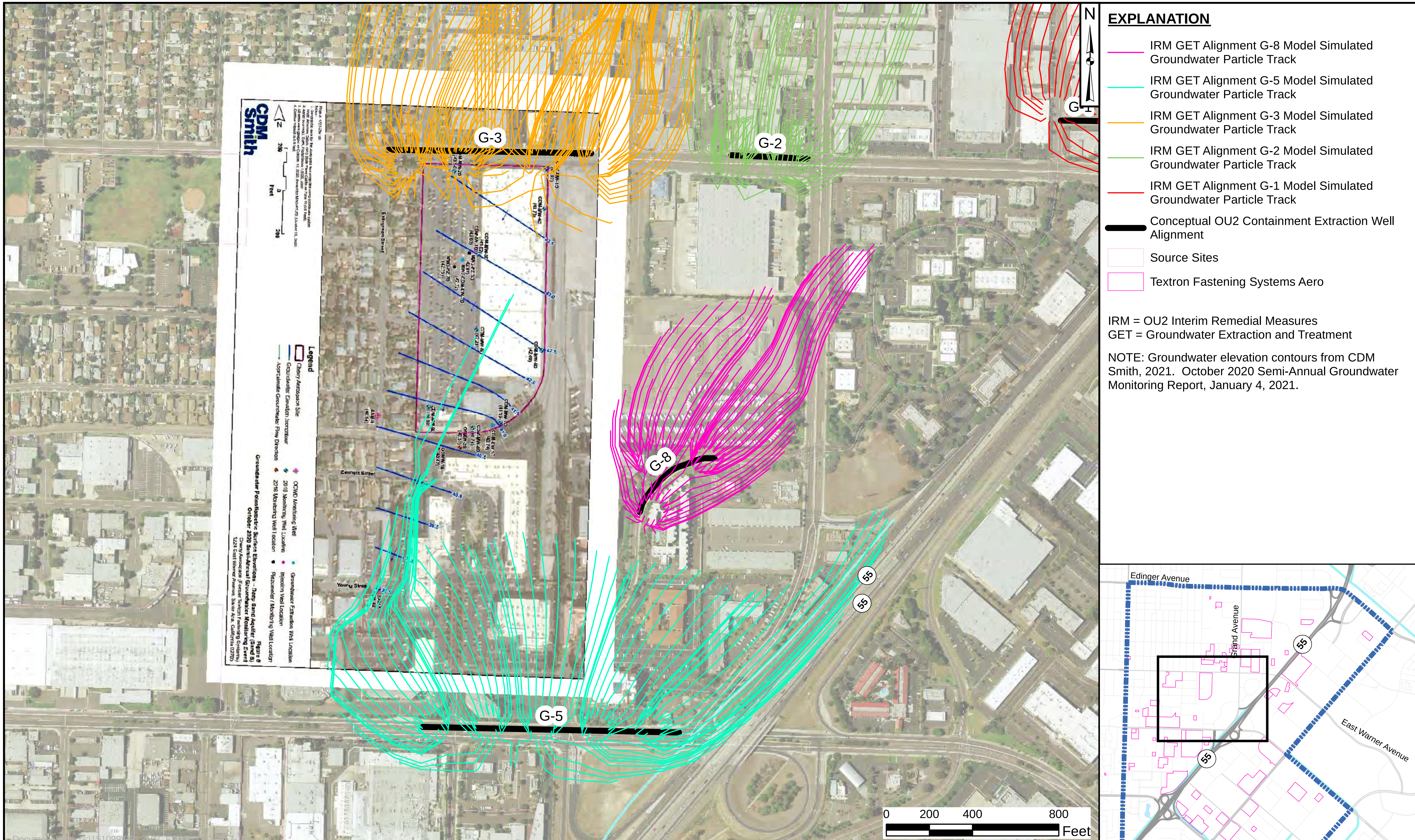
FIGURE 7-12B

COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED SAND A GROUNDWATER ELEVATION CONTOURS, CHERRY AEROSPACE ORANGE COUNTY WATER DISTRICT SOUTH BASIN



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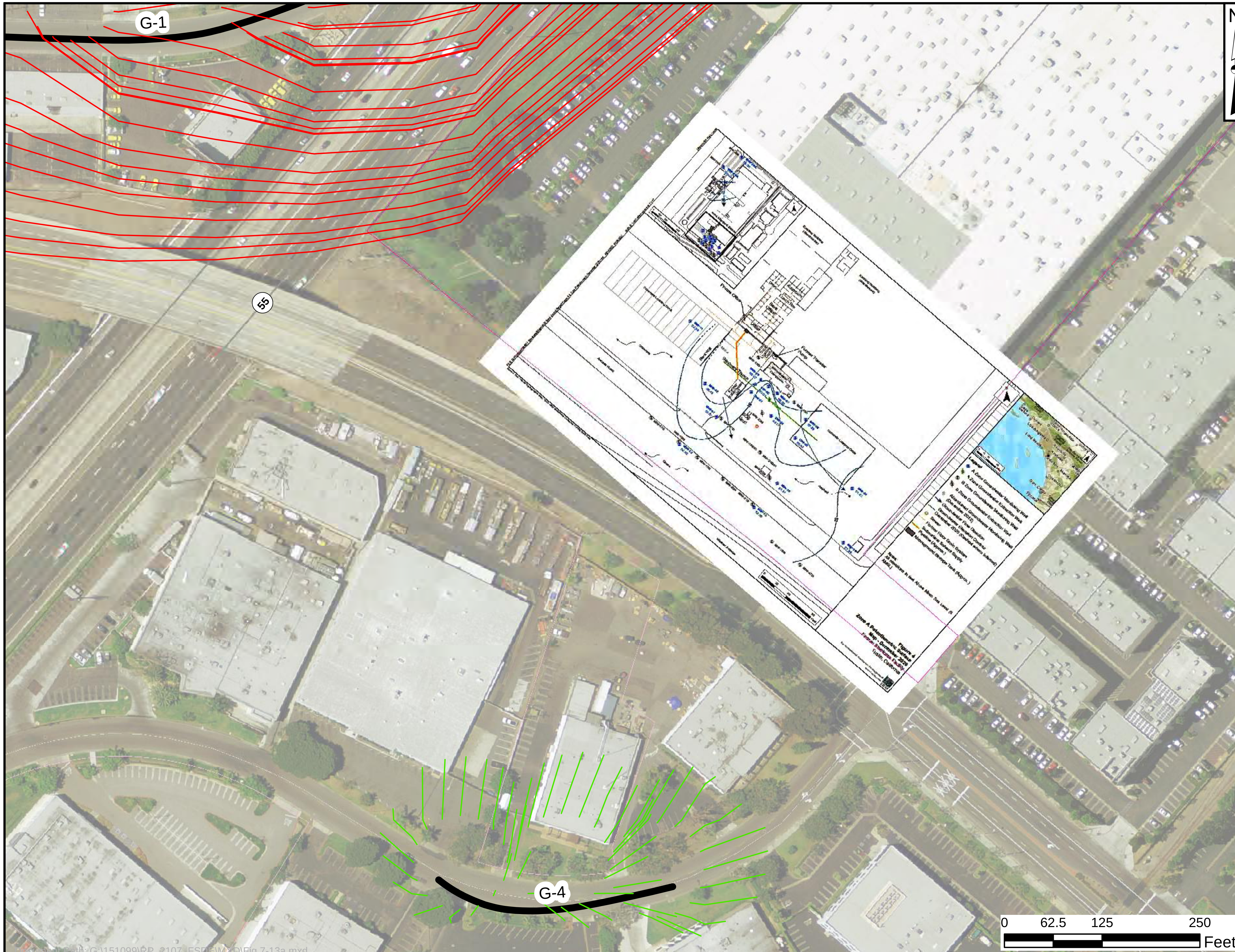
COMPARISON

FIGURE 7-12C

COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED SAND B GROUNDWATER ELEVATION CONTOURS, CHERRY AEROSPACE ORANGE COUNTY WATER DISTRICT SOUTH BASIN

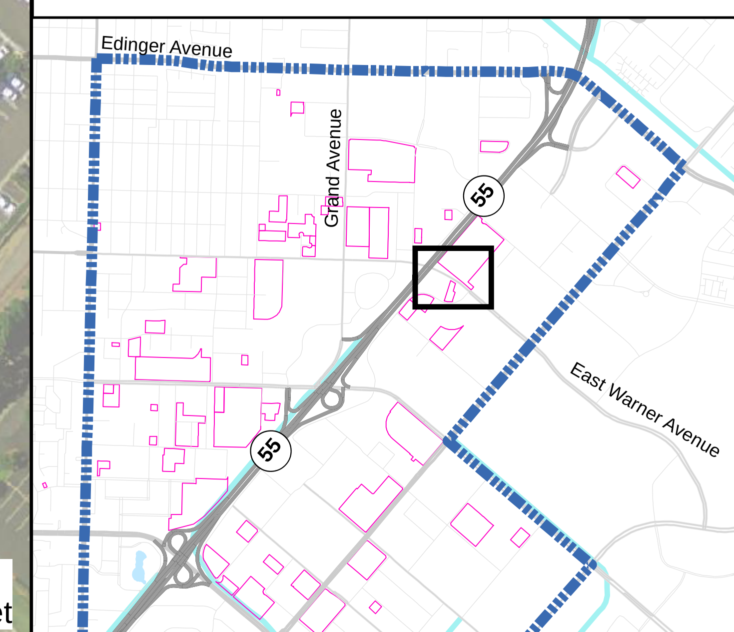


EXPLANATION

- IRM GET Alignment G-4 Model Simulated Groundwater Particle Track
- IRM GET Alignment G-1 Model Simulated Groundwater Particle Track
- Conceptual OU2 Containment Extraction Well Alignment
- Source Sites
- Steelcase Incorporated

IRM = OU2 Interim Remedial Measures
GET = Groundwater Extraction and Treatment

NOTE: Groundwater elevation contours from Environmental Resources Management, 2021. Second Half Report 2020, Steelcase Incorporated, February 10, 2021



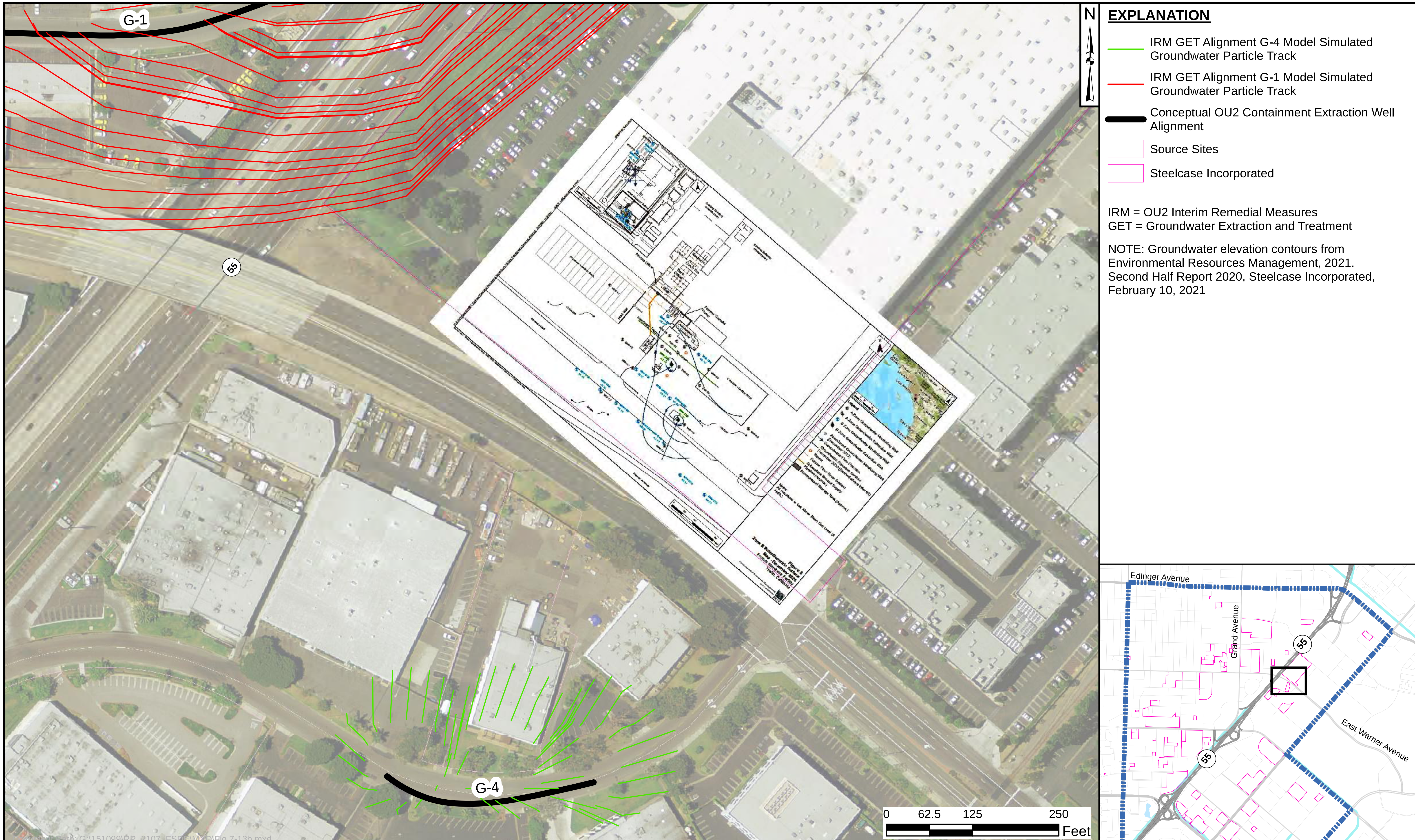
Project No. 151099.220

Engineering Analytics, Inc.

FIGURE 7-13A

COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED ZONE A GROUNDWATER ELEVATION CONTOURS, STEELCASE INCORPORATED

ORANGE COUNTY WATER DISTRICT SOUTH BASIN



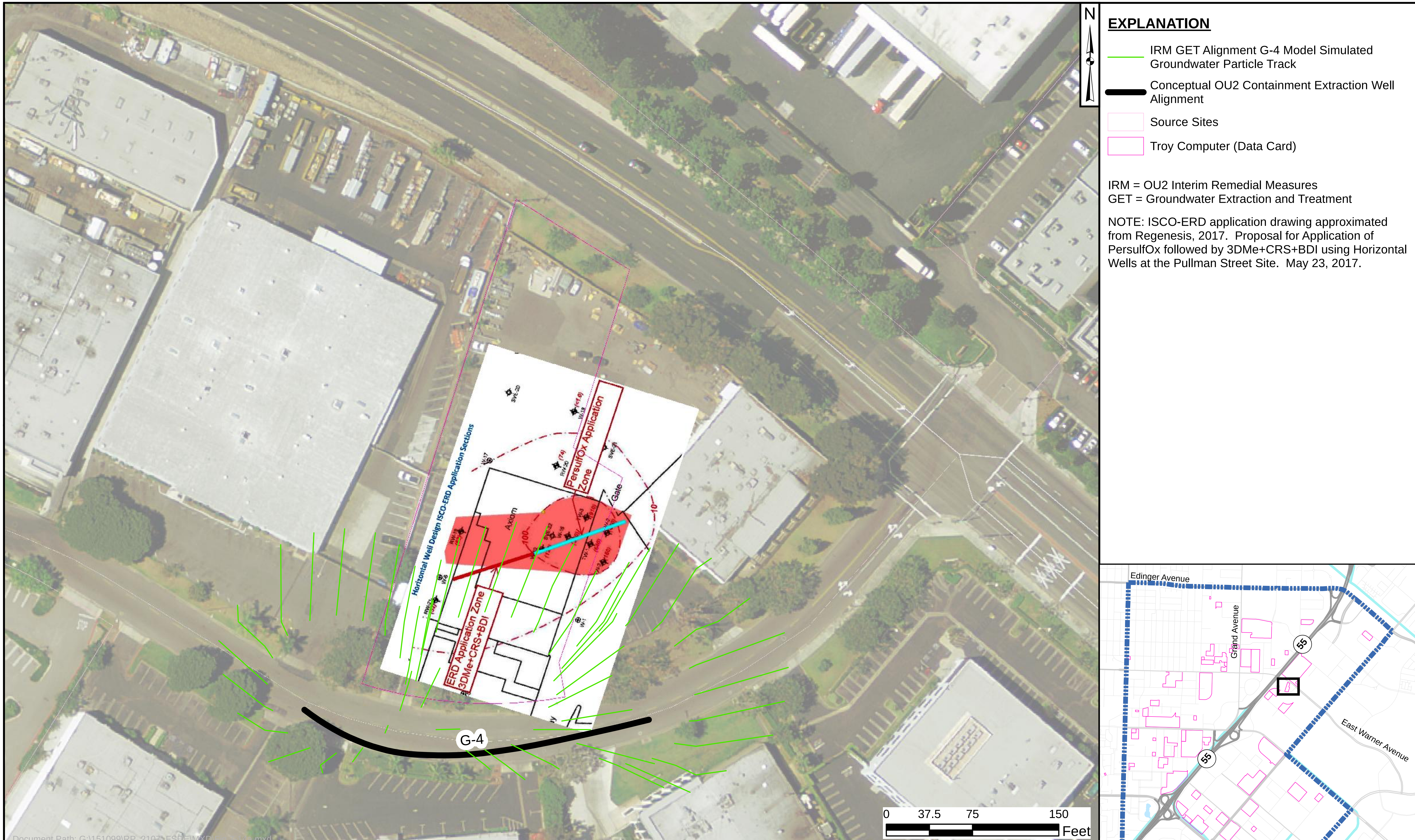
Project No. 151099.220

Engineering Analytics, Inc.

FIGURE 7-13B

COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED ZONE B GROUNDWATER ELEVATION CONTOURS, STEELCASE INCORPORATED

ORANGE COUNTY WATER DISTRICT SOUTH BASIN



EXPLANATION

- IRM GET Alignment G-4 Model Simulated Groundwater Particle Track
- Conceptual OU2 Containment Extraction Well Alignment
- Source Sites
- Troy Computer (Data Card)

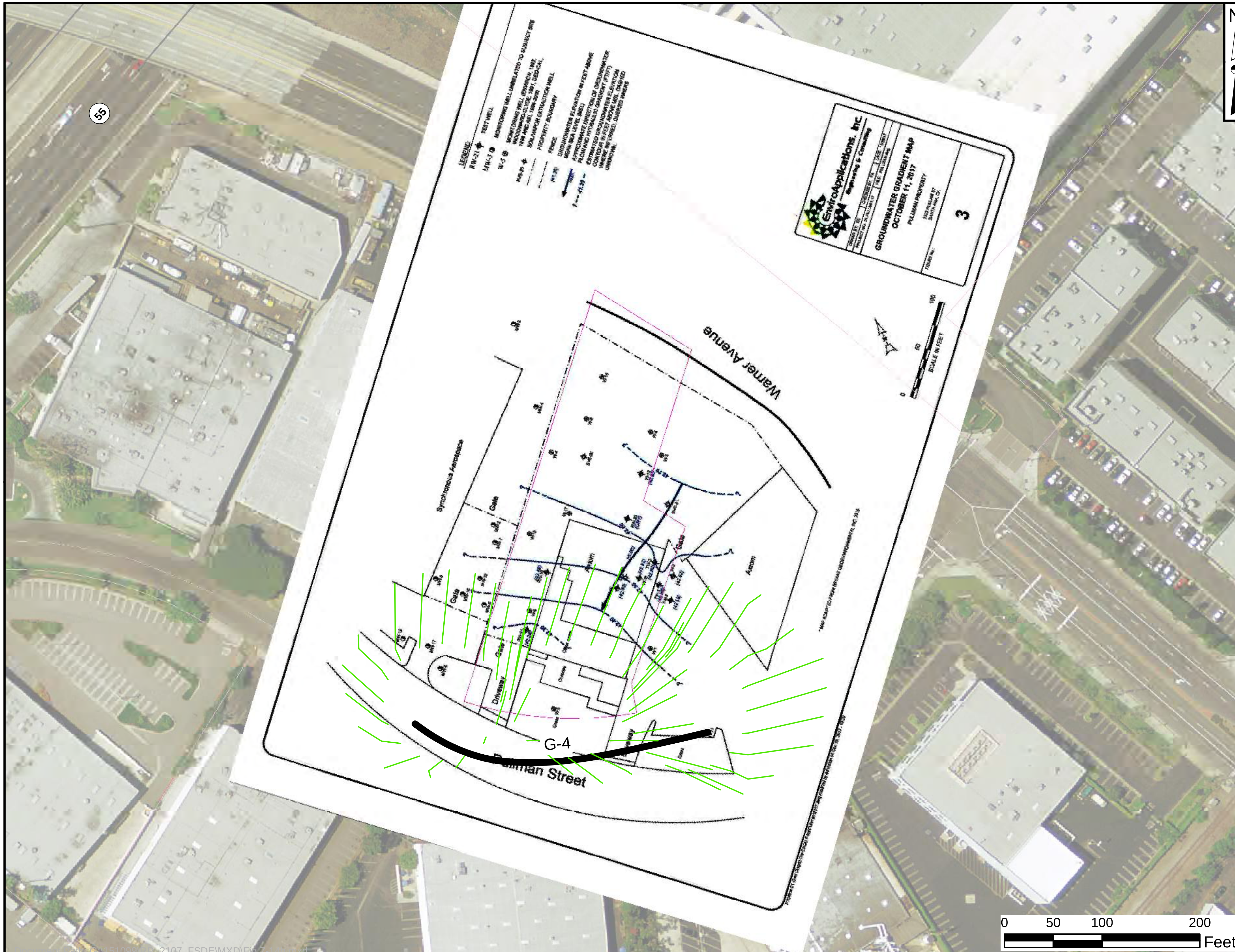
IRM = OU2 Interim Remedial Measures
GET = Groundwater Extraction and Treatment

NOTE: ISCO-ERD application drawing approximated from Regenesis, 2017. Proposal for Application of PersulfOx followed by 3DMe+CRS+BDI using Horizontal Wells at the Pullman Street Site. May 23, 2017.

Project No. 151099.220

Engineering Analytics, Inc.

FIGURE 7-14A
TROY COMPUTER PROPOSED HORIZONTAL WELL DESIGN ISCO-ERD APPLICATION SECTIONS AND OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS
ORANGE COUNTY WATER DISTRICT SOUTH BASIN

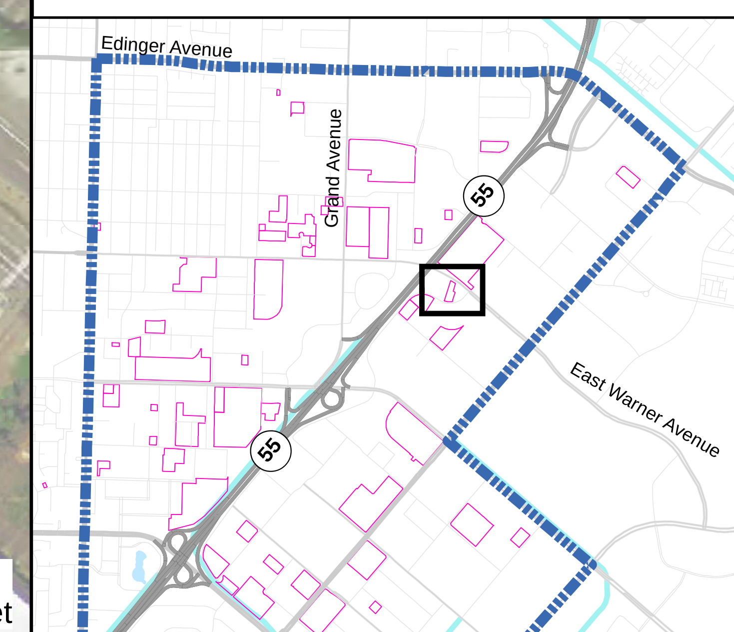


EXPLANATION

- IRM GET Alignment G-4 Model Simulated Groundwater Particle Track
- Conceptual OU2 Containment Extraction Well Alignment
- Source Sites
- Troy Computer (Data Card)

IRM = OU2 Interim Remedial Measures
GET = Groundwater Extraction and Treatment

NOTE: Groundwater elevation contour drawing approximated from EnviroApplication, Inc., 2017 Former Troy Computer Facility Groundwater Monitoring and Progress Report, December 22, 2017.



Project No. 151099.220

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FIGURE 7-14B
COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED GROUNDWATER ELEVATION CONTOURS, TROY COMPUTER ORANGE COUNTY WATER DISTRICT SOUTH BASIN

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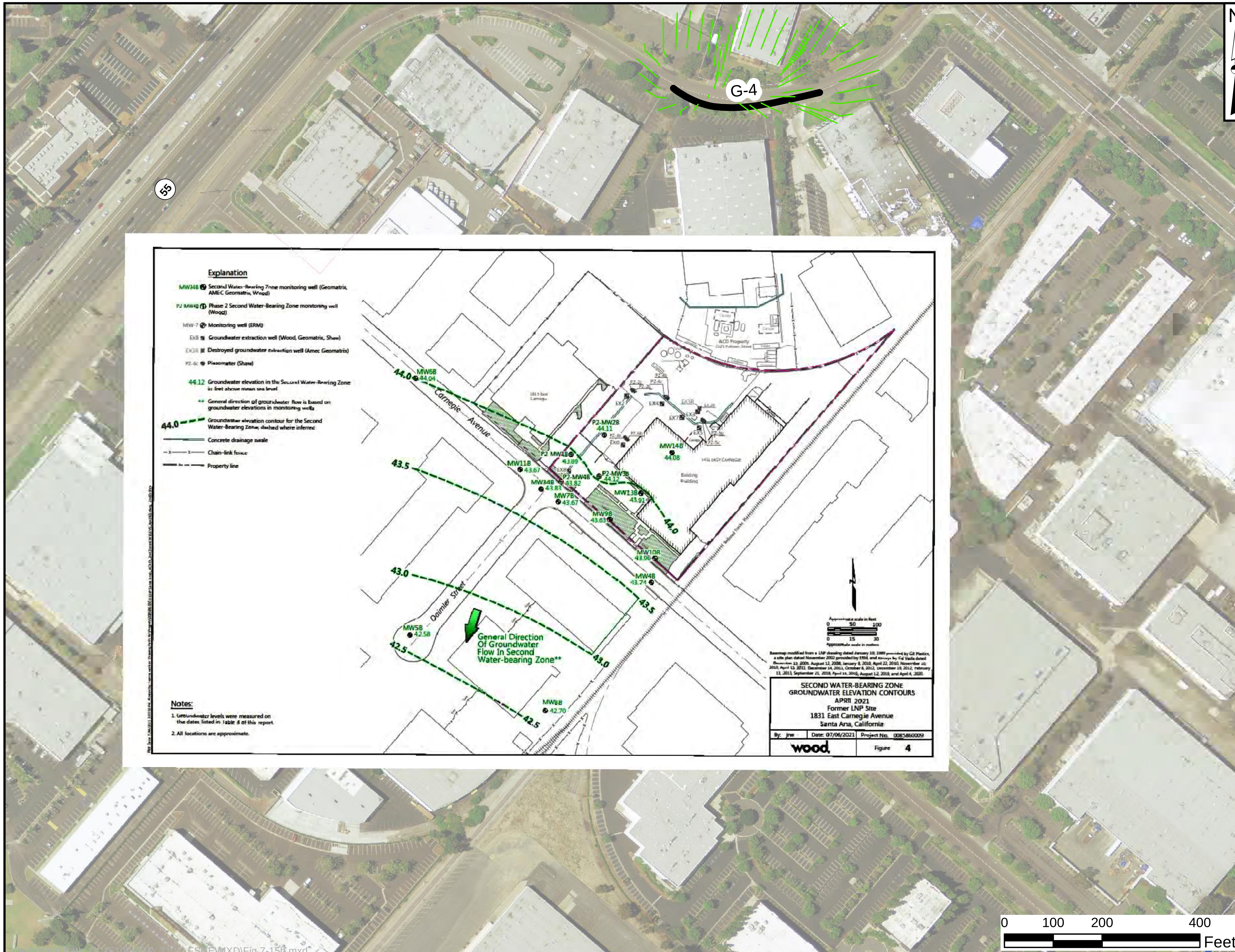
FIGURE 7-15A

COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED FIRST WATER-BEARING ZONE GROUNDWATER ELEVATION CONTOURS, GE PLASTICS

ORANGE COUNTY WATER DISTRICT SOUTH BASIN

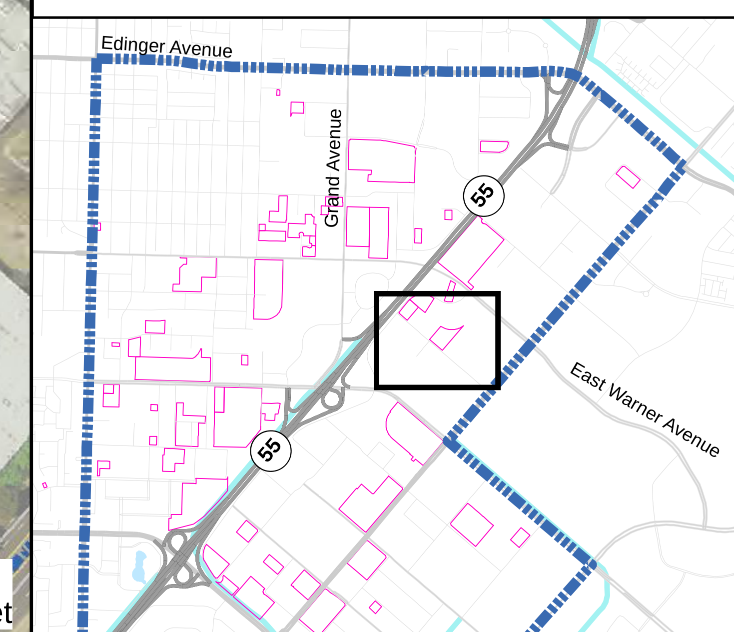


EXPLANATION

- IRM GET Alignment G-4 Model Simulated Groundwater Particle Track
- Conceptual OU2 Containment Extraction Well Alignment
- Study Area
- Source Sites
- GE Plastics

IRM = OU2 Interim Remedial Measures
GET = Groundwater Extraction and Treatment

NOTE: Groundwater elevation contours from Wood, 2021. Summary of Second Quarter 2021 Groundwater Monitoring Activities, Former LNP Site. July 14, 2021.



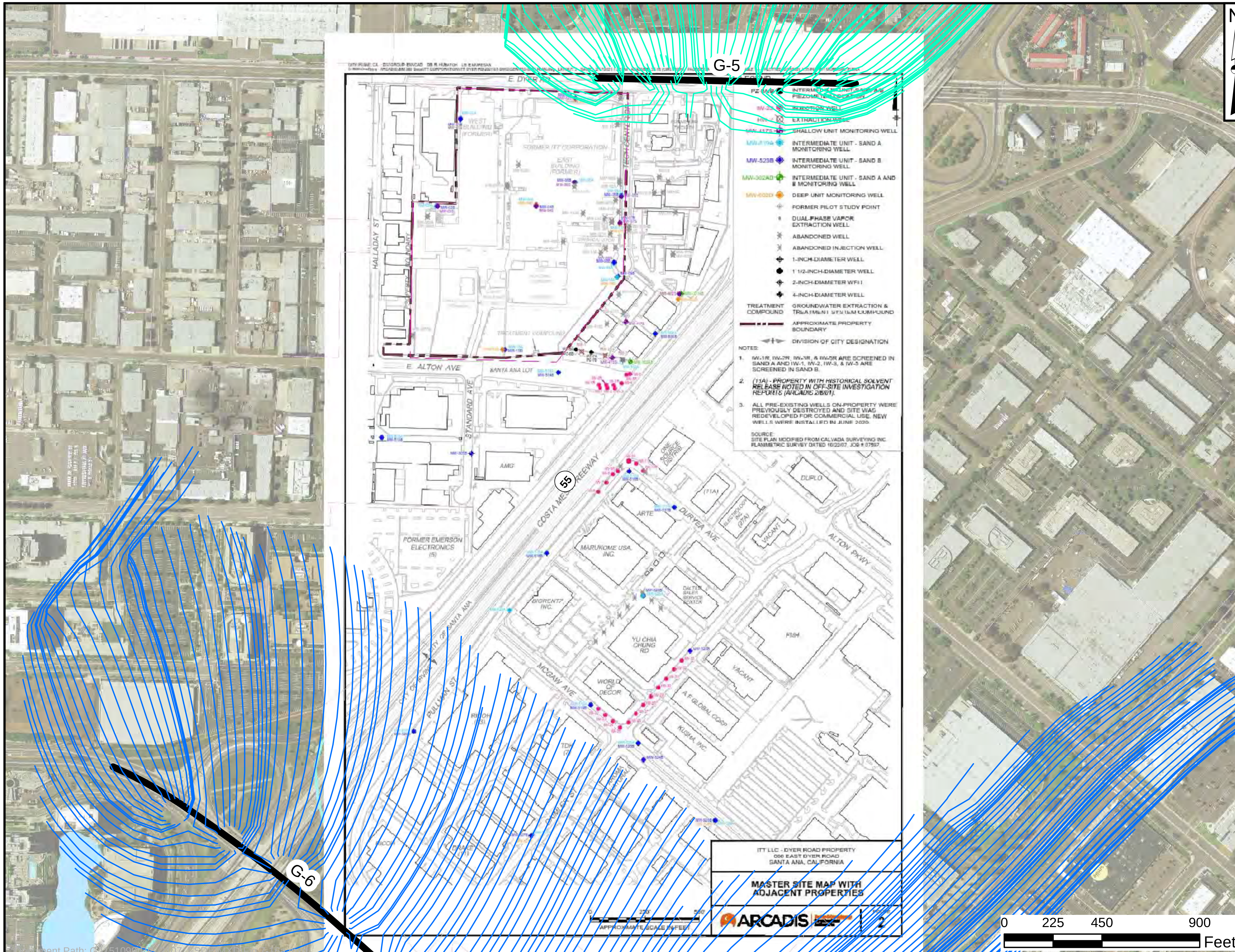
Project No. 151099.220

Engineering Analytics, Inc.

FIGURE 7-15B

COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED SECOND WATER-BEARING ZONE GROUNDWATER ELEVATION CONTOURS, GE PLASTICS

ORANGE COUNTY WATER DISTRICT SOUTH BASIN



EXPLANATION

- IRM GET Alignment G-6 Model Simulated Groundwater Particle Track
- IRM GET Alignment G-5 Model Simulated Groundwater Particle Track
- Conceptual OU2 Containment Extraction Well Alignment
- Source Sites
- ITT Cannon

IRM = OU2 Interim Remedial Measures
GET = Groundwater Extraction and Treatment

NOTE: Site plan from Arcadis, 2021. Semiannual Groundwater Monitoring Report, Third and Fourth Quarters 2020, ITT LLC - Former Dyer Road Property April 23, 2021.

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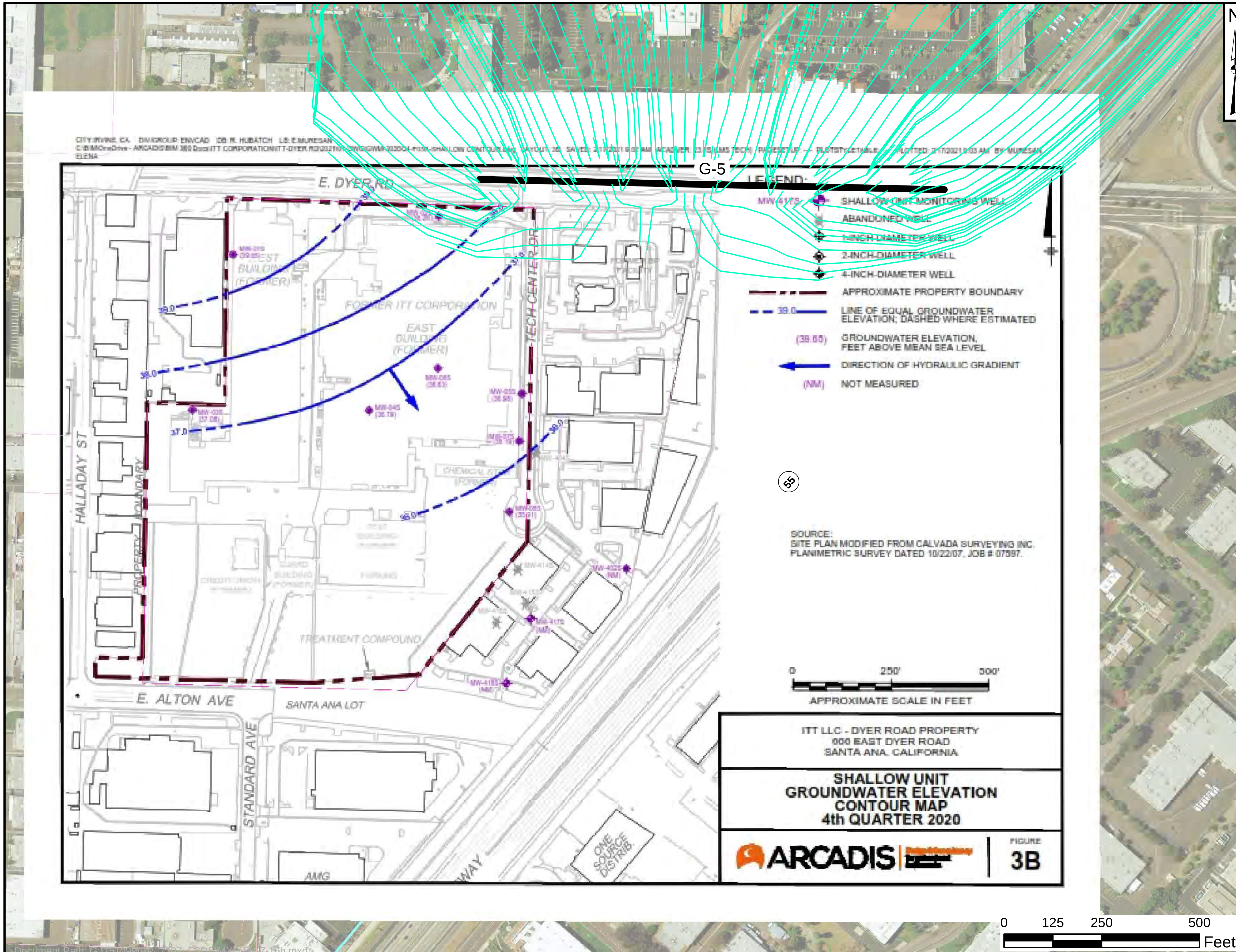
Engineering Analytics, Inc.

FIGURE 7-16A
ITT CANNON MASTER SITE MAP AND MODEL-SIMULATED GROUNDWATER PARTICLE TRACKS
ORANGE COUNTY WATER DISTRICT SOUTH BASIN



EXPLANATION

IRM GET Alignment G-5 Model Simulated Groundwater Particle Track

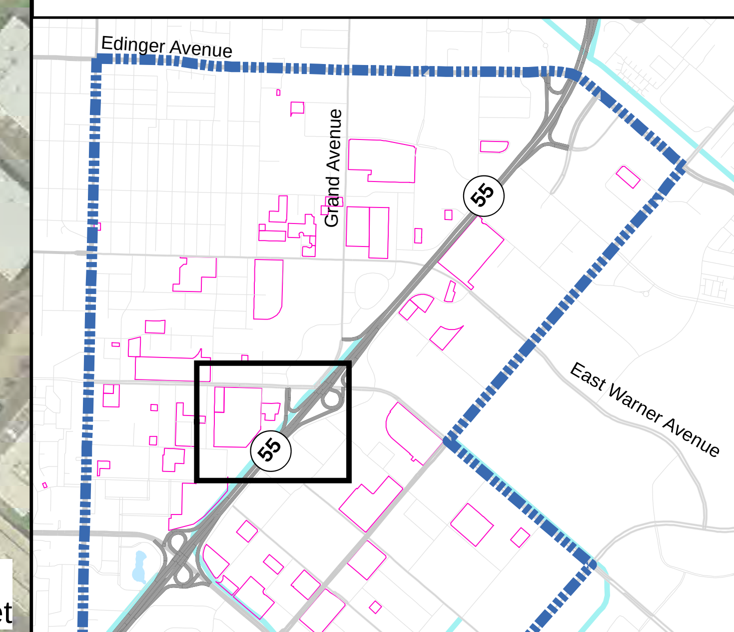
Conceptual OU2 Containment Extraction Well Alignment

Source Sites

ITT Cannon

IRM = OU2 Interim Remedial Measures
GET = Groundwater Extraction and Treatment

NOTE: Groundwater elevation contours from Arcadis, 2021. Semiannual Groundwater Monitoring Report, Third and Fourth Quarters 2020, ITT LLC - Former Dyer Road Property April 23, 2021.

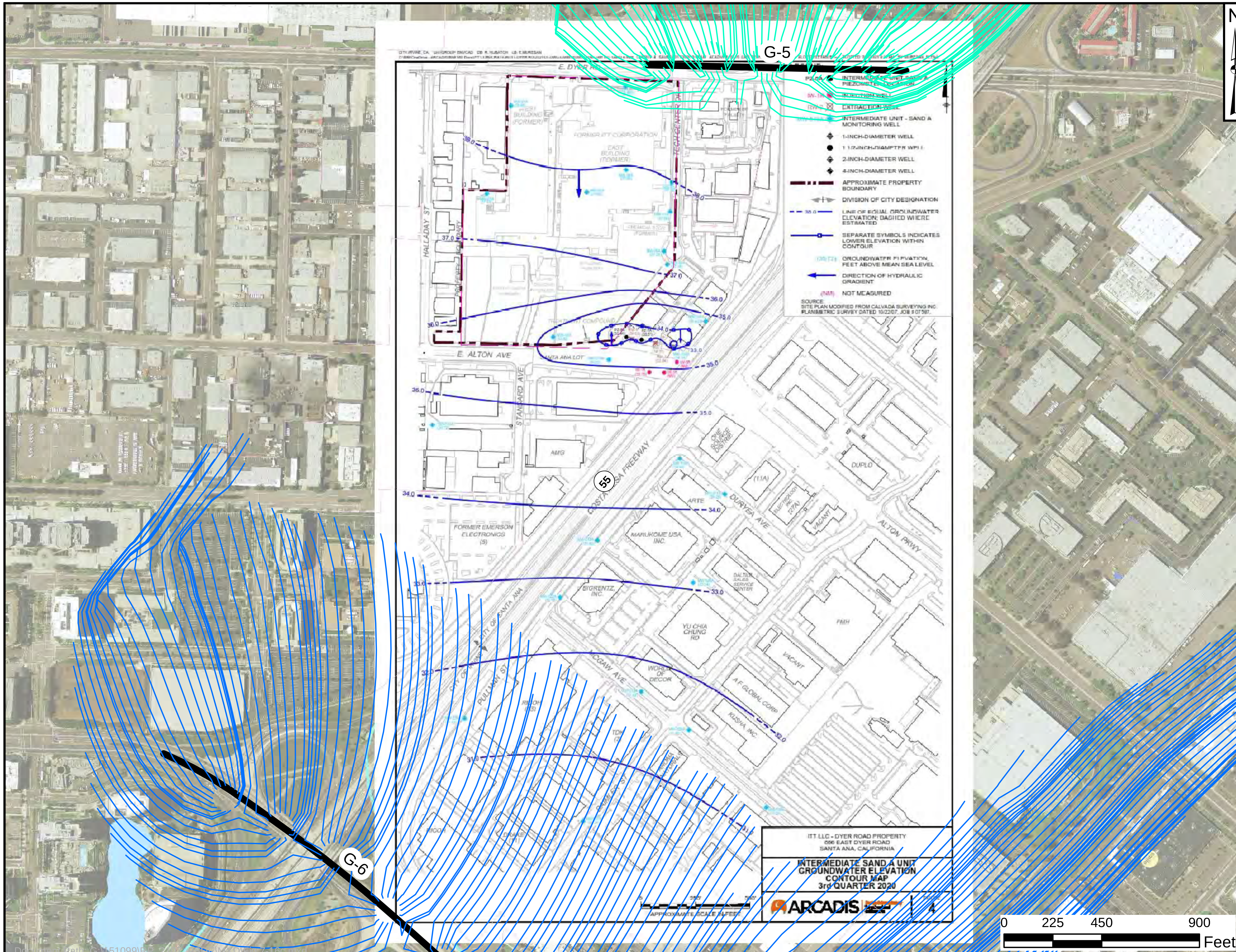


Project No. 151099.220

Engineering Analytics, Inc.

FIGURE 7-16B

COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED SHALLOW UNIT GROUNDWATER ELEVATION CONTOURS, ITT CANNON ORANGE COUNTY WATER DISTRICT SOUTH BASIN



N

EXPLANATION

- IRM GET Alignment G-6 Model Simulated Groundwater Particle Track
- IRM GET Alignment G-5 Model Simulated Groundwater Particle Track
- Conceptual OU2 Containment Extraction Well Alignment
- Source Sites
- ITT Cannon

IRM = OU2 Interim Remedial Measures
GET = Groundwater Extraction and Treatment

NOTE: Groundwater elevation contours from Arcadis, 2021. Semiannual Groundwater Monitoring Report, Third and Fourth Quarters 2020, ITT LLC - Former Dyer Road Property April 23, 2021.

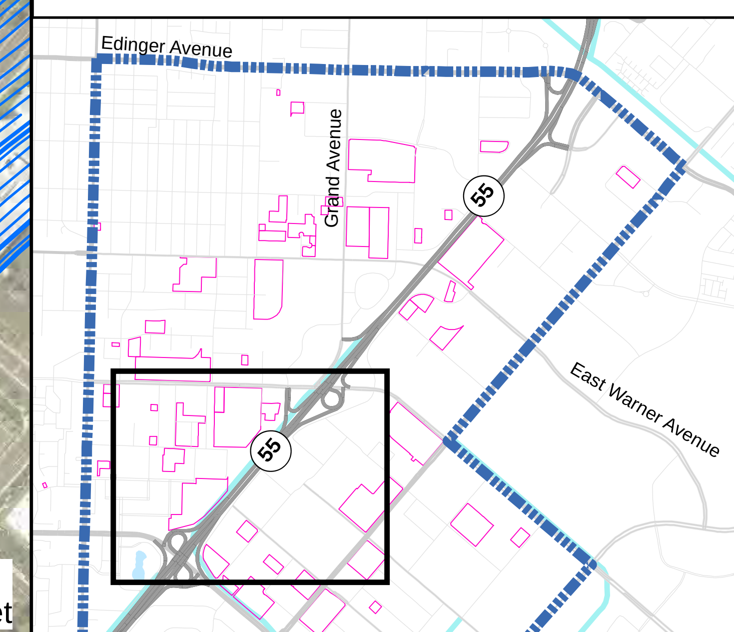


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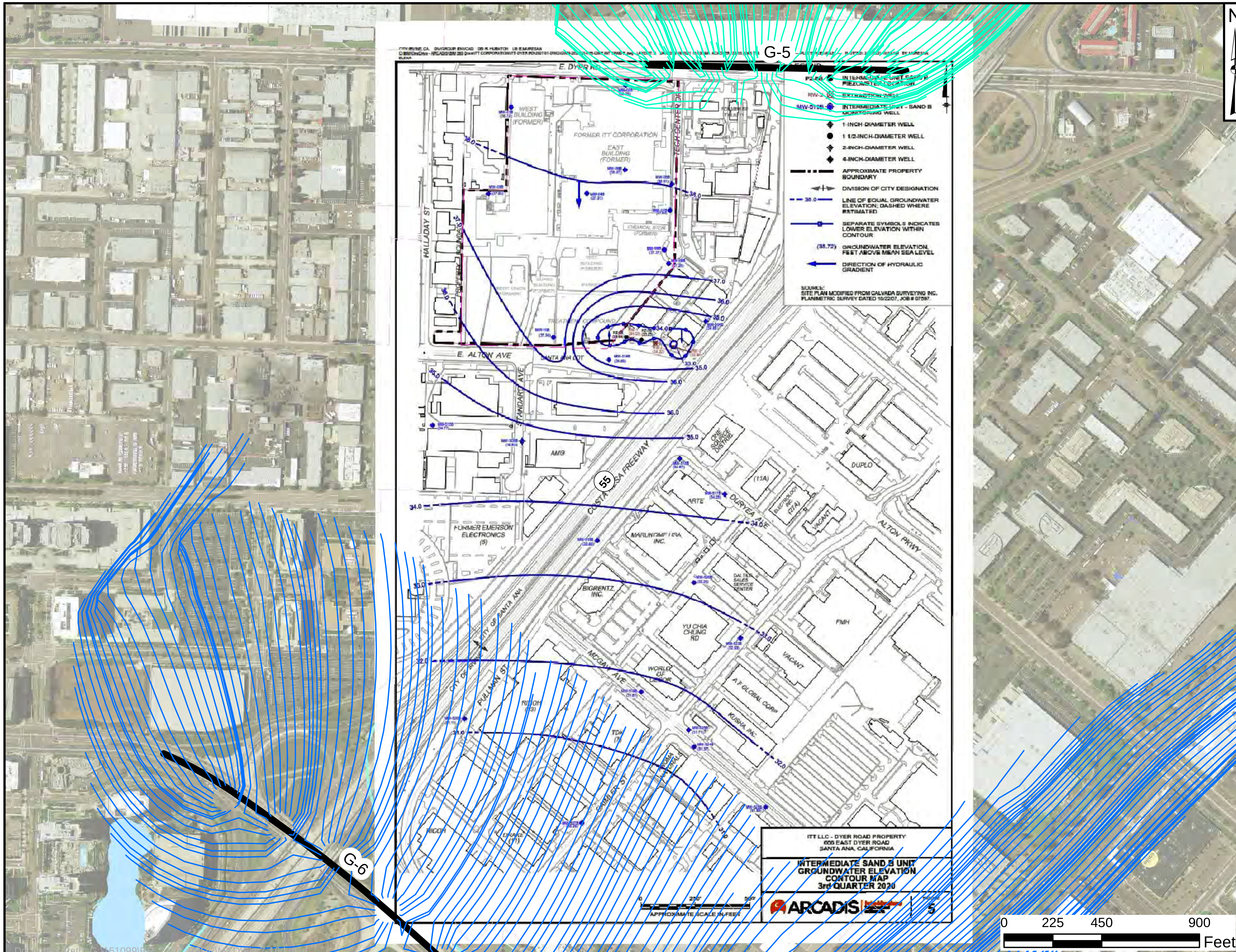
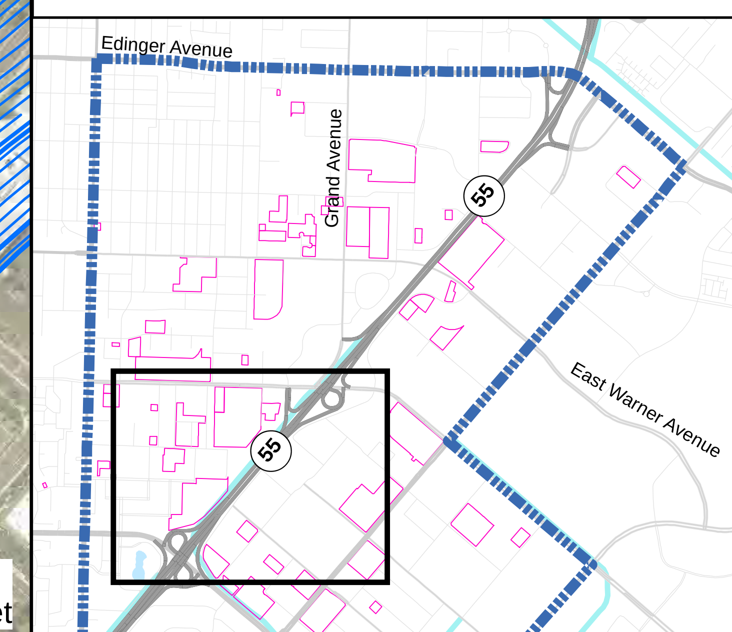
FIGURE 7-16C

COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED INTERMEDIATE SAND A UNIT GROUNDWATER ELEVATION CONTOURS, ITT CANNON

ORANGE COUNTY WATER DISTRICT SOUTH BASIN





EXPLANATION

- IRM GET Alignment G-6 Model Simulated Groundwater Particle Track
- IRM GET Alignment G-5 Model Simulated Groundwater Particle Track
- Conceptual OU2 Containment Extraction Well Alignment
- Source Sites
- ITT Cannon

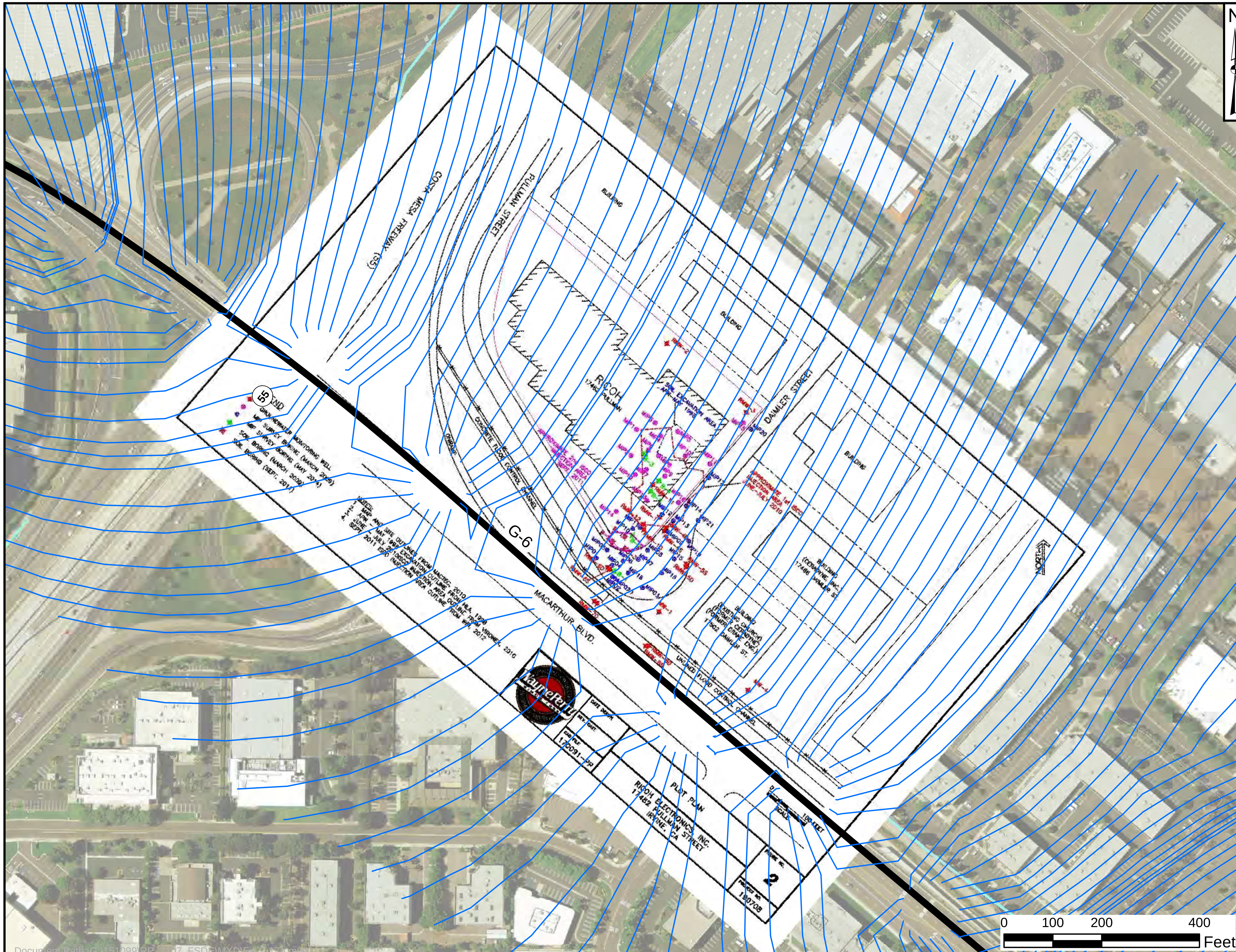
IRM = OU2 Interim Remedial Measures
GET = Groundwater Extraction and Treatment

NOTE: Groundwater elevation contours from Arcadis, 2021. Semiannual Groundwater Monitoring Report, Third and Fourth Quarters 2020, ITT LLC - Former Dyer Road Property April 23, 2021.

Project No. 151099.220

Engineering Analytics, Inc.

FIGURE 7-16D
COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED INTERMEDIATE SAND B UNIT GROUNDWATER ELEVATION CONTOURS, ITT CANNON
ORANGE COUNTY WATER DISTRICT SOUTH BASIN



EXPLANATION

IRM GET Alignment G-6 Model Simulated Groundwater Particle Track

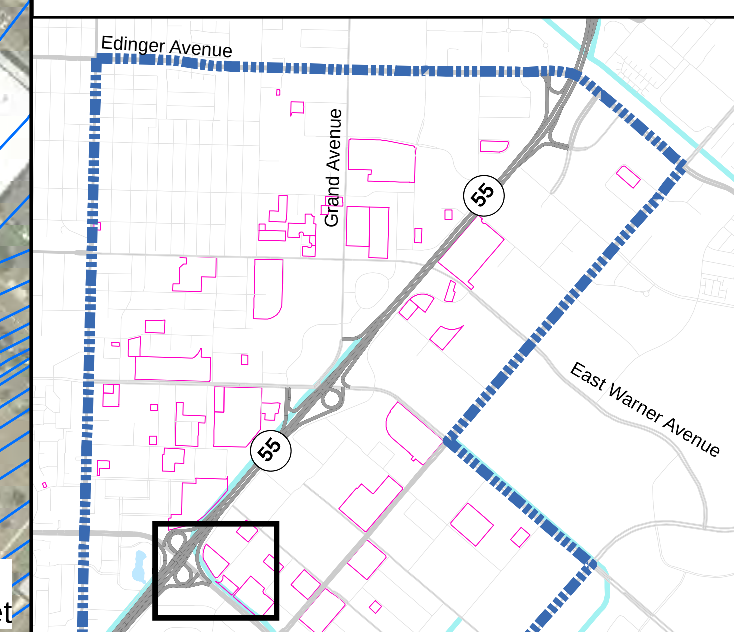
Conceptual OU2 Containment Extraction Well Alignment

Source Sites

Ricoh Electronics

IRM = OU2 Interim Remedial Measures
GET = Groundwater Extraction and Treatment

NOTE: Site plan from Wayne Perry, 2021.
First Half 2021 Groundwater Monitoring Report
February 25, 2021.



Project No. 151099.220

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FIGURE 7-17A
RICOH PLOT PLAN AND OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS
ORANGE COUNTY WATER DISTRICT SOUTH BASIN

Project No. 151099.220

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FIGURE 7-17B

COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED GROUNDWATER ELEVATION CONTOURS, FORMER RICOH ELECTRONICS FACILITY

ORANGE COUNTY WATER DISTRICT SOUTH BASIN

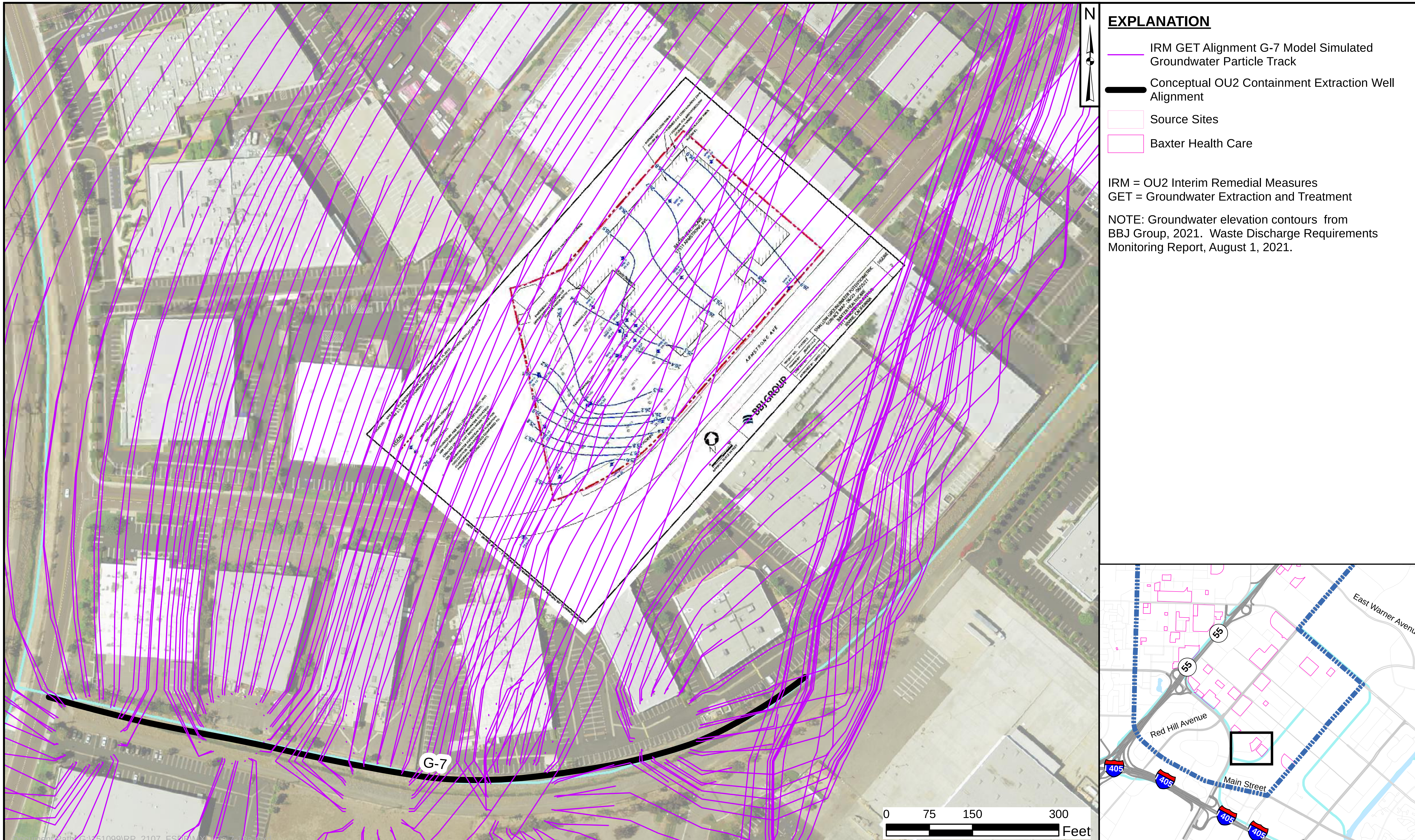

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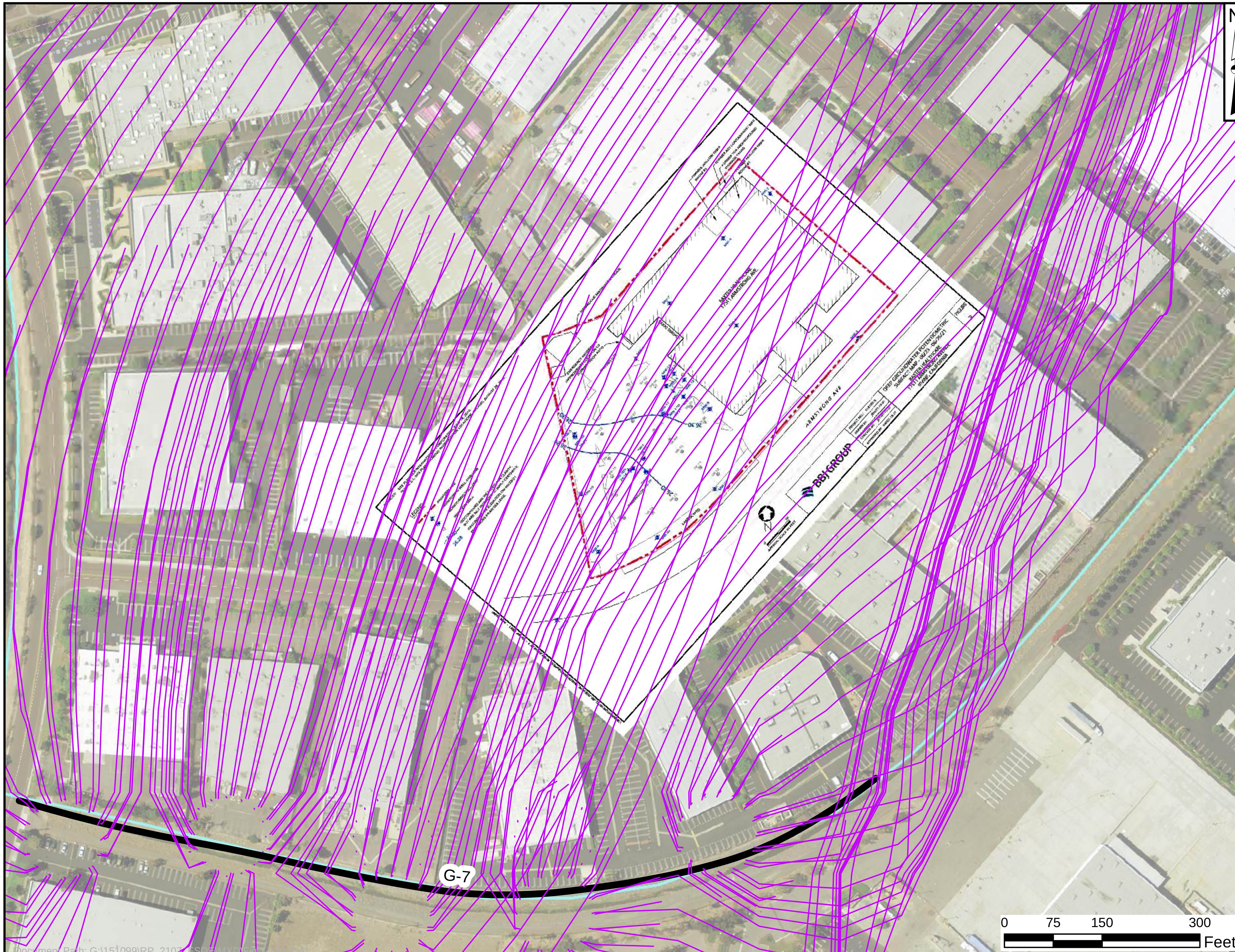
FIGURE 7-18A
COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED SHALLOW GROUNDWATER ELEVATION CONTOURS, BAXTER HEALTHCARE
ORANGE COUNTY WATER DISTRICT SOUTH BASIN

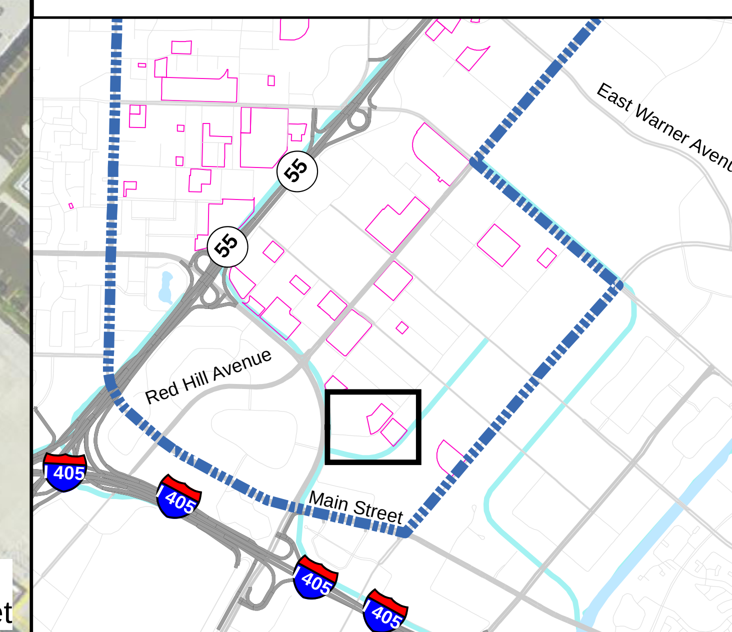


EXPLANATION

- IRM GET Alignment G-7 Model Simulated Groundwater Particle Track
- Conceptual OU2 Containment Extraction Well Alignment
- Source Sites
- Baxter Health Care

IRM = OU2 Interim Remedial Measures
GET = Groundwater Extraction and Treatment

NOTE: Groundwater elevation contours from BBJ Group, 2021. Waste Discharge Requirements Monitoring Report, August 1, 2021.



Project No. 151099.220

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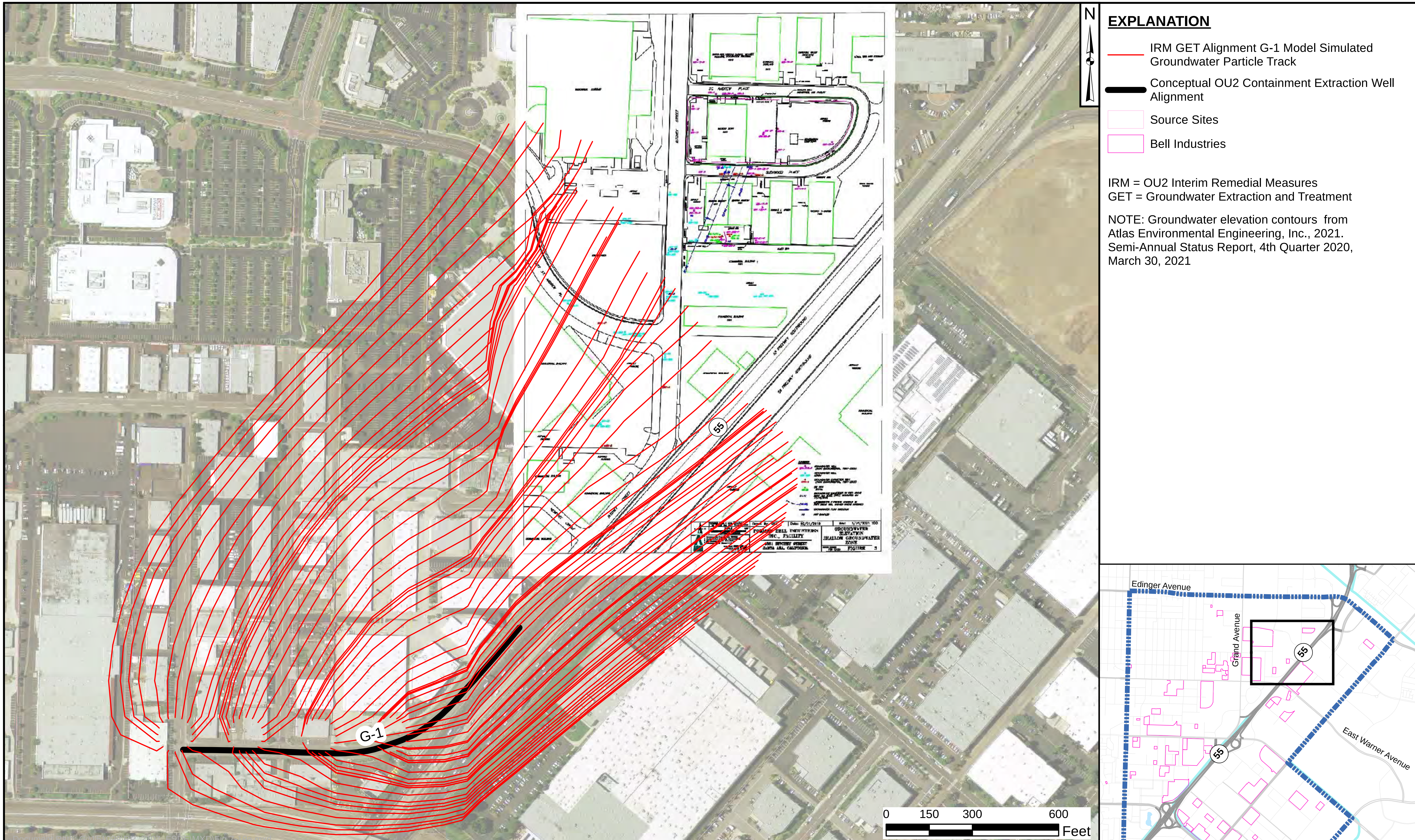
FIGURE 7-18B
COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED DEEP GROUNDWATER ELEVATION CONTOURS, BAXTER HEALTHCARE
ORANGE COUNTY WATER DISTRICT SOUTH BASIN



Project No. 151099.220

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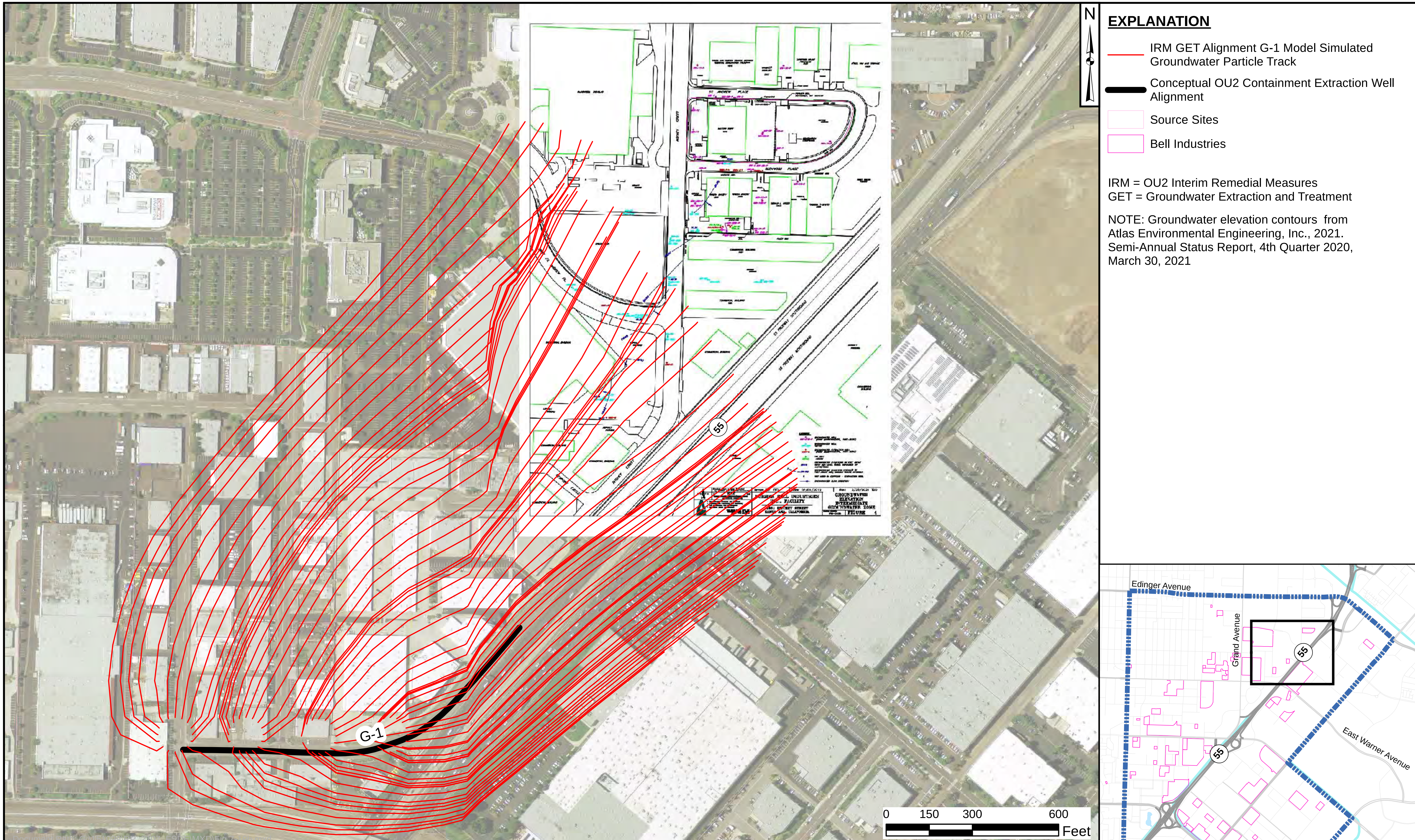
FIGURE 7-19A

COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED SHALLOW GROUNDWATER ZONE ELEVATION CONTOURS, BELL INDUSTRIES

ORANGE COUNTY WATER DISTRICT SOUTH BASIN



Project No. 151099.220

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FIGURE 7-19B

COMPARISON OF OCWD MODEL SIMULATED GROUNDWATER PARTICLE TRACKS VERSUS PUBLISHED INTERMEDIATE GROUNDWATER ZONE ELEVATION CONTOURS, BELL INDUSTRIES

ORANGE COUNTY WATER DISTRICT SOUTH BASIN

APPENDIX A
DATA AND METHODS USED TO PREPARE OU2 GROUNDWATER COC PLAN VIEW FIGURES

APPENDIX A
DATA AND METHODS USED TO PREPARE OU2 GROUNDWATER COC PLAN VIEW FIGURES

SOUTH BASIN GROUNDWATER PROTECTION PROJECT

Prepared for:

Orange County Water District

Prepared by:

Engineering Analytics, Inc.

9820 Willow Creek Rd., Suite 395

San Diego, CA 92131

(858) 221-0264

Project No. 151099

February 2022

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ACRONYMS AND ABBREVIATIONS

COC	Chemicals of Concern
EA	Engineering Analytics, Inc.
H+A	Hargis + Associates, Inc.
MCL	Maximum Contaminant Level
msl	Mean Sea Level
OCWD	Orange County Water District
OU2	Operable Unit 2
SRI	Supplemental Remedial Investigation

1.0 INTRODUCTION

This appendix has been prepared by Engineering Analytics, Inc. (EA) on behalf of Orange County Water District (OCWD) to document the data and methods used to prepare the Chemicals of Concern (COC) maps of Operable Unit 2 (OU2) in the south-central portion of the Orange County Groundwater Basin in Orange County, California (Study Area).

2.0 WATER QUALITY DATA

Groundwater samples were collected from wells and temporary grab sample locations across the Study Area by various parties over the past decades. Sampling data was assembled using databases compiled and maintained by OCWD and its data management contractors, augmented with supplemental data for individual source sites that were downloaded from SWRCB's GeoTracker electronic data management system website.

2.1 Chemicals of Concern

There are ten Chemicals of Concern (COCs) for OU2 groundwater as described in the feasibility study. COC figures for 1,1-DCA, 1,2-DCA, and 1,1,2-TCA were not prepared for this document since the frequencies of detection and/or relative concentrations of these COCs were low and the distributions of these COCs were encompassed by the distributions of COCs illustrated herein.

2.2 Screening Levels

Screening levels used for COC analysis, were assigned based on standards outlined in the 2020 SRI Report (H+A, 2020). The screening levels for the mapped OU2 COCs were made up of Federal and State primary Maximum Containment Levels (MCLs) for drinking water and California notification limits for drinking water. The screening levels can be found below.

Chemical Name	Units	Screening Level	Screening Level Basis
Trichloroethylene	ug/l	5	Federal Primary MCL
Tetrachloroethylene	ug/l	5	Federal Primary MCL
1,1-Dichloroethylene	ug/l	6	CA Primary MCL
1,4-Dioxane	ug/l	1	CA Notification Limit
Perchlorate	ug/l	6	CA Primary MCL
cis-1,2-Dichloroethylene	ug/l	6	CA Primary MCL
Vinyl Chloride	ug/l	0.5	CA Primary MCL
Hexavalent Chromium	ug/l	50	CA Primary MCL for Total Chromium

3.0 HYDROSTRATIGRAPHIC DATA

Hydrostratigraphic unit elevations for the sampling locations were assigned using the unit elevations in mean sea level (msl) that were identified using the four units identified SRI cross sections that were in turn used to support the model layering in the numerical groundwater flow model described in Appendix E.

4.0 METHOD OF EVALUATION

The available data for the Study Area spans decades with multiple samples collected for many of the sample locations. The concentrations of COCs within the four units of interest was evaluated taking the following general principles into consideration:

- In situations where latitude/longitude or sample interval information for a sample location could not be identified, the sample location was removed from the dataset;
- Quality control samples were removed from the dataset and only primary samples were retained;
- Since multiple groundwater samples were taken from a majority of the sample locations the most recent sampled value for each COC at each location was used as the posted value;
- Due to the large span of data, the dataset was limited to samples collected after December 31, 2009
- The sample dates were categorized as Pre 2018 or Post 2017 to provide context as to samples collected more recently;
- Grab and screened samples were categorized and identified separately in the maps;
- Sample depths were initially identified in feet below land surface so the depths had to be converted to msl by subtracting the sample depths from the location's land surface elevation;
- In situations where a sampling location's screen interval was completed in multiple units, their values were posted on maps for all penetrated units;
- Multi-layer sampling intervals and were identified by including the phrase "and adjacent layer" in the sample type description;
- In order to present context as to magnitude of COC concentrations, the final posted value was compared to the COC's screening level and was categorized under one of the following groups
    - Over 100 times screening level
    - 10 to 100 times screening level
    - 1 to 10 times screening level
    - Non-detect greater than screening level
    - Detect less than screening level
    - Non-detect less than screening level

5.0 CONCLUSION

Using the data and methods outlined in this appendix, source tables that identified the sample location, unit, COC, concentration, and sampled time period were created. This information was used to produce the Study Area COC maps.

6.0 REFERENCES

Hargis + Associates, Inc. (H+A), 2020. Supplemental Remedial Investigation Report, Orange County Water District South Basin Groundwater Protection Project, Operable Unit 2. May 6, 2020.

APPENDIX B
POTENTIAL FEDERAL AND STATE OF CALIFORNIA APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) FOR THE SBGPP

TABLE B-1
POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
SOUTH BASIN GROUNDWATER PROTECTION PROJECT
ORANGE COUNTY, CALIFORNIA

Requirements	Description	Applicable or Relevant and Appropriate
CHEMICAL-SPECIFIC ARARs		
Federal Primary Drinking Water Standards, 40 CFR Part 141	Federal primary MCLs under the Safe Drinking Water Act protect the public from contaminants that may be found in drinking water. The MCLs are only applicable "at the tap" for drinking water provided to 25 or more people or water systems with 15 or more service connections. Because the groundwater underlying the site has been identified as a potential source of drinking water, the requirements are relevant and appropriate to the aquifer underlying the SBGPP site.	Relevant and appropriate
California Toxics Rule	Establishes water quality criteria for surface water and is typically implemented through NPDES permits.	Applicable to Surface Water Discharge
California Primary Drinking Water Standards, Health and Safety Code (H&S Code) §4010 *et seq.*, 22 CCR §64431 and 64444	California primary MCLs are established to protect public health from contaminants "at the tap" that may be found in drinking water sources. The California MCLs established for the primary contaminants are at least as stringent as the federal standard. The MCLs would be relevant and appropriate to the aquifer underlying the SBGPP site.	Relevant and appropriate
Water Quality Control Plan for Santa Ana River Basin (adopted 01/24/95,updated 02/2008, 06/2011, 02/2016, and 02/2018) California Water Code §13240 et seq.	Establishes beneficial uses of ground and surface waters; establishes water quality objectives, including narrative and numerical standards; establishes implementation plans to meet WQOs and protect beneficial uses, and incorporates statewide water quality control plans and policies. The WQOs for groundwater are based on the primary MCLs. The Santa Ana River Basin Plan designates the beneficial uses of groundwater to be municipal and domestic, agricultural, industrial service, and industrial process supplies. Any activity that may affect water quality must not result in the water quality exceeding the WQOs.	Relevant and appropriate
SWRCB Resolution No. 92- 49 Policy and Procedures for Investigation and Cleanup and Abatement of Discharges under Water Code Section 13304 (amended 4/21/94), California Water Code §13307 23 CCR §2550.4	Establishes policies and procedures for oversight of investigations and cleanup and abatement activities resulting from discharges of waste that affect or threaten water quality. Section III requires cleanup to attainment of either background water quality or the best water quality that is reasonable if background water quality cannot be restored. Alternative cleanup levels greater than chemical background concentration for the aquifer will be consistent with maximum benefit to the public, present and anticipated future beneficial uses, and conform to water quality control plans and policies.	Relevant and appropriate

TABLE B-1
POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
SOUTH BASIN GROUNDWATER PROTECTION PROJECT
ORANGE COUNTY, CALIFORNIA

Requirements	Description	Applicable or Relevant and Appropriate
LOCATION-SPECIFIC ARARs		
National Historic Preservation Act 16 U.S.C. §470 et seq., 36 CFR §60.4	The requirements establish a National Register and Advisory Council on Historic Preservation. Remedial activities that would affect a property on or eligible for the National Register are required to consult with the Advisory Council and the State Historic Preservation Officer. Surveys that may be required will result in the determination of adverse effects and the development of mitigation reports. Historic sites that would be affected by potential remedial activity at this location may be identified on or adjacent to the site.	To be determined
Endangered Species Act of 1973 16 U.S.C. §1531	Establishes a means for conserving various species of fish, wildlife, and plants that are threatened with extinction. The ESA defines an endangered species and provides for the designation of critical habitats. Federal agencies may not jeopardize the continued existence of any listed species or cause the destruction or adverse modification of critical habitat. Federal agencies must carry out conservation programs for listed species. The Endangered Species Committee may grant an exemption for agency action if reasonable mitigation and enhancement measures such as propagation, transplantation, and habitat acquisition and improvement are implemented. Endangered, threatened, or sensitive species may potentially be found within the vicinity of the SBGPP.	Relevant and appropriate
Fish and Game Code §3800	This section prohibits the taking of nongame birds, except in accordance with regulations of the commission, or when related to mining operations with a mitigation plan approved by the department. This section further provides requirements concerning mitigation plans related to mining. This section is applicable and relevant to the extent that nongame birds or their eggs are located on or near the site.	To be determined
Fish and Game Code §5650	The requirements prohibit the deposition into waters of the state, petroleum products, factory refuse, and any substance deleterious to fish, plants, or birds. This requirement does not apply to discharges or release authorized through waste discharge requirements issued by the RWQCB. This is not an ARAR because none of the alternatives evaluate unpermitted surface water releases.	Not an ARAR
Hazardous Waste Seismic Considerations, 22 CCR §66264.18, 22 CCR §66264.25	Portions of a new hazardous waste facility where treatment, storage, or disposal of hazardous waste will be conducted must not be located within 61 meters (200 feet) of a fault which has had displacement in Holocene time. The site may be located within 61 meters (200 feet) of a fault that has had displacement in Holocene time.	To be determined

TABLE B-1
POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
SOUTH BASIN GROUNDWATER PROTECTION PROJECT
ORANGE COUNTY, CALIFORNIA

Requirements	Description	Applicable or Relevant and Appropriate
ACTION-SPECIFIC ARARs		
Federal Clean Water Act, NPDES, CWA §402 et seq.	The NPDES requirements are applied to point and nonpoint discharge sources. Requirements including the establishment of discharge limitations, monitoring requirements, and BMPs for surface water discharges. Applicable to the control of contaminants to stormwater runoff from a treatment plant construction site and groundwater treatment systems.	Evaluation of the Federal Clean Water Act provided below
Storm Water Discharges 40 CFR §122.26	Nonpoint sources address using BMPs for control of contaminants to stormwater runoff from construction activities. The SWRCB has established requirements for general construction activities, including clearing, grading, excavation reconstruction, and dredge and fill activities. Regulates pollutants in stormwater discharge from hazardous waste treatment plants, landfills, land application sites, and spent dumps.	To be determined
Technology Based Treatment Requirements in Permits 40 CFR §125.3	Point sources are primarily end-of-pipe discharge points such as treated effluent from a groundwater treatment plant. Discharges of treated effluent from a groundwater extraction system, monitor well development and sampling, and treatment system maintenance are the primary sources. The RWQCB will designate effluent limitations and monitoring conditions for discharges to surface water including treated water conveyed to storm drains and ditches. Technology-based treatment requirements represent the minimum level of control that must be imposed to meet the effluent limitations using best professional judgment and be economically achievable. For all toxic pollutants, the BAT is applied to the site. The requirement is applicable to alternatives evaluating surface water discharge.	Applicable to Surface Water Discharge
General Pretreatment Regulations for Existing and New Sources of Pollution 40 CFR §403 et seq.	Alternatives that include groundwater disposal at an offsite wastewater treatment facility must meet pretreatment requirements. Effluent discharged to sanitary sewers and POTWs are regulated by municipalities through the NPDES Program. Prevents pass-through, interference, violations of prohibitions, and violation of local limits. Applicable to treated groundwater discharge from treatment plant to the POTW.	Applicable to POTW Discharge
Water Quality Control Plan	The RWQCB has developed and adopted the regional water quality control plan (Basin Plan) to protect waters of beneficial use fulfilling the legal requirements of the California Water Code. While the WQOs vary for the water bodies affected, the objectives may be applicable for discharges to surface water or land.	Evaluation of the Water Quality Control Plan provided below

TABLE B-1
POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
SOUTH BASIN GROUNDWATER PROTECTION PROJECT
ORANGE COUNTY, CALIFORNIA

Requirements	Description	Applicable or Relevant and Appropriate
Water Quality Control Plan for Santa Ana River Basin (adopted 01/24/95,updated 02/2008, 06/2011, 02/2016, and 02/2018) California Water Code §13240 et seq.	The Basin Plan presents numerical and narrative WQOs for maintaining a high quality of protection for the inland surface water and groundwater in the region. Groundwater underlying the site has been identified by the Basin Plan as a potential drinking water aquifer. Groundwater and surface water WQOs are provided for contaminants including bacteria, chemicals, radioactivity, minerals, nitrogen, taste, and odor. The groundwater WQOs for the COCs at the site are based on primary MCLs. Additional WQOs are provided for surface water. The requirement is relevant to alternatives evaluating treated groundwater reinjection to the aquifer and applicable to alternatives evaluating discharge of treated groundwater to surface water.	Relevant and appropriate
Remediation of Pollution, (State Board Resolution No. 68-16; State Board Resolution No. 92-49; California Code of Regulations, Title 23, Chapter 15, Article 5.)	The Basin Plan recognizes the cleanup goals based on the State's Antidegradation Policy as set forth in State Board Resolution No. 68-16. Under the Antidegradation Policy, whenever the existing quality of water is better than that needed to protect present and potential beneficial uses, such existing quality will be maintained. Accordingly, the RWQCB prescribes cleanup goals that are based upon background concentrations. For those cases wherein dischargers have demonstrated that cleanup goals based on background concentrations cannot be attained due to technological and economic limitations, State Board Resolution No. 92-49 sets forth policy for cleanup and abatement based on the protection of beneficial uses. Under this policy, the RWQCB can, on a case-by-case basis, set cleanup levels as close to background as technologically and economically feasible. Such levels must, at a minimum, consider all beneficial uses of the waters. Furthermore, cleanup levels must be established in a manner consistent with CCR, Title 23, Chapter 15, Article 5; cannot result in water quality less than that prescribed in the Basin Plans and policies adopted by the state and regional boards; and must be consistent with maximum benefit to the people of the state.	Relevant and appropriate
Porter-Cologne Water Quality Control Act (California Water Code)	The following Porter-Cologne Water Quality Control Act and implementing regulations are reviewed for application to the site.	Evaluation of the California Water Code provided below
California Water Code §13140 – 13147, 13172, 13260, 13263, 132267, 13304, 27 CCR §20090	Actions taken by public agencies for cleanup of *nonhazardous* releases are exempt from 27 CCR Div. 2, Subdiv. 1 provided the contaminated materials removed from the immediate place of release shall be discharged according to 27 CCR Div. 2, Subdiv. 1, Chap. 3, Subchap. 2, Art. 2. Remedial actions intended to contain such wastes at the place of release shall implement applicable SWRCB-promulgated provisions of this division to the extent feasible.	To be determined

TABLE B-1
POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
SOUTH BASIN GROUNDWATER PROTECTION PROJECT
ORANGE COUNTY, CALIFORNIA

Requirements	Description	Applicable or Relevant and Appropriate
California Water Code §13140 – 13147, 13172, 13260, 13263, 132267, 13304, 27 CCR Div. 2, Subdiv. 1, Chap. 3, Subchap. 2, Art. 2	Wastes classified as a threat to water quality (designated waste) may be discharged to a Class I hazardous waste or Class II designated waste management unit. Nonhazardous solid waste may be discharged to a Class I, II, or III waste management unit. Inert waste would not be required to be discharged into a SWRCB-classified waste management unit (27 CCR §20200 et seq.).	To be determined
California Water Code §13260 Report of Waste Discharge (ROWD)/Waste Discharge Requirements (WDR)	Any discharge of waste to land is required to be authorized through WDRs from the Water Board; an ROWD must be submitted to obtain the WDRs. Numerical discharge limits would be based on MCLs, and the nondegradation policy in Resolution 68-16. WDRs are relevant and appropriate to the extent that: 1. in situ remediation with chemical or biological amendments are considered for remediation (General WDR for In-Situ Groundwater Remediation at Sites within the Santa Ana Region, Order No. R8-2018-0092), or 2. reinjection is considered as an end use for treated groundwater (General WDR for the Reinjection/Percolation of Extracted and Treated Groundwater Resulting from the Cleanup of Groundwater Polluted by Petroleum Hydrocarbons, Solvents and/or Petroleum Hydrocarbons Mixed with Lead and/or Solvents for the Santa Ana Region, Order No. R8-2002-0033, as amended by Order Numbers R8-2003-0085 and R8-2013-0020).	Relevant and Appropriate to In Situ Remediation Relevant and Appropiate to Reinjection End Use
Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California	Policy for implementing criteria for priority toxic pollutants contained in the California Toxics Rule promulgated by EPA as well as other priority toxic pollutant criteria and objectives. Criteria implemented through NPDES permit process. Applicable to discharges of treated groundwater to surface water.	Applicable to Surface Water Discharge
Water Quality Monitoring and Response Programs for Solid Waste Management Units, 27 CCR §20380 et seq.	The monitoring requirements apply to all determinations of alternative cleanup levels for unpermitted discharges to land of solid waste, pursuant to SWRCB Resolution No. 92-49, Section III. The provisions for Detection, Evaluation, and Corrective Action Monitoring requirements were developed for the purposes of detecting, characterizing, and responding to releases to groundwater, surface water, or the unsaturated vadose zone. For this removal, corrective action monitoring to demonstrate completion of the selected remedy at the site would be relevant and appropriate and is further discussed in Corrective Action Program (27 CCR §20430).	Relevant and appropriate

TABLE B-1
POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
SOUTH BASIN GROUNDWATER PROTECTION PROJECT
ORANGE COUNTY, CALIFORNIA

Requirements	Description	Applicable or Relevant and Appropriate
Concentration Limits 27 CCR §20400	Concentration limits must be established for groundwater, surface water, and the unsaturated zone. Must be based on background, equal to background, or for corrective actions, may be greater than background, not to exceed the lower of the applicable water quality objective or the concentration technologically or economically achievable. Specific factors must be considered in setting cleanup standards above background levels. The specific factors have been addressed in SWRCB Resolution No. 92-49.	Relevant and appropriate
Compliance Period 27 CCR §20410	Requires monitoring for compliance with remedial action objectives for years from the date of achieving cleanup standards.	Relevant and appropriate
General Water Quality Monitoring and Systems Requirements, 27 CCR §20415	Requires general soil, surface water, and groundwater monitoring. Applies to all areas at which waste has been discharged to land.	Relevant and appropriate
Evaluation Monitoring Program 27 CCR §20425	Requires an assessment of the nature and extent of the release, including a determination of the spatial distribution and concentration of each constituent. The nature and extent of contamination is still being determined.	To be determined
Corrective Action Program 27 CCR §20430	Corrective action measures taken (for example, groundwater pump-and-treat system) may be terminated when the discharger demonstrates that all the COC concentrations are reduced to levels below their respective concentration limits throughout the entire zone affected by the release. Corrective action completed when: * The concentration of each COC in each sample from each monitoring point in the Corrective Action Program for the Unit has remained at or below its respective concentration limit during a proof period of at least one year, beginning immediately after the suspension of corrective action measures. * The individual sampling events for each monitoring point have been evenly distributed throughout the proof period and have consisted of no less than eight sampling events per year per monitoring point. The schedule to confirm attainment of cleanup levels appears relevant and appropriate.	Relevant and appropriate

TABLE B-1
POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
SOUTH BASIN GROUNDWATER PROTECTION PROJECT
ORANGE COUNTY, CALIFORNIA

Requirements	Description	Applicable or Relevant and Appropriate
Water Code §13140 40 CFR §131.12, Maintaining High Quality Water in California, SWRCB Resolution No. 68-16	The policy derives its authority to maintain the highest quality of water through waste discharge regulations to surface water and land implemented through the federal NPDES or California's Discharges of Waste to Land (27 CCR Division 2, Chapter 3), respectively. SWRCB Resolution No. 68-16 requires maintenance of existing state water quality using best practicable treatment technology unless a demonstrated change will benefit the people of California, will not unreasonably affect present or potential uses, and will not result in water quality less than that prescribed in other state policies. Applies to the discharge of waste to waters, including alternatives that include reinjection into the aquifer and discharges to soil that may affect surface water or groundwater. In situ cleanup levels for contaminated groundwaters must be set at background level, unless allowed. If degradation of waters is allowed to remain, the discharge must meet best practical treatment or control standards, and result in the highest water quality possible that is consistent with the maximum benefit to the people of the state. In no case may water quality objectives be exceeded.	Applicable
Sources of Drinking Water SWRCB Resolution No. 88-63	This policy specifies that ground and surface waters of the state are either existing or potential sources of municipal and domestic supply except water supplies with one of the following: a. Total dissolved solids exceeding 3,000 mg/L b. Natural or anthropogenic contamination (unrelated to a specific pollution incident) that cannot reasonably be treated for domestic use using either BMPs or best economically achievable treatment practices, or c. The water source does not provide a sustained yield of 200 gpd. Listed exceptions are overruled for each body of water in the Santa Ana Region's Basin Plan. The requirement appears to be relevant and appropriate because groundwater underlying the site meets the criteria as a potential source for drinking water.	Relevant and appropriate
Fish & Game Code §3503	This law prohibits taking, possession, or needless destruction of any bird nests and eggs, except as provided by the Fish and Game Code or regulations. Implementation of the final remedy will comply with this requirement.	Applicable
California Hazardous Waste Control Law, H&S Code Div. 20, Chap. 6.5	The California law is more stringent than federal hazardous waste law and is applied to this site. The following hazardous waste requirements are reviewed for application to the site.	Evaluation of the Hazardous Waste Control Law provided below

TABLE B-1
POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
SOUTH BASIN GROUNDWATER PROTECTION PROJECT
ORANGE COUNTY, CALIFORNIA

Requirements	Description	Applicable or Relevant and Appropriate
Identification and Listing of Hazardous Waste, 22 CCR Div. 4.5, Chap. 11 22 CCR §66264.13, 22 CCR §66260.200	A generator must determine if the waste is classified as a hazardous waste in accordance with the criteria provided in these requirements. Waste characteristics of treated soil and groundwater will be defined prior to treatment and disposal. This methodology to characterize waste at the site may result in some of the waste being identified as meeting the characteristics of hazardous waste. Any subsequent hazardous waste requirement would be relevant and appropriate or not an ARAR.	Applicable
Standards Applicable to Generators of Hazardous Waste 22 CCR Div. 4.5, Chap. 12 22 CCR Div. 4.5, Chap. 12	Waste transport offsite for treatment or disposal must obtain and use a hazardous waste manifest and comply with the DOT packaging, labeling, marking, and placarding requirements. Waste may be accumulated onsite for 90 days without a permit. Offsite actions and administrative requirements such as transport, manifesting, permitting, and record keeping are not applicable or relevant because ARARs address onsite activities. The purpose of the 90-day storage limit is to prevent creating a greater environmental hazard than already exists at the site. Waste contained onsite will be maintained in a container in good condition (see Use and Management of Containers) prior to offsite disposal.	Relevant and appropriate
Hazardous Waste Security, 22 CCR §66264.14	Any proposed treatment facility is anticipated to maintain a fence in good repair that completely surrounds the active portion of the facility. A locked gate at the facility should restrict unauthorized personnel entrance. The security standards to prevent entry from unauthorized personnel for the proposed remedial treatment alternatives should be applied.	Relevant and appropriate
Hazardous Waste Facility General Inspection Requirements and Personnel Training, 22 CCR §66264.15 – 66264.16	The hazardous waste facility standards require routine facility inspections conducted by trained hazardous waste facility personnel. Inspections are to be conducted at a frequency to detect malfunctions and deterioration, operator errors, and discharges that may be causing or leading to a hazardous waste release and a threat to human health or the environment. Relevant to the proposed treatment facilities for this site.	Relevant and appropriate
Preparedness and Prevention, 22 CCR Div. 4.5, Chap. 14, Art. 3	Facility design and operation to minimize potential fire, explosion, or unauthorized release of hazardous waste.	Relevant and appropriate
Water Quality Monitoring and Response Systems for Permitted Systems 22 CCR Div. 4.5, Chap. 14, Art. 6	The requirements present the groundwater monitoring system objectives and standards to evaluate the effectiveness of the corrective action program (remedial activities). After completion of the remedial activities and closure of the facility, groundwater monitoring will continue for additional years to ensure attainment of the remedial action objectives. This requirement is similar to 27 CCR §20410. Groundwater monitoring considered for the remedial alternatives.	Relevant and appropriate

TABLE B-1
POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
SOUTH BASIN GROUNDWATER PROTECTION PROJECT
ORANGE COUNTY, CALIFORNIA

Requirements	Description	Applicable or Relevant and Appropriate
Closure and Post-Closure, 22 CCR Div. 4.5, Chap. 14, Art. 7	The closure and post-closure requirements establish standards to minimize maintenance after facility closure to protect human health and the environment. The closure and post-closure requirements may be dependent upon the treatment alternatives. Clean closure of the treatment facility through equipment decontamination and removal of any hazardous waste is anticipated.	Relevant and appropriate
Use and Management of Containers 22 CCR Div. 4.5, Chap. 14, Art. 9	Maintain container and dispose to a Class I hazardous waste disposal facility within 90 days. Storage of investigation-derived waste (soil cuttings and well development) will be generated. Requirements may apply for the storage of contaminated groundwater and sediments trapped by the bag filter during startup operation. The 90-day storage limit is to not create a greater environmental hazard than already exists. Maintaining the containers in good condition at all times and not creating an environmental hazard is relevant and appropriate.	Relevant and appropriate
Tank Systems, 22 CCR Div. 4.5, Chap. 14, Art. 10	Minimum design standards (shell strength, foundation, structural support, pressure controls, and seismic considerations) for tank and ancillary equipment are established. The requirements for minimum shell thickness and pressure controls to prevent collapse or rupture is to not create a greater environmental hazard than already exists. The requirements are relevant and appropriate for the proposed treatment alternatives (22 CCR§ 66264.193).	Relevant and appropriate
Incinerators, 22 CCR Div. 4.5, Chap. 14, Art. 15	Performance standards, operation, operational monitoring, closure requirements for incinerators. Site-related contamination may be hazardous waste; however, not at levels required appropriate for this regulation.	To be determined
Corrective Action for Waste Management Units, 22 CCR Div. 4.5, Chap. 14, Art. 15.5	Establishes placement, consolidation, and treatment of soils and wastes being generated as part of a corrective action under RCRA and will not be considered a new disposal to land as long as the materials are handled in a CAMU.	To be determined
Miscellaneous Units Requirements 22 CCR Div. 4.5, Chap. 14, Art. 16, 22 CCR §66264.601 – 66264.603	Minimum performance standards are established for miscellaneous equipment to protect health and the environment. Treatment of hazardous waste through an air stripper or GAC would qualify as a RCRA miscellaneous unit if the contaminated water constituted a hazardous waste. Therefore, the requirements for miscellaneous units and related closure requirements may be relevant and appropriate for the site.	To be determined
Land Disposal Restrictions, Schedule for Land Disposal Prohibition and Establishment of Treatment Standards, 22 CCR Div. 4.5, Chap. 18, Art. 2	Provides a list of waste subject to land disposal restrictions. Only relevant if excavated or treatment residual wastes are classified as hazardous waste and disposed or treated ex situ and onsite outside the CAMU-designated area.	To be determined

TABLE B-1
POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
SOUTH BASIN GROUNDWATER PROTECTION PROJECT
ORANGE COUNTY, CALIFORNIA

Requirements	Description	Applicable or Relevant and Appropriate
Land Disposal Restrictions Prohibition on Land Disposal, 22 CCR Div. 4.5, Chap. 18, Art. 3	Provides waste-specific land disposal restrictions for solvent waste, dioxin-containing wastes, and California-Listed waste. Only relevant if excavated or treatment residual wastes are classified as hazardous waste and disposed or treated ex situ and onsite outside the CAMU-designated area.	To be determined
Land Disposal Restrictions Treatment Standards, 22 CCR Div. 4.5, Chap. 18, Art. 4	Provides treatment standards expressed in contaminant concentrations in waste extract, specified technologies, and waste treatment concentrations. Only relevant if excavated wastes are classified as hazardous wastes and disposed or treated ex situ and onsite outside the CAMU-designated area.	To be determined
Land Disposal Restrictions Prohibition on Storage, 22 CCR Div. 4.5, Chap. 18, Art. 5	Provides prohibition on storage of restricted waste. Only relevant if excavated wastes are classified as hazardous wastes and disposed or treated ex situ and onsite outside the CAMU-designated area.	To be determined
Land Disposal Restrictions, Land Disposal Prohibitions – Non-RCRA Wastes, 22 CCR Div. 4.5, Chap. 18, Art. 10	The requirements establish hazardous waste disposal standards through numerical treatment limitations and treatment technologies. Only relevant if excavated wastes are classified as hazardous wastes and disposed or treated ex situ and onsite outside the CAMU-designated area.	To be determined
Land Disposal Restrictions, Treatment Standards – Non-RCRA Waste Categories, 22 CCR Div. 4.5, Chap. 18, Art. 11	The requirements establish hazardous waste disposal standards through numerical treatment limitations and treatment technologies. Only applicable or relevant if excavated wastes are classified as hazardous wastes and disposed or treated ex situ and onsite outside the CAMU-designated area.	To be determined
SCAQMD Rules and Regulations	The SCAQMD regulations are established to achieve and maintain state and federal ambient air quality standards through the federal-approved SIP.	Evaluation of SCAQMD rules and regulations provided below
Regulation IV, Rule 401, Visible Emissions	Prohibitions on gross visible smoke emission exceeding Ringlemann standards, open burning, burn refuse, gross SOx and PM combustion contaminants, organic solvent emissions, SOx, NOx, and PM emissions from generators, circumvention of rules, and storage of organic liquids.	To be determined
Regulation IV, Rule 402, Nuisance	A person shall not discharge from any source whatsoever such quantities of air contaminants or other material that cause injury, detriment, nuisance, or annoyance to any considerable number of persons or to the public or that endanger the comfort, repose, health, or safety of any such persons or the public or that cause to have a natural tendency to cause injury or damage to business or property.	To be determined

TABLE B-1
POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
SOUTH BASIN GROUNDWATER PROTECTION PROJECT
ORANGE COUNTY, CALIFORNIA

Requirements	Description	Applicable or Relevant and Appropriate
Regulation IV, Rule 403, Fugitive Dust	Emissions of fugitive dust shall not remain visible in the atmosphere beyond the property line of the emission source. Activities conducted in the South Coast Air Basin shall use best available control measures to minimize fugitive dust emissions and take necessary steps to prevent the trackout of bulk material onto public paved roadways as a result of their operations.	To be determined
Regulation IV, Rule 404, Particulate Matter – Concentration	Particulate matter in excess of the concentration standard conditions shall not be discharged from any source. Particulate matter in excess of 450 mg/m3 (0.196 grain per cubic foot) in discharged gas, calculated as dry gas at standard conditions, shall not be discharged to the atmosphere from any source.	To be determined
Regulation IV, Rule 405, Solid Particulate Matter – Weight	Solid particulate matter including lead and lead compounds discharged into the atmosphere from any source shall not exceed the rates Table 450(a) of Rule 405. Nor shall solid particulate matter including lead and lead compounds in excess of 0.23 kg (0.5 lb) per 907 kg (2,000 lb) of process weight be discharged to the atmosphere. Emissions shall be averaged over one complete cycle of operation or 1 hour, whichever is the lesser time period.	To be determined
Regulation XIII, Rule 1303 – New Source Review	Construction for any relocation or for any new or modified source that results in an emission increase of any nonattainment air contaminant, any ozone-depleting compound, or ammonia must include BACT for the new or relocated source or for the actual modification to an existing source. This requirement would apply to treatment technologies with potential to emit primary pollutant(s) to the atmosphere.	To be determined
Regulation XIV, Rule 1401, New Source of Toxic Air Contaminants.	Construction or reconstruction of major stationary source emitting hazardous air pollutants shall be constructed with T-BACT and comply with all other applicable requirements.	To be determined
POTW Requirements	Treated effluent discharge to sanitary sewer will need to comply with any requirements set forth by the current POTW owner: Orange County Sanitation District.	To be determined

Acronyms/Abbreviations:

ARARs = Applicable or Relevant and Appropriate Requirements
BACT = Best Available Control Technology
BAT = Best Available Technology
BMPs = Best management practices
CAMU = Corrective Action Management Unit
CCR = California Code of Regulations
CFR = Code of Federal Regulations
COCs = Contaminants of concern
CWA = Clean Water Act
DOT = Department of Transportation

TABLE B-1
POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
SOUTH BASIN GROUNDWATER PROTECTION PROJECT
ORANGE COUNTY, CALIFORNIA

Requirements	Description	Applicable or Relevant and Appropriate

EPA = United States Environmental Protection Agency
ESA = Endangered Species Act
GAC = Granulated activated carbon
gpd = Gallons per day
H&S = Health and safety
kg = Kilogram
lb = Pound
MCLs = Maximum Contaminant Levels
mg/L = Milligrams per liter
mg/m3 = Milligram per cubic meter
NOx = Nitrogen oxides
NPDES = National Pollutant Discharge Elimination System
PM = Particulate matter
POTWs = Publicly Owned Treatment Works
RCRA = Resource Conservation and Recovery Act
RWQCB = Regional Water Quality Control Board
SBGPP = South Basin Groundwater Protection Project
SCAQMD = South Coast Air Quality Management District
SIP = State Implementation Plan
SOx = Sulfur oxides
SWRCB = State Water Resources Control Board
T-BACT = Best Available Control Technology for Toxics
U.S.C. = United States Code
WQOs = Water quality objectives

TABLE B-2
TO-BE-CONSIDERED DOCUMENTS
SOUTH BASIN GROUNDWATER PROTECTION PROJECT
ORANGE COUNTY, CALIFORNIA

Requirements	Description	Applicable or Relevant and Appropriate
The Designated Level Methodology for Waste Classification and Cleanup Level Determination	Provides guidance on how to classify wastes to meet SWRCB hazardous waste management requirements (23 CCR Div. 3, Chap. 15, Art. 2) and designated, nonhazardous, and inert waste management requirements (27 CCR Div. 2, Subdiv. 1, Chap. 3, Subchap. 2, Art. 2). Not considered as usually used to evaluate control of contaminants in the vadose zone.	Not Considered
Secondary Drinking Water Standards 22 CCR §64471	Secondary MCLs are applicable to public water system and establish aesthetic characteristics “at the tap” (that is, taste, odors, or appearance) of drinking water.	TBC
California NLs	NLs are health-based advisory levels established by the California Department of Health Services for contaminants that lack primary MCLs. NLs are advisory levels and not enforceable standards. A NL is the level of a contaminant in drinking water that is considered not to pose a significant health risk to people ingesting that water on a daily basis. It is calculated using standard risk assessment methods for noncancer and cancer endpoints, and typical exposure assumptions, including a 2-liter-per-day ingestion rate, a 70-kilogram adult body weight, and a 70-year lifetime. For 1,4-dioxane, a chemical considered a probable carcinogen and a COC at the Site, the NL is generally a level considered to pose “de minimis” risk (that is, a theoretical lifetime increase in risk of up to one excess case of cancer in a population of 1,000,000 people—the 10E-6 risk level).	TBC
California Well Standards California Department of Water Resources Bulletin 74-90	This is a supplement to Bulletin 74-81 (domestic water well standards) that addresses minimum specifications for monitor wells, extractions wells, injection wells, and exploratory borings. Design and construction specifications are considered for construction and destruction of wells and borings.	Applicable
California Department of Public Health Policy Guidance for Direct Domestic Use of Extremely Impaired Sources (Policy 97-005)	This policy establishes a process, including permitting, that must be followed before using an extremely impaired water source as a drinking water supply. This policy is not a promulgated requirement and would be included as a TBC for drinking water end use to the extent this is considered.	TBC

Acronyms/Abbreviations:

CCR = California Code of Regulations
COC = Contaminant of concern
MCLs = Maximum Contaminant Levels
NLs = Notification Levels
SWRCB = State Water Resources Control Board
TBC = To-be-considered

APPENDIX C
OU2 REMEDIAL ALTERNATIVES SUSTAINABILITY ASSESSMENT

Table C-1. SiteWise™ Sustainable Remediation - Environmental Footprint Summary
Alternative 2 - Monitored Natural Attenuation
Orange County Water District South Basin Groundwater Protection Project

Phase	Activities	GHG Emissions (metric ton)	Total Energy Used (MMBTU)	Electricity Usage (MWH)
Alt 2 Construction	Consumables	719	2.8E+05	NA
	Transportation-Personnel	31	3.9E+02	NA
	Transportation-Equipment	0.00	0.0E+00	NA
	Equipment Use and Misc	119	1.4E+03	0.00
	Residual Handling	6	1.0E+02	NA
	Sub-Total	875	2.79E+05	0.00
Alt 2 OMM	Consumables	0.00	0.0E+00	NA
	Transportation-Personnel	81	1.1E+03	NA
	Transportation-Equipment	0.00	0.0E+00	NA
	Equipment Use and Misc	9.8	1.3E+02	0.00
	Residual Handling	0.00	0.0E+00	NA
	Sub-Total	91	1.19E+03	0.00E+00
Total		**9.7E+02**	**2.8E+05**	**0.0E+00**

Remedial Alternative Phase	Non-Hazardous Waste Landfill Space (tons)	Hazardous Waste Landfill Space (tons)
Alt 2 Construction	2.4E+02	0.0E+00
Alt 2 OMM	0.0E+00	0.0E+00
Component 3	0.0E+00	0.0E+00
Component 4	0.0E+00	0.0E+00
Total	**2.4E+02**	**0.0E+00**

Table C-2. SiteWise™ Sustainable Remediation - Environmental Footprint Summary
Alternative 3 - Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS
Orange County Water District South Basin Groundwater Protection Project

Phase	Activities	GHG Emissions	Total Energy Used	Electricity Usage
		metric ton	MMBTU	MWH
Alt 3 Construction	Consumables	653	2.5E+05	NA
	Transportation-Personnel	28	3.5E+02	NA
	Transportation-Equipment	0.00	0.0E+00	NA
	Equipment Use and Misc	149	1.8E+03	0
	Residual Handling	71	1.3E+03	NA
	Sub-Total	901	2.54E+05	0.00
Alt 3 OMM	Consumables	1,787	2.0E+04	NA
	Transportation-Personnel	90	1.2E+03	NA
	Transportation-Equipment	0	0.0E+00	NA
	Equipment Use and Misc	10,446	2.5E+05	31,387
	Residual Handling	0.00	0.0E+00	NA
	Sub-Total	12,324	2.73E+05	31,386.82
Total		**1.3E+04**	**5.3E+05**	**3.1E+04**

Remedial Alternative Phase	Non-Hazardous Waste Landfill Space	Hazardous Waste Landfill Space
	tons	tons
Alt 3 Construction	4.6E+03	0.0E+00
Alt 3 OMM	0.0E+00	0.0E+00
Component 3	0.0E+00	0.0E+00
Component 4	0.0E+00	0.0E+00
Total	**4.6E+03**	**0.0E+00**

Table C-3. SiteWise™ Sustainable Remediation - Environmental Footprint Summary
Alternative 4 - Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to the Basal Sand
Orange County Water District South Basin Groundwater Protection Project

Phase	Activities	GHG Emissions	Total Energy Used	Electricity Usage
		metric ton	MMBTU	MWH
Alt 4 Construction	Consumables	701	2.7E+05	NA
	Transportation-Personnel	30	3.7E+02	NA
	Transportation-Equipment	0.00	0.0E+00	NA
	Equipment Use and Misc	225	2.6E+03	0.00
	Residual Handling	179	3.2E+03	NA
	Sub-Total	1,135	2.72E+05	0.00
Alt 4 OMM	Consumables	1,377	1.9E+04	NA
	Transportation-Personnel	140	1.8E+03	NA
	Transportation-Equipment	0.00	0.0E+00	NA
	Equipment Use and Misc	15,652	3.8E+05	47,017
	Residual Handling	0.00	0.0E+00	NA
	Sub-Total	17,169	3.99E+05	4.70E+04
Total		**1.8E+04**	**6.7E+05**	**4.7E+04**

Remedial Alternative Phase	Non-Hazardous Waste Landfill Space	Hazardous Waste Landfill Space
	tons	tons
Alt 4 Construction	1.2E+04	0.0E+00
Alt 4 OMM	0.0E+00	0.0E+00
Component 3	0.0E+00	0.0E+00
Component 4	0.0E+00	0.0E+00
Total	**1.2E+04**	**0.0E+00**

Table C-4. SiteWise™ Sustainable Remediation - Environmental Footprint Summary
Alternative 5 - In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation
Orange County Water District South Basin Groundwater Protection Project

Phase	Activities	GHG Emissions (metric ton)	Total Energy Used (MMBTU)	Electricity Usage (MWH)
Alt 5 Construction	Consumables	6,042	2.3E+06	NA
	Transportation-Personnel	259.77	3.3E+03	NA
	Transportation-Equipment	0.00	0.0E+00	NA
	Equipment Use and Misc	1,003	1.2E+04	0.00
	Residual Handling	70.58	1.1E+03	NA
	Sub-Total	7,375.71	2.35E+06	0.00
Alt 5 OMM	Consumables	150,072	2.4E+06	NA
	Transportation-Personnel	12,889	1.7E+05	NA
	Transportation-Equipment	0.00	0.0E+00	NA
	Equipment Use and Misc	917	1.1E+04	0.00
	Residual Handling	0.00	0.0E+00	NA
	Sub-Total	163,878	2.61E+06	0.00E+00
Total		**1.7E+05**	**5.0E+06**	**0.0E+00**

Remedial Alternative Phase	Non-Hazardous Waste Landfill Space (tons)	Hazardous Waste Landfill Space (tons)
Alt 5 Construction	2.6E+03	0.0E+00
Alt 5 OMM	0.0E+00	0.0E+00
Component 3	0.0E+00	0.0E+00
Component 4	0.0E+00	0.0E+00
Total	**2.6E+03**	**0.0E+00**

Table C-5. SiteWise™ Sustainable Remediation - Environmental Footprint Summary
Alternative 6 - Containment and In-Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with Discharge to POTW and GWRS
Orange County Water District South Basin Groundwater Protection Project

Phase	Activities	GHG Emissions (metric ton)	Total Energy Used (MMBTU)	Electricity Usage (MWH)
Alt 6 Construction	Consumables	2,133	8.2E+05	NA
	Transportation-Personnel	92	1.2E+03	NA
	Transportation-Equipment	0.00	0.0E+00	NA
	Equipment Use and Misc	394	4.7E+03	0.00
	Residual Handling	84	1.5E+03	NA
	Sub-Total	2,702.69	8.30E+05	0.00
Alt 6 OMM	Consumables	39,491	6.3E+05	NA
	Transportation-Personnel	3,795	5.0E+04	NA
	Transportation-Equipment	0.00	0.0E+00	NA
	Equipment Use and Misc	10,693	2.6E+05	31,387
	Residual Handling	0.00	0.0E+00	NA
	Sub-Total	53,980	9.36E+05	3.14E+04
Total		**5.7E+04**	**1.8E+06**	**3.1E+04**

Remedial Alternative Phase	Non-Hazardous Waste Landfill Space (tons)	Hazardous Waste Landfill Space (tons)
Alt 6 Construction	5.0E+03	0.0E+00
Alt 6 OMM	0.0E+00	0.0E+00
Component 3	0.0E+00	0.0E+00
Component 4	0.0E+00	0.0E+00
Total	**5.0E+03**	**0.0E+00**

APPENDIX D
DETAILED COST ESTIMATES FOR OU2 INTERIM REMEDIAL ALTERNATIVES

Table D-1. Alternatives Cost Summary

Alternative	Alternative Description		PDI Cost	Capital Cost	OMM Cost	Non-NPV Total Cost	NPV (2.5%) Total Cost[1]
	Approach	End Use					
1	No Action	No Action	$ -	$ -	$ -	$ -	$ -
2	MNA	N/A	$ 5,200,000	$ -	$ 26,400,000	$ 31,600,000	$ 24,600,000
3	GET	POTW	$ 3,100,000	$ 11,500,000	$ 31,200,000	$ 45,700,000	$ 35,800,000
4	GET	Injection	$ 3,600,000	$ 31,300,000	$ 43,600,000	$ 78,500,000	$ 64,000,000
5	ISCO	N/A	$ 7,500,000	$ 50,500,000	$ 424,600,000	$ 482,600,000	$ 348,600,000
6	GET/ISCO	POTW	$ 4,500,000	$ 24,300,000	$ 109,200,000	$ 138,100,000	$ 103,400,000
6a	GET/ISCO	POTW	$ 3,900,000	$ 17,400,000	$ 122,000,000	$ 143,300,000	$ 104,700,000

Notes:

[1] = The 2.5% discount rate is based on OCWD's financial personnel input and is the typical current discount rate used by OCWD for assessing longer-term projects.

GET = Groundwater Extraction and Treatment
ISCO = In-Situ Chemical Oxidation
MNA = Monitored Natural Attenuation
N/A = Not Applicable
NPV = Net Present Value
OMM = Operations, Maintenance and Monitoring
PDI = Pre-Design Investigation
POTW = Public Owned Treatment Works

Table D-2. Alternatives Annual Cost and Net Present Value Summary

Year	Cost per Year					
	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 6a
1	$ 5,158,504	$ 3,089,149	$ 3,589,149	$ 7,478,850	$ 4,525,641	$ 3,870,224
2	$ 1,612,197	$ 4,581,177	$ 18,773,089	$ 25,247,853	$ 9,739,412	$ 6,949,536
3	$ 1,372,628	$ 6,871,765	$ 12,515,392	$ 25,247,853	$ 14,609,118	$ 10,424,303
4	$ 1,372,628	$ 1,633,213	$ 2,165,675	$ 17,844,822	$ 4,931,705	$ 5,129,075
5	$ 1,372,628	$ 1,317,790	$ 1,745,393	$ 16,280,757	$ 4,312,578	$ 4,713,173
6	$ 1,748,197	$ 1,317,790	$ 1,745,393	$ 16,280,757	$ 4,312,578	$ 4,713,173
7	$ 747,334	$ 1,317,790	$ 1,745,393	$ 16,280,757	$ 4,312,578	$ 4,713,173
8	$ 747,334	$ 1,450,790	$ 1,883,393	$ 16,416,757	$ 4,445,578	$ 4,846,173
9	$ 747,334	$ 1,072,482	$ 1,535,252	$ 15,498,724	$ 3,924,512	$ 4,426,719
10	$ 747,334	$ 1,072,482	$ 1,535,252	$ 15,498,724	$ 3,924,512	$ 4,426,719
11	$ 1,003,119	$ 1,072,482	$ 1,535,252	$ 15,498,724	$ 3,924,512	$ 4,426,719
12	$ 747,334	$ 1,072,482	$ 1,535,252	$ 15,498,724	$ 3,924,512	$ 4,426,719
13	$ 747,334	$ 1,205,482	$ 1,673,252	$ 15,634,724	$ 4,057,512	$ 4,559,719
14	$ 747,334	$ 1,072,482	$ 1,535,252	$ 15,498,724	$ 3,924,512	$ 4,426,719
15	$ 747,334	$ 1,072,482	$ 1,535,252	$ 15,498,724	$ 3,924,512	$ 4,426,719
16	$ 1,003,119	$ 1,072,482	$ 1,535,252	$ 15,498,724	$ 3,924,512	$ 4,426,719
17	$ 747,334	$ 1,072,482	$ 1,535,252	$ 15,498,724	$ 3,924,512	$ 4,426,719
18	$ 747,334	$ 1,205,482	$ 1,673,252	$ 15,634,724	$ 4,057,512	$ 4,559,719
19	$ 747,334	$ 1,072,482	$ 1,535,252	$ 15,498,724	$ 3,924,512	$ 4,426,719
20	$ 747,334	$ 1,072,482	$ 1,535,252	$ 15,498,724	$ 3,924,512	$ 4,426,719
21	$ 1,003,119	$ 1,072,482	$ 1,535,252	$ 15,498,724	$ 3,924,512	$ 4,426,719
22	$ 747,334	$ 1,072,482	$ 1,535,252	$ 15,498,724	$ 3,924,512	$ 4,426,719
23	$ 747,334	$ 1,205,482	$ 1,673,252	$ 15,634,724	$ 4,057,512	$ 4,559,719
24	$ 747,334	$ 1,072,482	$ 1,535,252	$ 15,498,724	$ 3,924,512	$ 4,426,719
25	$ 747,334	$ 1,072,482	$ 1,535,252	$ 15,498,724	$ 3,924,512	$ 4,426,719
26	$ 1,003,119	$ 1,072,482	$ 1,535,252	$ 15,498,724	$ 3,924,512	$ 4,426,719
27	$ 747,334	$ 1,072,482	$ 1,535,252	$ 15,498,724	$ 3,924,512	$ 4,426,719
28	$ 747,334	$ 1,205,482	$ 1,673,252	$ 15,634,724	$ 4,057,512	$ 4,559,719
29	$ 747,334	$ 1,072,482	$ 1,535,252	$ 15,498,724	$ 3,924,512	$ 4,426,719
30	$ 747,334	$ 1,072,482	$ 1,535,252	$ 15,498,724	$ 3,924,512	$ 4,426,719
Total	$ 31,595,938	$ 45,706,075	$ 78,490,428	$482,594,331	$138,060,456	$143,278,648
Total NPV (2.5% Discount Rate)	$ 24,585,316	$ 35,789,546	$ 64,038,881	$ 348,637,727	$ 103,373,342	$ 104,678,835

Acronyms

% = Percent

NPV = Net Present Value

Table D-3. Alternative 2 - Monitored Natural Attentuation

Quick Reference		
PDI Costs	$	5,158,504
Capital Costs	$	-
OMM Costs	$	26,437,434
Grand Total	$	31,595,938

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
	PRE-DESIGN INVESTIGATION (Monitor Well Installation Only)					
MONITOR WELL INSTALLATION						
Monitor Wells	Layer 1 monitor well: 2" 40' PVC well with PVC Slotted Screen	60	per well	$ 12,719.00	$ 763,140	Southern California Contracted Unit Costs[1]
	Layer 2 monitor well: 2" 60' PVC well with PVC Slotted Screen	60	per well	$ 13,969.00	$ 838,140	Southern California Contracted Unit Costs[1]
	Layer 3 monitor well: 2" 80' PVC well with PVC Slotted Screen	60	per well	$ 15,318.00	$ 919,080	Southern California Contracted Unit Costs[1]
	Layer 4 monitor well: 2" 130' PVC well with PVC Slotted Screen	7	per well	$ 20,764.00	$ 145,348	Southern California Contracted Unit Costs[1]
	MONITOR WELL INSTALLATION SUBTOTAL				**$ 2,665,708**	
	Permitting	2%	of Monitor Well Installation Subtotal		$ 53,314.16	
	Remedial Design and Project Management (Sliding scale based on total estimate)	13%	of Monitor Well Installation Subtotal		$ 346,542.04	
	Construction Management (Sliding scale based on total estimate)	6%	of Monitor Well Installation Subtotal		$ 159,942.48	
	Scope (20%) and Bid Contingency (15%)	35%	of Monitor Well Installation Subtotal		$ 932,997.80	
	MONITOR WELL SYSTEM TOTAL				**$ 4,158,504**	
INVESTIGATION						
Testing	Sampling, hydraulic testing, and documentation	1	total	$ 1,000,000	$ 1,000,000	ROM estimate
	INVESTIGATION TOTAL				**$ 1,000,000**	
	GRAND TOTAL PDI COST				**$ 5,158,504**	
	OPERATION, MAINTENANCE, AND MONITORING (OMM)					
OPERATION						
Other	Institutional controls/Sealing legacy water supply wells	29	year	$ 50,000.00	$ 1,450,000	Instituational controls/Sealing wells
Permits/Access	Well Easement, Monitor Wells	5,220	well	$ 303.00	$ 1,581,660	Fullerton license fee, assumed typical for cities in OC
	OPERATION SUBTOTAL A (Not including Permits/Access)				**$ 1,450,000**	
	Project Management (Sliding scale based on total estimate)	10%	of Operation Subtotal A		$ 145,000	
	Scope (15%) and Bid Contingency (10%)	25%	of Operation Subtotal A		$ 362,500	
	OPERATION SUBTOTAL B (Permit/Access)				**$ 1,581,660**	
	OPERATION TOTAL				**$ 3,539,160**	

Table D-3. Alternative 2 - Monitored Natural Attentuation

Quick Reference		
PDI Costs	$	5,158,504
Capital Costs	$	-
OMM Costs	$	26,437,434
Grand Total	$	31,595,938

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
MONITORING AND REPORTING						
Monitoring	MNA sampling year 2	374	sample	$ 2,796.00	$ 1,045,704	Southern California Contracted Unit Costs[1]
	MNA sampling years 3-5, reduced analyte list	1,122	sample	$ 2,325.00	$ 2,608,650	Southern California Contracted Unit Costs[1]
	MNA sampling year 6	374	sample	$ 2,796.00	$ 1,045,704	Southern California Contracted Unit Costs[1]
	MNA sampling every 5 years starting year 11	748	sample	$ 2,796.00	$ 2,091,408	Southern California Contracted Unit Costs[1]
	MNA sampling other years up to year 30, reduced analyte list	3,740	sample	$ 2,325.00	$ 8,695,500	Southern California Contracted Unit Costs[1]
Reporting	Monitoring report years 2-6	10	report	$ 25,000.00	$ 250,000	ROM estimate
	Monitoring report years 7-30	24	report	$ 25,000.00	$ 600,000	ROM estimate
	Five-year Remedy Review	5	report	$ 100,000.00	$ 500,000	ROM estimate

MONITORING SUBTOTAL			**$ 16,836,966**
Project Management (Sliding scale based on total estimate)	6%	of monitoring Subtotal	$ 1,010,218
Scope (20%) and Bid Contingency (10%)	30%	of monitoring Subtotal	$ 5,051,090
MONITORING TOTAL			**$ 22,898,274**
GRAND TOTAL OMM COST			**$ 26,437,434**

Notes:

1. Southern California Contracted Unit Costs reflect actual contracted costs for similar work items at other Southern California environmental investigation/remediation sites.

MNA = Monitored Natural Attenuation
OC = Orange County
OMM = Operations, Maintenance and Monitoring
PDI = Pre-Design Investigation
PVC = Polyvinyl Chloride
ROM = Rough Order of Magnitude

Table D-4. Alternative 3 - Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS

Quick Reference		
PDI Costs	$	3,089,149
Capital Costs	$	11,452,942
OMM Costs	$	31,163,985
Grand Total	$	45,706,075

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
PRE-DESIGN INVESTIGATION (Monitor Well Installation Only)						
MONITOR WELL INSTALLATION						
Monitor Wells	Layer 1 monitor well: 2" 40' PVC well with PVC Slotted Screen	36	per well	$ 12,719.00	$ 457,884	Southern California Contracted Unit Costs[1]
	Layer 2 monitor well: 2" 60' PVC well with PVC Slotted Screen	34	per well	$ 13,969.00	$ 474,946	Southern California Contracted Unit Costs[1]
	Layer 3 monitor well: 2" 80' PVC well with PVC Slotted Screen	20	per well	$ 15,318.00	$ 306,360	Southern California Contracted Unit Costs[1]
	Layer 4 monitor well: 2" 130' PVC well with PVC Slotted Screen	4	per well	$ 20,764.00	$ 83,056	Southern California Contracted Unit Costs[1]
	MONITOR WELL INSTALLATION SUBTOTAL				**$ 1,322,246**	
	Permitting	2%	of Monitor Well Installation Subtotal		$ 26,445	
	Remedial Design and Project Management (Sliding scale based on total estimate)	18%	of Monitor Well Installation Subtotal		$ 238,004	
	Construction Management (Sliding scale based on total estimate)	8%	of Monitor Well Installation Subtotal		$ 105,780	
	Scope (15%) and Bid Contingency (15%)	30%	of Monitor Well Installation Subtotal		$ 396,674	
	MONITOR WELL SYSTEM TOTAL				**$ 2,089,149**	
INVESTIGATION						
Testing	Sampling, hydraulic testing, and documentation	1	total	$ 1,000,000.00	$ 1,000,000	ROM estimate
	INVESTIGATION TOTAL				**$ 1,000,000**	
	GRAND TOTAL PDI COST				**$ 3,089,149**	
CAPITAL COSTS (Design and Construction)						
WELL AND CONVEYANCE SYSTEM COSTS						
Extraction Wells	4" 40' PVC well with SS WW Screen	3	per well	$ 20,076	$ 60,228	Southern California Contracted Unit Costs[1]
	4" 60' PVC well with SS WW Screen	39	per well	$ 23,304	$ 908,856	Southern California Contracted Unit Costs[1]
	4" 80' PVC well with SS WW Screen	33	per well	$ 26,959	$ 889,647	Southern California Contracted Unit Costs[1]
Extraction Well Pumps and Well Head Ancillaries	Pumps, Traffic Vaults, Valves, Gauges, Flow Meters/Totalizer, Transmitter, Local Control Panels (motor, instrument), Instrumentation	75	per well	$ 25,000	$ 1,875,000	Includes installation, engineer estimate
Extraction System Power Drops	Power drop, Internet, PLC for distribution to wells at each transect	9	per transect	$ 70,000	$ 630,000	ROM estimate
Water Pipelines	Pipeline (0-10 gpm); 1"x3"; DCHDPE	850	1 ft	$ 124.36	$ 105,703	Calculated from RSMeans Data 2020 and material prices
	Pipeline (11-40 gpm); 2"x4"; DCHDPE	4550	1 ft	$ 132.19	$ 601,474	Calculated from RSMeans Data 2020 and material prices
	Pipeline (41-100 gpm); 3"x6"; DCHDPE	5400	1 ft	$ 150.20	$ 811,093	Calculated from RSMeans Data 2020 and material prices

Table D-4. Alternative 3 - Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS

Quick Reference		
PDI Costs	$	3,089,149
Capital Costs	$	11,452,942
OMM Costs	$	31,163,985
Grand Total	$	45,706,075

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
	WELL AND CONVEYANCE SYSTEM				**$ 5,882,002**	
	Permits	2%	Of well and conveyance		$ 117,640	
	Remedial Design and Project Management (Sliding scale based on total estimate)	13%	Of well and conveyance		$ 764,660	
	Construction Management (Sliding scale based on total estimate)	6%	Of well and conveyance		$ 352,920	
	Scope (15%) and Bid Contingency (15%)	30%	Of well and conveyance		$ 1,764,601	
	CONVEYANCE AND EXTRACTION WELL SYSTEM TOTAL				**$ 8,881,823**	
TREATMENT PLANT						
Bag Filter System	Duplex filter system up to 100 gpm capacity; 304SS	6	unit	$ 4,500.00	$ 27,000	PRM Filtration, online pricing
	Single filter system, up to 50 gpm capacity; 304SS	3	unit	$ 910.00	$ 2,730	PRM Filtration, online pricing
	Instrumentation and Control	1	unit	$ 2,000	$ 2,000	Engineer Estimate
GAC System	Lead-lag GAC vessels PV-500 (pre-filled), with manifold	1	unit	$ 22,400.00	$ 22,400	Evoqua quote 8/21/2022 and 25% for manifold
	Lead-lag GAC vessels PV-1000 (pre-filled), with manifold	2	unit	$ 25,800.00	$ 51,600	Evoqua quote 8/21/2022 and 25% for manifold
	Lead-lag GAC vessels PV-2000 (pre-filled), with manifold	5	unit	$ 31,900.00	$ 159,500	Evoqua quote 8/21/2022 and 25% for manifold
Concrete Slab and Roof Canopy	Concrete for system; 10x10x2ft slab	9	slab	$ 1,440	$ 12,960	RS Means 03 30 53.40 4900 Page 80, 2020 Edition
	Concrete for GAC vessels; 12x10x2ft slab	1	slab	$ 1,728	$ 1,728	RS Means 03 30 53.40 4900 Page 80, 2020 Edition
	Concrete for GAC vessels; 15x12x2ft slab	7	slab	$ 2,592	$ 18,144	RS Means 03 30 53.40 4900 Page 80, 2020 Edition
	Roof canopy - corrugated metal 10x10ft canopy for GAC vessels	9	unit	$ 1,500	$ 13,500	Online pricing - 6/18/2021
	Roof canopy - corrugated metal 12x10ft canopy	1	unit	$ 1,800	$ 1,800	Online pricing - 6/18/2021
	Roof canopy - corrugated metal 15x12ft canopy for GAC vessels	7	unit	$ 2,700	$ 18,900	Online pricing - 6/18/2021
Sewer Connection	Sewer connection installation, energy dissipaton box, manhole, instantaeous/totalizing flow meter, sampling station	9	unit	$ 25,000	$ 225,000	Includes installation, engineer estimate
	City Sewer Connection fee	9	per connection	$ 7,000	$ 63,000	Estimate
	OCSD SPDP Application Fee	9	per connection	$ 1,138	$ 10,242	OSCD Fee Sheet
	TREATMENT PLANT SUBTOTAL A				**$ 332,262**	
	Installation cost for bag filter system, slab and roof canopy (assume 3 times unit cost)	3	of above		$ 996,786	
	TREATMENT PLANT- EQUIPMENT/MATERIAL INSTALLED SUBTOTAL B				**$ 1,329,048**	
	TREATMENT PLANT - SEWER CONNECTION COSTS SUBTOTAL C				**$ 298,242**	
	TREATMENT PLANT SUBTOTAL D (Subtotal B+Subtotal C)				**$ 1,627,290**	
	Permits	2%	of Subtotal D		$ 32,546	
	Remedial Design and Project Management (Sliding scale based on total estimate)	18%	of Subtotal D		$ 292,912	
	Construction Management (Sliding scale based on total estimate)	8%	of Subtotal D		$ 130,183	
	Scope (15%) and Bid Contingency (15%)	30%	of Subtotal D		$ 488,187	
	TREATMENT PLANT TOTAL				**$ 2,571,118**	
	GRAND TOTAL CAPITAL COST				**$ 11,452,942**	

Table D-4. Alternative 3 - Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS

Quick Reference		
PDI Costs	$	3,089,149
Capital Costs	$	11,452,942
OMM Costs	$	31,163,985
Grand Total	$	45,706,075

OPERATION, MAINTENANCE, AND MONITORING (OMM)

OPERATION

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
Utilities	Electricity (1hp extraction pumps, Annual Operation, 90% uptime)	13,227,972	kWh	$ 0.12	$ 1,587,357	
	Data/internet Line (for 9 locations)	2,916	months	$ 100	$ 291,600	
Consumables	Bag filters, 2 bags per month per system	5,832	bags	$ 15	$ 87,480	
	GAC changeout PV-500, first 5 years	4	unit	$ 2,950	$ 11,800	Evoqua quote 8/21/2022
	GAC changeout PV-1000, first 5 years	8	unit	$ 3,550	$ 28,400	Evoqua quote 8/21/2022
	GAC changeout PV-2000, first 5 years	48	unit	$ 4,575	$ 219,600	Evoqua quote 8/21/2022
	GAC changeout PV-500, 0.5 changeout a year, after 5 years	22	unit	$ 2,950	$ 64,900	Evoqua quote 8/21/2022
	GAC changeout PV-1000, 1 changeout a year, after 5 years	22	unit	$ 3,550	$ 78,100	Evoqua quote 8/21/2022
	GAC changeout PV-2000, 1 changeout a year, after 5 years	132	unit	$ 4,575	$ 603,900	Evoqua quote 8/21/2022
Permits/Access	Well Easement, Monitor and Extraction Wells	4,563	well	$ 303.00	$ 1,382,589	Fullerton license fee, assumed typical for cities in OC
	Pipeline Easement Fee	291,600	l ft	$ 4.85	$ 1,414,260	Fullerton license fee, assumed typical for cities in OC
	OCSD SPDP Renewal Fee, $795 per 2 years, per permit	126	$/(2 years)	$ 795	$ 100,170	2021-2022 OCSD Fee Schedule
	OCSD Special Purpose Discharge Permit (extraction volume, backwash, well development discharge)	5,171	$/MGal	$ 1,601	$ 8,279,520	2021-2022 OCSD Fee Schedule
	Replenishment Assessment	0	acre-foot (100% extracted volume)	$ 504	$ -	Assessment requirement waived
	Basin Equity Assessment	0	acre-foot (23% extracted volume)	$ 578	$ -	Assessment requirement waived
Routine OMM	Operations Technician, 1 visit per 2 weeks, 20 hours per visit	14,040	hours	$ 100	$ 1,404,000	Estimate
Non-Routine OMM	Percent of treatment system cost and well equipment costs	1%	percent per year	$ 4,446,118	$ 1,200,452	
Other	Institutional controls/Sealing legacy water supply wells	27	year	$ 50,000.0	$ 1,350,000	Instituational controls/Sealing wells

OPERATION SUBTOTAL A (Not including Permits/Access)			**$ 6,927,589**
Project Management (Sliding scale based on total estimate)	8%	of Operation Subtotal	$ 554,207
Scope (15%) and Bid Contingency (15%)	30%	of Operation Subtotal	$ 2,078,277
OPERATION SUBTOTAL B (Permit/Access)			**$ 11,176,539**
OPERATION TOTAL			**$ 20,736,612**

MAINTENANCE

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
Development	Extraction well development	375	per day	$ 2,853.5	$ 1,070,063	Southern California Contracted Unit Costs[1]

MAINTENANCE SUBTOTAL			**$ 1,070,063**
Project Management (Sliding scale based on total estimate)	10%	of Maintenance Subtotal	$ 107,006
Construction Management (Sliding scale based on total estimate)	8%	of Maintenance Subtotal	$ 85,605
Scope (15%) and Bid Contingency (15%)	30%	of Maintenance Subtotal	$ 321,019
MAINTENANCE TOTAL			**$ 1,583,693**

Table D-4. Alternative 3 - Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS

Quick Reference		
PDI Costs	$	3,089,149
Capital Costs	$	11,452,942
OMM Costs	$	31,163,985
Grand Total	$	45,706,075

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
MONITORING AND REPORTING						
Monitoring	VOC & 1,4-Dioxane sampling year 4	376	sample	$ 1,354	$ 509,104	Southern California Contracted Unit Costs[1]
	VOC & 1,4-Dioxane sampling years 5-8	752	sample	$ 1,354	$ 1,018,208	Southern California Contracted Unit Costs[1]
	VOC & 1,4-Dioxane sampling years 9-30	2068	sample	$ 1,354	$ 2,800,072	Southern California Contracted Unit Costs[1]
	Sewer discharge semi-annual monitoring per transect, years 4-30	486	sample	$ 500	$ 243,000	Southern California laboratory costs
Reporting	Monitoring report year 4	4	report	$ 25,000	$ 100,000	ROM estimate
	Monitoring report years 5-8	8	report	$ 25,000	$ 200,000	ROM estimate
	Monitoring report years 9-30	22	report	$ 25,000	$ 550,000	ROM estimate
	Five-year Remedy Review	5	report	$ 100,000	$ 500,000	ROM estimate
	Sewer discharge semi-annual reporting per transect, years 4-30	486	report	$ 1,500	$ 729,000	ROM estimate

MONITORING AND REPORTING SUBTOTAL			**$ 6,649,384**
Project Management (Sliding scale based on total estimate)	8%	of Maintenance Subtotal	$ 531,951
Scope (15%) and Bid Contingency (10%)	25%	of Maintenance Subtotal	$ 1,662,346
MONITORING TOTAL			**$ 8,843,681**
GRAND TOTAL OMM COST			**31,163,985**

Notes:

1. Southern California Contracted Unit Costs reflect actual contracted costs for similar work items at other Southern California environmental investigation/remediation sites.

DCHDPE = Double Contained High Density Polyethylene
gpm = gallons per minute
GAC = Granular Activated Carbon
hp = horsepower
kWh = kilowatt hours
l ft = lineal feet
Mgal = Million Gallons
MNA = Monitored Natural Attenuation
OC = Orange County
OCSD = Orange County Sanitation District
OMM = Operations, Maintenance and Monitoring
PDI = Pre-Design Investigation
PVC = Polyvinyl Chloride
ROM = Rough Order of Magnitude
SPDP = Special Purpose Discharge Permit
SS = Stainless Steel
VOC = Volatile Organic Compound
WW = Wire Wrap

Table D-5. Alternative 4 - Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to Basal Sand

Quick Reference		
PDI Costs	$	3,589,149
Capital Costs	$	31,288,481
OMM Costs	$	43,612,798
Grand Total	$	78,490,428

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
	PRE-DESIGN INVESTIGATION					
MONITOR WELL INSTALLATION						
Monitor Wells	Layer 1 monitor well: 2" 40' PVC well with PVC Slotted Screen	36	per well	$ 12,719	$ 457,884	Southern California Contracted Unit Costs[1]
	Layer 2 monitor well: 2" 60' PVC well with PVC Slotted Screen	34	per well	$ 13,969	$ 474,946	Southern California Contracted Unit Costs[1]
	Layer 3 monitor well: 2" 80' PVC well with PVC Slotted Screen	20	per well	$ 15,318	$ 306,360	Southern California Contracted Unit Costs[1]
	Layer 4 monitor well: 2" 130' PVC well with PVC Slotted Screen	4	per well	$ 20,764	$ 83,056	Southern California Contracted Unit Costs[1]
	MONITOR WELL INSTALLATION SUBTOTAL				**$ 1,322,246**	
	Permitting	2%	of Monitor Well Installation Subtotal		$ 26,445	
	Remedial Design and Project Management (Sliding scale based on total estimate)	18%	of Monitor Well Installation Subtotal		$ 238,004	
	Construction Management (Sliding scale based on total estimate)	8%	of Monitor Well Installation Subtotal		$ 105,780	
	Scope (15%) and Bid Contingency (15%)	30%	of Monitor Well Installation Subtotal		$ 396,674	
	MONITOR WELL SYSTEM TOTAL				**$ 2,089,149**	
INVESTIGATION						
Testing	Sampling, hydraulic testing, and documentation	1	total	$ 1,500,000	$ 1,500,000	ROM estimate
	INVESTIGATION TOTAL				**$ 1,500,000**	
	GRAND TOTAL PDI COST				**$ 3,589,149**	
	CAPITAL COSTS (Design and Construction)					
EXRACTION AND INJECTION WELLS AND CONVEYANCE SYSTEM COSTS						
Extraction Wells	4" 40' PVC well with SS WW Screen	3	per well	$ 20,076	$ 60,228	Southern California Contracted Unit Costs[1]
	4" 60' PVC well with SS WW Screen	39	per well	$ 23,304	$ 908,856	Southern California Contracted Unit Costs[1]
	4" 80' PVC well with SS WW Screen	33	per well	$ 26,959	$ 889,647	Southern California Contracted Unit Costs[1]
Injection Wells	6" 130' PVC well with SS WW Screen	10	well	$ 41,079	$ 410,790	Southern California Contracted Unit Costs[1]
Extraction Well Pumps and Well Head Ancillaries	Pumps, Traffic Vaults (3'x5'), Valves, Gauges, Flow Meters/Totalizer, Transmitter, Local Control Panels (motor, instrument), Instrumentation (level)	75	per well	$ 25,000	$ 1,875,000	Engineer estimate, includes installation
	Power drop, Internet, PLC for distribution to wells at each transect	9	per transect	$ 70,000	$ 630,000	Engineer estimate, includes installation
Injection Well Head Ancillaries	Vaults (3'x5'), Valves, Gauges, Flow Meters/Totalizers, relief valves, Local Control Panel, Instrumentation	10	per well	$ 25,000	$ 250,000	See REF - Well Construction Costs
	Power drop, Internet, PLC for distribution to wells at each injection area	2	per inj area	$ 70,000	$ 140,000	Engineer estimate
Water Pipelines	Collection Pipeline (0-10 gpm); 1"x3"; DCHDPE	250	1 ft	$ 124	$ 31,089	Calculated from RSMeans Data 2020 and material prices
	Collection Pipeline (11-40 gpm); 2"x4"; DCHDPE	2950	1 ft	$ 132	$ 389,967	Calculated from RSMeans Data 2020 and material prices
	Collection Pipeline (41-100 gpm); 3"x6"; DCHDPE	6450	1 ft	$ 150	$ 968,806	Calculated from RSMeans Data 2020 and material prices
	Collection Pipeline (101-180 gpm); 4"x8"; DCHDPE	2200	1 ft	$ 186	$ 409,993	Calculated from RSMeans Data 2020 and material prices
	Collection Pipeline (181-400 gpm); 6"x10"; DCHDPE	12850	1 ft	$ 233	$ 2,992,821	Calculated from RSMeans Data 2020 and material prices
	Injection Pipeline (101-180 gpm); 4"; HDPE	5000	1 ft	$ 109	$ 544,950	Calculated from RSMeans Data 2020 and material prices

Table D-5. Alternative 4 - Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to Basal Sand

Quick Reference		
PDI Costs	$	3,589,149
Capital Costs	$	31,288,481
OMM Costs	$	43,612,798
Grand Total	$	78,490,428

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
	WELL AND CONVEYANCE SYSTEM				**$ 10,502,147**	
	Permits	2%	Of well and conveyance		$ 210,043	
	Remedial Design and Project Management (Sliding scale based on total estimate)	11%	Of well and conveyance		$ 1,155,236	
	Construction Management (Sliding scale based on total estimate)	6%	Of well and conveyance		$ 630,129	
	Scope (15%) and Bid Contingency (15%)	30%	Of well and conveyance		$ 3,150,644	
	CONVEYANCE AND WELL SYSTEM TOTAL				**$ 15,648,199**	
GROUNDWATER TREATMENT PLANT						
Filtration	Multistrainer particulate filter	2	each	$ 18,500	$ 37,000	Pentek HIF 150FL (400-600 gpm)
Liquid Phase Granular Activated Carbon	2 vessel lead/lag system (2-5,000 lb units, package system includes valves, backwash system and tank, instrumentation and control, fully automated); 12' diameter x 5'; CS	1	unit	$ 220,000	$ 220,000	EPA GAC Model, direct cost (not including building, initial GAC)
	Carbon media initial fill	10,000	cu ft	$ 1.84	$ 18,400	EPA GAC Model
Untreated Water Tank	Fiberglass, 5,300 gal	1	tank	$ 13,500	$ 13,500	Online estimate - 6/18/2021
AOP Feed Pumps	240/460 V, 7.5 hp centrifugal pump, 180 gpm @ 90ft, Goulds; 3" x 2.5", CS / Buna-	2	pump	$ 3,300	$ 6,600	Online estimate - 6/22/2021
AOP System	UV/H2O2 Reactor. Complete system including auto sleeve wiper system, local panel control, H2O2 tank and dosing/injection system.	1	reactor	$ 352,000	$ 352,000	EA estimate, 2013 Trojan quote, 2.5log reduction; inflation escalated to 2021 (ave US inflation 1.5%)
Reverse Osmosis System	Reverse Osmosis Train and Peripherals (complete package, includes Feed pumps; Dosing and tank systems for pH adjustment, Anti-scalant, calcium chloride, fully automatedetc)	1	system	$ 784,400	$ 784,400	EPA RO Model, direct cost, without building
Treatment Building	Treatment Building, 2130 sq ft, mid-cost	1	each	$ 250,000	$ 250,000	EPA RO Model, direct cost, building only, plus 25% for additional treatment units
Concentrate Tank	Fiberglass, 5300 gal	1	tank	$ 13,500	$ 13,500	Online estimate - 6/18/2021
Product Water Tank	Fiberglass, 20,000 gal	1	tank	$ 30,000	$ 30,000	Online estimate - 6/18/2021
Utility Tank	Fiberglass, 10,000 gal	1	tank	$ 21,000	$ 21,000	Online estimate - 6/18/2021
Injection Pump	240/460 V, 10 hp centrifugal pump, 150 gpm @ 190 ft, Goulds; 2" x 1.5"; CS /	2	pump	$ 3,400	$ 6,800	Online pricing - 6/22/201
Concentrate Pump	240/460 V, 1 hp centrifugal pump, 96 gpm @ 61 ft, Goulds; 1-1/4" x 1"; SS / Buna-	1	pump	$ 1,200	$ 1,200	Online estimate - 5/24/2021
Sewer Connection	Sewer connection installation, energy dissipaton box, manhole, instantaeous/totalizing flow meter, sampling station	1	unit	$ 25,000	$ 25,000	Includes installation, engineer estimate
	City Sewer Connection fee	1	per connection	$ 7,000	$ 7,000	Estimate
	OCSD SPDP Application Fee	1	per connection	$ 1,138	$ 1,138	OSCD Fee Sheet
	TREATMENT PLANT RAW EQUIPMENT (not RO or building) SUBTOTAL A				**$ 720,000**	
	Installation of RAW Equipment, Assume 2 times Subtoal A	2	of Subtotal A		$ 1,440,000	
	TREATMENT PLANT (RO and building) SUBTOTAL B				**$ 1,034,400**	
	TREATMENT PLANT- EQUIPMENT/MATERIAL INSTALLED SUBTOTAL C				**$ 3,194,400**	
	TREATMENT PLANT - SEWER CONNECTION SUBTOTAL D				**$ 33,138**	
	TREATMENT PLANT SUBTOTAL E (Subtotals C+D)				**$ 3,227,538**	
	Permits	2%	of Subtotal E		$ 64,551	
	Remedial Design and Project Management (Sliding scale based on total estimate)	13%	of Subtotal E		$ 419,580	
	Construction Management (Sliding scale based on total estimate)	6%	of Subtotal E		$ 193,652	
	Scope (25%) and Bid Contingency (15%)	40%	of Subtotal E		$ 1,291,015	
	TREATMENT PLANT TOTAL				**$ 5,196,336**	

PROPERTY FOR TREATMENT PLANT

Table D-5. Alternative 4 - Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to Basal Sand□

Quick Reference		
PDI Costs	$	3,589,149
Capital Costs	$	31,288,481
OMM Costs	$	43,612,798
Grand Total	$	78,490,428

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
Treatment System Property	1-acre property, Santa Ana, Purchase	43560	sq ft	$ 222	**$ 9,670,320**	Online estimate, industrial property - 6/29/2021. https://commercialorangecounty.com/santa-ana-commercial-real-estate-sale-lease/
	Site Prep Work	8%			**$ 773,626**	ROM Cost

PROPERTY TOTAL	**$ 10,443,946**
GRAND TOTAL CAPITAL COST	**$ 31,288,481**

OPERATION, MAINTENANCE, AND MONITORING (OMM)

OPERATION

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
Utilities	Electricity (1 hp Extraction pumps, Annual Operation, 90% uptime)	13,227,972	kWh	$ 0.12	$ 1,587,357	
	Electricity (7.5kW AOP System)	1,951,290	kWh	$ 0.12	$ 234,155	
	Electricity (54.3kW RO System)	12,852,000	kWh	$ 0.12	$ 1,542,240	EPA RO Model, not including building electricity
	Electricity (40hp Transfer Pumps)	7,054,919	kWh	$ 0.12	$ 846,590	
	Electricity (Lights and Control System)	1,182,600	kWh	$ 0.12	$ 141,912	
Consumables	Bag Filters	162	ea	$ 500	$ 81,000	Engineer estimate. 6 per year
	Carbon Usage (change-out non-hazardous, 12 month life)	135,000	lb	$ 2	$ 248,400	EPA RO Model unit cost
	UV Lamps; 0.25kW	81	each	$ 13,000	$ 1,053,000	Annualized lamp replacment costs
	Chemicals (hydrogen peroxide 27% solution, to makeup 16 ppm dose) assume 30 gal/day	287,550	gal	$ 3	$ 833,895	
	Cartridge filters, 2 per month	648	each	$ 30	$ 19,440	
	Sulfuric Acid	4,050,000	lb	$ 0	$ 1,255,500	EPA RO Model
	Anti-Scalant	162,000	lb	$ 3	$ 417,960	EPA RO Model
	Membrane Cleaner	2,430	gal	$ 30	$ 72,900	EPA RO Model
	Membrane replacement	27	per year	$ 14,000	$ 378,000	EPA RO Model
Permits/Access	Well Easement, Monitor, Extration and Injection	4,833	wells	$ 303	$ 1,464,399	Fullerton license fee, assumed typical for cities in OC
	Pipeline Easement Fee	1,027,350	l ft	$ 5	$ 4,982,648	Fullerton license fee, assumed typical for cities in OC
	Waste Discharge Permit fee, per permit (assuming general WDR TTWQ and CPLX rating of 3-A)	0	per year	$ 5,000	$ -	This General WDR is currently not available, RWQCB may renew, as of end of 2020 had not. Must have Se<5-6 ug/l.
	Waste Discharge Permit fee, individual (assuming General WDR not available or applicable)	27	per year	$ 11,000	$ 297,000	
	OCSD SPDP Renewal Fee, $795 per 2 years, per permit	14	$/(2 years)	$ 795	$ 11,130	
	OCSD SPDP (RO concentrate, backwash, well development discharge)	1,350	$/MGal	$ 1,601	$ 2,161,350	2020-2021 OCSD Fee Schedule
	Replenishment Assessment (for RO brine disposal)	0	acre-foot (RO reject)	$ 504	$ -	Assessment requirement waived
	Basin Equity Assessment (for RO brine diposal)	0	acre-foot (23% RO reject)	$ 578	$ -	Assessment requirement waived
Routine OMM	Operations technical, assume full time on-site staff of 1	54,000	hours	$ 100	$ 5,400,000	Estimate
Other	Institutional controls/Sealing legacy water supply wells	27	year	$ 50,000	$ 1,350,000	Instituational controls/Sealing wells
	Property tax	27	year	$ 96,703	$ 2,610,986	

Table D-5. Alternative 4 - Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using Groundwater Extraction and Treatment with Injection to Basal Sand

Quick Reference		
PDI Costs	$	3,589,149
Capital Costs	$	31,288,481
OMM Costs	$	43,612,798
Grand Total	$	78,490,428

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
	OPERATION SUBTOTAL A (Not including Permits/Access)				**$ 18,073,335**	
	Project Management (Sliding scale based on total estimate)	6%	of Operation Subtotal		$ 1,084,400	
	Scope (15%) and Bid Contingency (15%)	30%	of Operation Subtotal		$ 5,422,001	
	OPERATION SUBTOTAL B (Permit/Access)				**$ 8,916,527**	
	OPERATION TOTAL				**$ 33,496,262**	
MAINTENANCE						
Development	Extraction well development	375	per day	$ 2,854	$ 1,070,063	Southern California Contracted Unit Costs[1]
	Groundwater injection well development	130	per day	$ 2,854	$ 370,955	Southern California Contracted Unit Costs[1]
	MAINTENANCE SUBTOTAL				**$ 1,441,017.50**	
	Project Management (Sliding scale based on total estimate)	10%	of Maintenance Subtotal		$ 144,102	
	Construction Management (Sliding scale based on total estimate)	8%	of Maintenance Subtotal		$ 115,281	
	Scope (15%) and Bid Contingency (15%)	30%	of Maintenance Subtotal		$ 432,305	
	MAINTENANCE TOTAL				**$ 2,132,705.90**	
MONITORING AND REPORTING						
Monitoring	VOC & 1,4-Dioxane sampling year 4	376	sample	$ 1,354	$ 509,104	Southern California Contracted Unit Costs[1]
	VOC & 1,4-Dioxane sampling years 5-8	752	sample	$ 1,354	$ 1,018,208	Southern California Contracted Unit Costs[1]
	VOC & 1,4-Dioxane sampling years 9-30	2068	sample	$ 1,354	$ 2,800,072	Southern California Contracted Unit Costs[1]
	Sewer discharge semi-annual monitoring (RO concentrate), years 4-30	54	sample	$ 500	$ 27,000	
Reporting	Monitoring report year 4	4	report	$ 25,000	$ 100,000	ROM estimate
	Monitoring report years 5-8	8	report	$ 25,000	$ 200,000	ROM estimate
	Monitoring report years 9-30	22	report	$ 25,000	$ 550,000	ROM estimate
	Five-year Remedy Review	5	report	$ 100,000	$ 500,000	ROM estimate
	Sewer discharge semi-annual reporting RO concentrate, years 4-30	54	report	$ 1,500	$ 81,000	ROM estimate
	MONITORING AND REPORTING SUBTOTAL				**$ 5,785,384**	
	Project Management (Sliding scale based on total estimate)	8%	of Maintenance Subtotal		$ 462,831	
	Scope (15%) and Bid Contingency (15%)	30%	of Maintenance Subtotal		$ 1,735,615	
	MONITORING TOTAL				**$ 7,983,830**	
	GRAND TOTAL OMM COST				**43,612,798**	

Notes:

1. Southern California Contracted Unit Costs reflect actual contracted costs for similar work items at other Southern California environmental investigation/remediation sites.

AOP = Advanced Oxidation Process
CPLX = Complexity
CS = Carbon Steel
cu ft = cubic feet
DCHDPE = Double Contained High Density Polyethylene
HDPE = High Density Polyethylene
EPA = Environmental Protection Agency
GAC = Grannular Activated Carbon
gal = Gallon
H2O2 = hydrogen peroxide
hp = horsepower
kWh = Kilowatt Hour
lb = pound
l ft = lineal feet
Mgal = Million Gallons
MNA = Monitored Natural Attenuation
OC = Orange County
OCSD = Orange County Sanitation District
OMM = Operations, Maintenance and Monitoring
PDI = Pre-Design Investigation
PLC = Programmable Logic Controllers
ppm = parts per million
PVC = Polyvinyl Chloride
RO = Reverse Osmosis
ROM = Rough Order of Magnitude
RWQCB = Regional Water Quality Control Board
SPDP = Special Purpose Discharge Permit
sq ft = square feet
SS = Stainless Steel
TTWQ = Threat to Water Quality
ug/l = micrograms per liter
UV = ultraviolet
V = Volt
VOC = Volatile Organic Compound
WDR = Waste Discharge Requirements
WW = Wire Wrap

Table D-6. Alternative 5 - In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation

Quick Reference		
PDI Costs	$	7,478,850
Capital Costs	$	50,495,707
OMM Costs	$	424,619,775
Grand Total	$	482,594,331

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
	PRE-DESIGN INVESTIGATION					
MONITOR WELL INSTALLATION						
Monitor Wells	Layer 1 monitor well: 2" 40' PVC well with PVC Slotted Screen	92	per well	$ 12,719.00	$ 1,170,148	Southern California Contracted Unit Costs[1]
	Layer 2 monitor well: 2" 60' PVC well with PVC Slotted Screen	91	per well	$ 13,969.00	$ 1,271,179	Southern California Contracted Unit Costs[1]
	Layer 3 monitor well: 2" 80' PVC well with PVC Slotted Screen	72	per well	$ 15,318.00	$ 1,102,896	Southern California Contracted Unit Costs[1]
	Layer 4 monitor well: 2" 130' PVC well with PVC Slotted Screen	20	per well	$ 20,764.00	$ 415,280	Southern California Contracted Unit Costs[1]
	MONITOR WELL INSTALLATION SUBTOTAL				**$ 3,959,503**	
	Permitting	2%	of Monitor Well Installation Subtotal		$ 79,190	
	Remedial Design and Project Management (Sliding scale based on total estimate)	13%	of Monitor Well Installation Subtotal		$ 514,735	
	Construction Management (Sliding scale based on total estimate)	6%	of Monitor Well Installation Subtotal		$ 237,570	
	Scope (15%) and Bid Contingency (15%)	30%	of Monitor Well Installation Subtotal		$ 1,187,851	
	MONITOR WELL SYSTEM TOTAL				**$ 5,978,850**	
INVESTIGATION						
Testing	Sampling, hydraulic testing, and documentation	1	total	$ 1,500,000	$ 1,500,000	ROM estimate
	INVESTIGATION TOTAL				**$ 1,500,000**	
	GRAND TOTAL PDI COST				**$ 7,478,850**	
	CAPITAL COSTS (Design and Construction)					
WELL AND CONVEYANCE SYSTEM COSTS						
ISCO Injection Wells	4" 40' PVC well with SS WW Screen	524	per well	$ 20,076	$ 10,519,824	Southern California Contracted Unit Costs[1]
	4" 60' PVC well with SS WW Screen	509	per well	$ 23,304	$ 11,861,736	Southern California Contracted Unit Costs[1]
	4" 80' PVC well with SS WW Screen	264	per well	$ 26,959	$ 7,117,176.00	Southern California Contracted Unit Costs[1]
Injection Well Pumps and Well Head Ancillaries	Pumps, Traffic Vaults, Valves, Gauges, Flow Meters/Totalizer, Relief Valves	1297	per well	$ 3,000	$ 3,891,000	ROM estimate
Injection Manifold	A single 10 channel manifold	2	manifold	$ 10,000	$ 20,000	ROM estimate
ISCO Treatability Testing	Assumes one set of groundwater and soil samples collected from Layers 1-3	8	test	$ 60,000	$ 480,000	Southern California Contracted Unit Costs[1]

Table D-6. Alternative 5 - In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation

Quick Reference		
PDI Costs	$	7,478,850
Capital Costs	$	50,495,707
OMM Costs	$	424,619,775
Grand Total	$	482,594,331

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
	WELL AND CONVEYANCE SYSTEM				**$ 33,889,736**	
	Permits	2%	Of well and conveyance		$ 677,795	
	Remedial Design and Project Management (Sliding scale based on total estimate)	11%	Of well and conveyance		$ 3,727,871	
	Construction Management (Sliding scale based on total estimate)	6%	Of well and conveyance		$ 2,033,384	
	Scope (15%) and Bid Contingency (15%)	30%	Of well and conveyance		$ 10,166,921	
	CONVEYANCE AND EXTRACTION WELL SYSTEM TOTAL				**$ 50,495,707**	
	GRAND TOTAL CAPITAL COST				**$ 50,495,707**	

OPERATION, MAINTENANCE, AND MONITORING (OMM)

OPERATION

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
ISCO INJECTION	Injection event at a Layer 1 well	3144	per injection event	$ 3,655.50	$ 11,492,892	Southern California Contracted Unit Costs[1]
	Injection event at a Layer 2 well	54972	per injection event	$ 3,655.50	$ 200,950,146	Southern California Contracted Unit Costs[1]
	Injection event at a Layer 3 well	14256	per injection event	$ 3,655.50	$ 52,112,808	Southern California Contracted Unit Costs[1]
Permits/Access	Well Easement, Monitor and ISCO Injection	35316	wells	$ 303	$ 10,700,748	Fullerton license fee, assumed typical for cities in OC
	Initial WDR Permit	10	permit	$ 10,000.00	$ 100,000	Southern California Contracted Unit Costs[1]
	Annual WDR Permit Costs	260	year	$ 5,000.00	$ 1,300,000	Southern California Contracted Unit Costs[1]
Other	Institutional controls/Sealing legacy water supply wells	27	year	$ 50,000.00	$ 1,350,000	Instituational controls/Sealing wells

	Component	Quantity	Unit	Cost
	OPERATION SUBTOTAL A (Not including Permits/Access)			**$ 265,905,846**
	Project Management (Sliding scale based on total estimate)	5%	of Operation Subtotal	$ 13,295,292
	Scope (15%) and Bid Contingency (15%)	30%	of Operation Subtotal	$ 79,771,754
	OPERATION SUBTOTAL B (Permit/Access)			**$ 12,100,748**
	OPERATION TOTAL			**$ 371,073,640.10**

MAINTENANCE

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
Development	ISCO injection well development	6,485	per day	$ 2,853.50	$ 18,504,948	Southern California Contracted Unit Costs[1]

	Component	Quantity	Unit	Cost
	MAINTENANCE SUBTOTAL			**$ 18,504,947.50**
	Project Management (Sliding scale based on total estimate)	6%	of Maintenance Subtotal	$ 1,110,297
	Construction Management (Sliding scale based on total estimate)	6%	of Maintenance Subtotal	$ 1,110,297
	Scope (15%) and Bid Contingency (15%)	30%	of Maintenance Subtotal	$ 5,551,484
	MAINTENANCE TOTAL			**$ 26,277,025.45**

Table D-6. Alternative 5 - In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation

Quick Reference		
PDI Costs	$	7,478,850
Capital Costs	$	50,495,707
OMM Costs	$	424,619,775
Grand Total	$	482,594,331

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
MONITORING AND REPORTING						
Monitoring	ISCO analyte sampling year 4	1,036	sample	$ 2,040.00	$ 2,113,440	Southern California Contracted Unit Costs[1]
	ISCO analyte sampling years 5-8	2,072	sample	$ 2,040.00	$ 4,226,880	Southern California Contracted Unit Costs[1]
	ISCO analyte sampling years 9-30	5,698	sample	$ 2,040.00	$ 11,623,920	Southern California Contracted Unit Costs[1]
	VOC & 1,4-Dioxane sampling year 4	64	sample	$ 1,354.00	$ 86,656	Southern California Contracted Unit Costs[1]
	VOC & 1,4-Dioxane sampling years 5-8	128	sample	$ 1,354.00	$ 173,312	Southern California Contracted Unit Costs[1]
	VOC & 1,4-Dioxane sampling years 9-30	352	sample	$ 1,354.00	$ 476,608	Southern California Contracted Unit Costs[1]
Reporting	Monitoring report year 4	4	report	$ 25,000.00	$ 100,000	ROM estimate
	Monitoring report years 5-8	8	report	$ 25,000.00	$ 200,000	ROM estimate
	Monitoring report years 9-30	22	report	$ 25,000.00	$ 550,000	ROM estimate
	Five-year Remedy Review	5	report	$ 100,000.00	$ 500,000	ROM estimate

MONITORING SUBTOTAL			**$ 20,050,816.00**
Project Management (Sliding scale based on total estimate)	6%	of Maintenance Subtotal	$ 1,203,049
Scope (15%) and Bid Contingency (15%)	30%	of Maintenance Subtotal	$ 6,015,245
MONITORING TOTAL			**$ 27,269,109.76**

GRAND TOTAL OMM COST	**$ 424,619,775**

Notes:

1. Southern California Contracted Unit Costs reflect actual contracted costs for similar work items at other Southern California environmental investigation/remediation sites.

ISCO = In-Situ Chemical Oxidation
OC = Orange County
OMM = Operations, Maintenance and Monitoring
PDI = Pre-Design Investigation
PVC = Polyvinyl Chloride
ROM = Rough Order of Magnitude
SS = Stainless Steel
VOC = Volatile Organic Compound
WDR = Waste Discharge Requirements
WW = Wire Wrap

Table D-7. Alternative 6 - Containment and In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with Discharge to POTW and GWRS

Quick Reference		
PDI Costs	$	4,525,641
Capital Costs	$	24,348,530
OMM Costs	$	109,186,284
Grand Total	$	138,060,456

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
	PRE-DESIGN INVESTIGATION (Monitor Well Installation Only)					
MONITOR WELL INSTALLATION						
Monitor Wells	Layer 1 monitor well: 2" 40' PVC well with PVC Slotted Screen	51	per well	$ 12,719	$ 648,669	Southern California Contracted Unit Costs[1]
	Layer 2 monitor well: 2" 60' PVC well with PVC Slotted Screen	49	per well	$ 13,969	$ 684,481	Southern California Contracted Unit Costs[1]
	Layer 3 monitor well: 2" 80' PVC well with PVC Slotted Screen	37	per well	$ 15,318	$ 566,766	Southern California Contracted Unit Costs[1]
	Layer 4 monitor well: 2" 130' PVC well with PVC Slotted Screen	5	per well	$ 20,764	$ 103,820	Southern California Contracted Unit Costs[1]
	MONITOR WELL INSTALLATION SUBTOTAL				**$ 2,003,736**	
	Permitting	2%	of Monitor Well Installation Subtotal		$ 40,075	
	Remedial Design and Project Management (Sliding scale based on total estimate)	13%	of Monitor Well Installation Subtotal		$ 260,486	
	Construction Management (Sliding scale based on total estimate)	6%	of Monitor Well Installation Subtotal		$ 120,224	
	Scope (15%) and Bid Contingency (15%)	30%	of Monitor Well Installation Subtotal		$ 601,121	
	MONITOR WELL SYSTEM TOTAL				**$ 3,025,641**	
INVESTIGATION						
Testing	Sampling, hydraulic testing, and documentation	1	total	$ 1,500,000	$ 1,500,000	ROM estimate
	INVESTIGATION TOTAL				**$ 1,500,000**	
	GRAND TOTAL PDI COST				**$ 4,525,641**	
	CAPITAL COSTS (Design and Construction)					
WELL AND CONVEYANCE SYSTEM COSTS						
ISCO Injection Wells	4" 40' PVC well with SS WW Screen	113	per well	$ 20,076.00	$ 2,268,588	Southern California Contracted Unit Costs[1]
	4" 60' PVC well with SS WW Screen	113	per well	$ 23,304.00	$ 2,633,352	Southern California Contracted Unit Costs[1]
	4" 80' PVC well with SS WW Screen	113	per well	$ 26,959.00	$ 3,046,367	Southern California Contracted Unit Costs[1]
Injection Well Pumps and Well Head Ancillaries	Pumps, Traffic Vaults, Valves, Gauges, Flow Meters/Totalizer, Relief Valves	339	per well	$ 3,000	$ 1,017,000	ROM Estimate
Injection Manifold	A single 10 channel manifold	2	manifold	$ 10,000	$ 20,000	ROM estimate
ISCO Treatability Testing	Assumes one set of groundwater and soil samples collected from Layers 1-3	1	test	$ 60,000	$ 60,000	Southern California Contracted Unit Costs[1]
Extraction Wells	4" 40' PVC well with SS WW Screen	3	per well	$ 20,076	$ 60,228	Southern California Contracted Unit Costs[1]
	4" 60' PVC well with SS WW Screen	39	per well	$ 23,304	$ 908,856	Southern California Contracted Unit Costs[1]
	4" 80' PVC well with SS WW Screen	32	per well	$ 26,959	$ 862,688	Southern California Contracted Unit Costs[1]
Extraction Well Pumps and Well Head Ancillaries	Pumps, Traffic Vaults, Valves, Gauges, Flow Meters/Totalizer, Transmitter, Local Control Panels (motor, instrument), Instrumentation (level)	74	per well	$ 25,000	$ 1,850,000	Includes installation, engineer estimate

Table D-7. Alternative 6 - Containment and In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with Discharge to POTW and GWRS

Quick Reference		
PDI Costs	$	4,525,641
Capital Costs	$	24,348,530
OMM Costs	$	109,186,284
Grand Total	$	138,060,456

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
Extraction System Power Drops	Power drop, Internet, PLC for distribution to wells at each transect	8	per transect	$ 70,000	$ 560,000	Engineer estimate
Water Pipelines	Pipeline (0-10 gpm); 1"x3"; DCHDPE	250	l ft	$ 124.36	$ 31,089.22	Calculated from RSMeans Data 2020 and material prices
	Pipeline (11-40 gpm); 2"x4"; DCHDPE	4550	l ft	$ 132.19	$ 601,474.43	Calculated from RSMeans Data 2020 and material prices
	Pipeline (41-100 gpm); 3"x6"; DCHDPE	5400	l ft	$ 150.20	$ 811,093.45	Calculated from RSMeans Data 2020 and material prices

WELL AND CONVEYANCE SYSTEM SUBTOTAL			**$ 14,730,736**
Permits	2%	Of well and conveyance	$ 294,615
Remedial Design and Project Management (Sliding scale based on total estimate)	11%	Of well and conveyance	$ 1,620,381
Construction Management (Sliding scale based on total estimate)	6%	Of well and conveyance	$ 883,844
Scope (15%) and Bid Contingency (15%)	30%	Of well and conveyance	$ 4,419,221
CONVEYANCE AND EXTRACTION WELL SYSTEM TOTAL			**$ 21,948,797**

TREATMENT PLANT

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
Bag Filter System	Duplex filter system up to 100 gpm capacity; 304SS	6	unit	$ 4,500.00	$ 27,000	PRM Filtration, online pricing
	Single filter system, up to 40 gpm capacity; 304SS	2	unit	$ 910.00	$ 1,820	PRM Filtration, online pricing
	Instrumentation and Control	1	unit	$ 2,000	$ 2,000	
GAC System	Lead-lag GAC vessels PV-500 (pre-filled), with manifold	1	unit	$ 22,400.00	$ 22,400	Evoqua quote 8/21/2022 and 25% for manifold
	Lead-lag GAC vessels PV-1000 (pre-filled), with manifold	1	unit	$ 25,800.00	$ 25,800	Evoqua quote 8/21/2022 and 25% for manifold
	Lead-lag GAC vessels PV-2000 (pre-filled), with manifold	5	unit	$ 31,900.00	$ 159,500	Evoqua quote 8/21/2022 and 25% for manifold
Concrete Slab and Roof Canopy	Concrete for system; 10x10x2ft slab	8	slab	$ 1,440.00	$ 11,520	RS Means 03 30 53.40 4900 Page 80, 2020 Edition
	Concrete for GAC vessels; 12x10x2ft slab	1	slab	$ 1,728	$ 1,728	RS Means 03 30 53.40 4900 Page 80, 2020 Edition
	Concrete for GAC vessels; 15x12x2ft slab	6	slab	$ 2,592	$ 15,552	RS Means 03 30 53.40 4900 Page 80, 2020 Edition
	Roof canopy - corrugated metal 10x10ft canopy for GAC vessels	8	unit	$ 1,500	$ 12,000	Online pricing - 6/18/2021
	Roof canopy - corrugated metal 12x10ft canopy	1	unit	$ 1,800	$ 1,800	Online pricing - 6/18/2021
	Roof canopy - corrugated metal 15x12ft canopy for GAC vessels	6	unit	$ 2,700	$ 16,200	Online pricing - 6/18/2021
Sewer Connection	Sewer connection installation, energy dissipaton box, manhole, instantaeous/totalizing flow meter, sampling station	8	unit	$ 25,000.00	$ 200,000	Includes installation, ROM Estimate
	City Sewer Connection fee	8	unit	$ 7,000.00	$ 56,000	ROM Estimate
	OCSD SPDP Application Fee	8	unit	$ 1,138	$ 9,104	OSCD Fee Sheet

TREATMENT PLANT SUBTOTAL A			**$ 297,320**
Installation cost for bag filter system, slab and roof canopy (assume 3 times unit cost)	3	of above	$ 891,960
TREATMENT PLANT- EQUIPMENT/MATERIAL INSTALLED SUBTOTAL B			**$ 1,189,280**
TREATMENT PLANT - SEWER CONNECTION COSTS SUBTOTAL C			**$ 265,104**
TREATMENT PLANT SUBTOTAL D (Subtotal B+Subtotal C)			**$ 1,454,384**
Permits	2%	of Subtotal D	$ 29,088
Remedial Design and Project Management (Sliding scale based on total estimate)	23%	of Subtotal D	$ 334,508
Construction Management (Sliding scale based on total estimate)	10%	of Subtotal D	$ 145,438
Scope (15%) and Bid Contingency (15%)	30%	of Subtotal D	$ 436,315
TREATMENT PLANT TOTAL			**$ 2,399,734**

GRAND TOTAL CAPITAL COST	**$ 24,348,530**

Quick Reference		
PDI Costs	$	4,525,641
Capital Costs	$	24,348,530
OMM Costs	$	109,186,284
Grand Total	$	138,060,456

Table D-7. Alternative 6 - Containment and In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with Discharge to POTW and GWRS

OPERATION, MAINTENANCE, AND MONITORING (OMM)

OPERATION

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
Utilities	Electricity (1hp extraction pumps, Annual Operation, 90% uptime)	13,051,599	kWh	$ 0.12	$ 1,566,192	
	Data/internet Line (for 8 locations)	2,592	months	$ 100.00	$ 259,200	
Consumables	Bag filters, 2 bags per month per system	5,184	bags	$ 15.00	$ 77,760	
	GAC changeout PV-500, first 5 years	4	unit	$ 2,950	$ 11,800	Evoqua quote 8/21/2022
	GAC changeout PV-1000, first 5 years	4	unit	$ 3,550	$ 14,200	Evoqua quote 8/21/2022
	GAC changeout PV-2000, first 5 years	48	unit	$ 4,575	$ 219,600	Evoqua quote 8/21/2022
	GAC changeout PV-500, 0.5 changeout a year, after 5 years	22	unit	$ 2,950	$ 64,900	Evoqua quote 8/21/2022
	GAC changeout PV-1000, 1 changeout a year, after 5 years	22	unit	$ 3,550	$ 78,100	Evoqua quote 8/21/2022
	GAC changeout PV-2000, 1 changeout a year, after 5 years	132	unit	$ 4,575	$ 603,900	Evoqua quote 8/21/2022
Permits/Access	Well Easement, Extraction, Monitor and ISCO Wells	14,985	well	$ 303.00	$ 4,540,455	Fullerton license fee, assumed typical for cities in OC
	Pipeline Easement Fee	275,400	l ft	$ 4.85	$ 1,335,690	Fullerton license fee, assumed typical for cities in OC
	OCSD SPDP Renewal Fee, $795 per 2 years, per permit	126	$/(2 years)	$ 795	$ 100,170	2021-2022 OCSD Fee Schedule
	OCSD Special Purpose Discharge Permit (extraction volume, backwash, well development discharge)	5,051	$/MGal	$ 1,601	$ 8,088,638	2021-2022 OCSD Fee Schedule
ISCO INJECTION	Injection event at a Layer 1 well	678	per injection event	$ 3,655.50	$ 2,478,429	Southern California Contracted Unit Costs[1]
	Injection event at a Layer 2 well	6102	per injection event	$ 3,655.50	$ 22,305,861	Southern California Contracted Unit Costs[1]
	Injection event at a Layer 3 well	6102	per injection event	$ 3,655.50	$ 22,305,861	Southern California Contracted Unit Costs[1]
Permits	Initial WDR Permit	1	permit	$ 10,000.00	$ 10,000	
	Annual WDR Permit Costs	26	year	$ 5,000.00	$ 130,000	
	Replenishment Assessment	0	acre-foot (100% extracted volume)	$ 504	$ -	Assessment requirement waived
	Basin Equity Assessment	0	acre-foot (23% extracted volume)	$ 578	$ -	Assessment requirement waived
Routine OMM	Operations Technicial, 1 visit per 2 weeks, 20 hours per visit	14040	hours	$ 100.00	$ 1,404,000	Estimate
Non-Routine OMM	Percent of treatment system cost and well equipment costs	1%	percent	$ 4,249,734	$ 1,147,428	Estimate
Other	Institutional controls/Sealing legacy water supply wells	27	year	$ 50,000.00	$ 1,350,000	Instituational controls/Sealing wells

OPERATION SUBTOTAL A (Not including Permits/Access)			**$ 53,887,231**
Project Management (Sliding scale based on total estimate)	5%	of Operation Subtotal	$ 2,694,362
Scope (15%) and Bid Contingency (15%)	30%	of Operation Subtotal	$ 16,166,169
OPERATION SUBTOTAL B (Permit/Access)			**$ 14,204,953**
OPERATION TOTAL			**$ 86,952,715**

MAINTENANCE

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
Development	Extraction well development	370	per day	$ 2,853.50	$ 1,055,795	Southern California Contracted Unit Costs[1]
	ISCO injection well development	1,695	per day	$ 2,853.50	$ 4,836,683	Southern California Contracted Unit Costs[1]

Table D-7. Alternative 6 - Containment and In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation Combined with Groundwater Extraction and Treatment with Discharge to POTW and GWRS

Quick Reference		
PDI Costs	$	4,525,641
Capital Costs	$	24,348,530
OMM Costs	$	109,186,284
Grand Total	$	138,060,456

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
	MAINTENANCE SUBTOTAL				**$ 5,892,478**	
	Project Management (Sliding scale based on total estimate)	8%	of Maintenance Subtotal		$ 471,398	
	Construction Management (Sliding scale based on total estimate)	6%	of Maintenance Subtotal		$ 353,549	
	Scope (15%) and Bid Contingency (15%)	30%	of Maintenance Subtotal		$ 1,767,743	
	MAINTENANCE TOTAL				**$ 8,485,168**	
MONITORING AND REPORTING						
Monitoring	ISCO sampling year 4	272	sample	$ 2,040.00	$ 554,880	Southern California Contracted Unit Costs[1]
	ISCO sampling years 5-8	544	sample	$ 2,040.00	$ 1,109,760	Southern California Contracted Unit Costs[1]
	ISCO sampling years 9-30	1496	sample	$ 2,040.00	$ 3,051,840	Southern California Contracted Unit Costs[1]
	VOC & 1,4-Dioxane sampling year 4	296	sample	$ 1,354.00	$ 400,784	Southern California Contracted Unit Costs[1]
	VOC & 1,4-Dioxane sampling years 5-8	592	sample	$ 1,354.00	$ 801,568	Southern California Contracted Unit Costs[1]
	VOC & 1,4-Dioxane sampling years 9-30	1628	sample	$ 1,354.00	$ 2,204,312	Southern California Contracted Unit Costs[1]
	Sewer discharge semi-annual monitoring per transect, years 4-30	432	sample	$ 500.00	$ 216,000	Southern California laboratory costs
Reporting	Monitoring report year 4	4	report	$ 25,000.00	$ 100,000	ROM estimate
	Monitoring report years 5-8	8	report	$ 25,000.00	$ 200,000	ROM estimate
	Monitoring report years 9-30	22	report	$ 25,000.00	$ 550,000	ROM estimate
	Five-year Remedy Review	5	report	$ 100,000.00	$ 500,000	ROM estimate
	Sewer discharge semi-annual reporting per transect, years 4-30	432	report	$ 1,500.00	$ 648,000	ROM estimate
	MONITORING SUBTOTAL				**$ 10,337,144**	
	Project Management (Sliding scale based on total estimate)	8%	of OMM Subtotal		$ 826,972	
	Scope (15%) and Bid Contingency (10%)	25%	of OMM Subtotal		$ 2,584,286	
	MONITORING TOTAL				**$ 13,748,402**	
	GRAND TOTAL OMM COST				**109,186,284**	

Notes:

1. Southern California Contracted Unit Costs reflect actual contracted costs for similar work items at other Southern California environmental investigation/remediation sites.

DCHDPE = Double Contained High Density Polyethylene
gpm = gallons per minute
hp = horsepower
ISCO = In-Situ Chemical Oxidation
kWh = kilowatt hours
GAC = Granular Activated Carbon
GWRS = OCWD Groundwater Replenishment System Advanced Wastewater Purification Facility
l ft = lineal feet
Mgal = Million Gallons
MNA = Monitored Natural Attenuation
OC = Orange County
OCSD = Orange County Sanitation District
OMM = Operations, Maintenance and Monitoring
PDI = Pre-Design Investigation
POTW = Public Owned Treatment Works
PVC = Polyvinyl Chloride
ROM = Rough Order of Magnitude
SPDP = Special Purpose Discharge Permit
SS = Stainless Steel
VOC = Volatile Organic Compound
WDR = Waste Discharge Requirements
WW = Wire Wrap

Table D-7a. Alternative 6a - Containment and In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation with 50-Feet Injection Spacing Combined with Groundwater Extraction and Treatment with discharge to POTW and GWRS

Quick Reference		
PDI Costs	$	3,870,224
Capital Costs	$	17,373,839
OMM Costs	$	122,034,585
Grand Total	$	143,278,648

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
Monitor Wells	Layer 1 monitor well: 2" 40' PVC well with PVC Slotted Screen	40	per well	$ 12,719	$ 508,760	Southern California Contracted Unit Costs[1]
	Layer 2 monitor well: 2" 60' PVC well with PVC Slotted Screen	38	per well	$ 13,969	$ 530,822	Southern California Contracted Unit Costs[1]
	Layer 3 monitor well: 2" 80' PVC well with PVC Slotted Screen	26	per well	$ 15,318	$ 398,268	Southern California Contracted Unit Costs[1]
	Layer 4 monitor well: 2" 130' PVC well with PVC Slotted Screen	3	per well	$ 20,764	$ 62,292	Southern California Contracted Unit Costs[1]

MONITOR WELL INSTALLATION SUBTOTAL			**$ 1,500,142**
Permitting	2%	of Monitor Well Installation Subtotal	$ 30,003
Remedial Design and Project Management (Sliding scale based on total estimate)	18%	of Monitor Well Installation Subtotal	$ 270,026
Construction Management (Sliding scale based on total estimate)	8%	of Monitor Well Installation Subtotal	$ 120,011
Scope (15%) and Bid Contingency (15%)	30%	of Monitor Well Installation Subtotal	$ 450,043
MONITOR WELL SYSTEM TOTAL			**$ 2,370,224**

INVESTIGATION

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
Testing	Sampling, hydraulic testing, and documentation	1	total	$ 1,500,000	$ 1,500,000	ROM estimate

INVESTIGATION TOTAL	**$ 1,500,000**
GRAND TOTAL PDI COST	**$ 3,870,224**

CAPITAL COSTS (Design and Construction)

WELL AND CONVEYANCE SYSTEM COSTS

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
ISCO Injection Wells	4" 40' PVC well with SS WW Screen	54	per well	$ 20,076.00	$ 1,084,104	Southern California Contracted Unit Costs[1]
	4" 60' PVC well with SS WW Screen	54	per well	$ 23,304.00	$ 1,258,416	Southern California Contracted Unit Costs[1]
	4" 80' PVC well with SS WW Screen	54	per well	$ 26,959.00	$ 1,455,786	Southern California Contracted Unit Costs[1]
Injection Well Pumps and Well Head Ancillaries	Pumps, Traffic Vaults, Valves, Gauges, Flow Meters/Totalizer, Relief Valves	162	per well	$ 3,000	$ 486,000	ROM Estimate
Injection Manifold	A single 10 channel manifold	2	manifold	$ 10,000	$ 20,000	ROM estimate
ISCO Treatability Testing	Assumes one set of groundwater and soil samples collected from Layers 1-3	1	test	$ 60,000	$ 60,000	Southern California Contracted Unit Costs[1]
Extraction Wells	4" 40' PVC well with SS WW Screen	3	per well	$ 20,076	$ 60,228	Southern California Contracted Unit Costs[1]
	4" 60' PVC well with SS WW Screen	39	per well	$ 23,304	$ 908,856	Southern California Contracted Unit Costs[1]
	4" 80' PVC well with SS WW Screen	32	per well	$ 26,959	$ 862,688	Southern California Contracted Unit Costs[1]
Extraction Well Pumps and Well Head Ancillaries	Pumps, Traffic Vaults, Valves, Gauges, Flow Meters/Totalizer, Transmitter, Local Control Panels (motor, instrument), Instrumentation (level)	74	per well	$ 25,000	$ 1,850,000	Includes installation, engineer estimate
Extraction System Power Drops	Power drop, Internet, PLC for distribution to wells at each transect	8	per transect	$ 70,000	$ 560,000	Engineer estimate
Water Pipelines	Pipeline (0-10 gpm); 1"x3"; DCHDPE	250	1 ft	$ 124.36	$ 31,089.22	Calculated from RSMeans Data 2020 and material prices
	Pipeline (11-40 gpm); 2"x4"; DCHDPE	4550	1 ft	$ 132.19	$ 601,474.43	Calculated from RSMeans Data 2020 and material prices
	Pipeline (41-100 gpm); 3"x6"; DCHDPE	5400	1 ft	$ 150.20	$ 811,093.45	Calculated from RSMeans Data 2020 and material prices

WELL AND CONVEYANCE SYSTEM SUBTOTAL	**$ 10,049,735**

Table D-7a. Alternative 6a - Containment and In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation with 50-Feet Injection Spacing Combined with Groundwater Extraction and Treatment with discharge to POTW and GWRS

Quick Reference		
PDI Costs	$	3,870,224
Capital Costs	$	17,373,839
OMM Costs	$	122,034,585
Grand Total	$	143,278,648

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
	Permits	2%	Of well and conveyance		$ 200,995	
	Remedial Design and Project Management (Sliding scale based on total estimate)	11%	Of well and conveyance		$ 1,105,471	
	Construction Management (Sliding scale based on total estimate)	6%	Of well and conveyance		$ 602,984	
	Scope (15%) and Bid Contingency (15%)	30%	Of well and conveyance		$ 3,014,921	
	CONVEYANCE AND EXTRACTION WELL SYSTEM TOTAL				**$ 14,974,105**	
TREATMENT PLANT						
Bag Filter System	Duplex filter system up to 100 gpm capacity; 304SS	6	unit	$ 4,500.00	$ 27,000	PRM Filtration, online pricing
	Single filter system, up to 40 gpm capacity; 304SS	2	unit	$ 910.00	$ 1,820	PRM Filtration, online pricing
	Instrumentation and Control	1	unit	$ 2,000	$ 2,000	
GAC System	Lead-lag GAC vessels PV-500 (pre-filled), with manifold	1	unit	$ 22,400.00	$ 22,400	Evoqua quote 8/21/2022 and 25% for manifold
	Lead-lag GAC vessels PV-1000 (pre-filled), with manifold	1	unit	$ 25,800.00	$ 25,800	Evoqua quote 8/21/2022 and 25% for manifold
	Lead-lag GAC vessels PV-2000 (pre-filled), with manifold	5	unit	$ 31,900.00	$ 159,500	Evoqua quote 8/21/2022 and 25% for manifold
Concrete Slab and Roof Canopy	Concrete for system; 10x10x2ft slab	8	slab	$ 1,440.00	$ 11,520	RS Means 03 30 53.40 4900 Page 80, 2020 Edition
	Concrete for GAC vessels; 12x10x2ft slab	1	slab	$ 1,728	$ 1,728	RS Means 03 30 53.40 4900 Page 80, 2020 Edition
	Concrete for GAC vessels; 15x12x2ft slab	6	slab	$ 2,592	$ 15,552	RS Means 03 30 53.40 4900 Page 80, 2020 Edition
	Roof canopy - corrugated metal 10x10ft canopy	8	unit	$ 1,500.00	$ 12,000	Online pricing - 6/18/2021
	Roof canopy - corrugated metal 12x10ft canopy	1	unit	$ 1,800	$ 1,800	Online pricing - 6/18/2021
	Roof canopy - corrugated metal 15x12ft canopy for GAC vessels	6	unit	$ 2,700	$ 16,200	Online pricing - 6/18/2021
Sewer Connection	Sewer connection installation, energy dissipaton box, manhole, instantaeous/totalizing flow meter, sampling station	8	unit	$ 25,000.00	$ 200,000	Includes installation, ROM Estimate
	City Sewer Connection fee	8	unit	$ 7,000.00	$ 56,000	ROM Estimate
	OCSD SPDP Application Fee	8	unit	$ 1,138	$ 9,104	OSCD Fee Sheet

Component	Quantity	Unit		Cost
TREATMENT PLANT SUBTOTAL A				**$ 297,320**
Installation cost for bag filter system, slab and roof canopy (assume 3 times unit cost)	3	of above		$ 891,960
TREATMENT PLANT- EQUIPMENT/MATERIAL INSTALLED SUBTOTAL B				**$ 1,189,280**
TREATMENT PLANT - SEWER CONNECTION COSTS SUBTOTAL C				**$ 265,104**
TREATMENT PLANT SUBTOTAL D (Subtotal B+Subtotal C)				**$ 1,454,384**
Permits	2%	of Subtotal D		$ 29,088
Remedial Design and Project Management (Sliding scale based on total estimate)	23%	of Subtotal D		$ 334,508
Construction Management (Sliding scale based on total estimate)	10%	of Subtotal D		$ 145,438
Scope (15%) and Bid Contingency (15%)	30%	of Subtotal D		$ 436,315
TREATMENT PLANT TOTAL				**$ 2,399,734**

GRAND TOTAL CAPITAL COST	**$ 17,373,839**

Table D-7a. Alternative 6a - Containment and In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation with 50-Feet Injection Spacing Combined with Groundwater Extraction and Treatment with discharge to POTW and GWRS

Quick Reference		
PDI Costs	$	3,870,224
Capital Costs	$	17,373,839
OMM Costs	$	122,034,585
Grand Total	$	143,278,648

OPERATION, MAINTENANCE, AND MONITORING (OMM)

OPERATION

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
Utilities	Electricity (1hp extraction pumps, Annual Operation, 90% uptime)	13,051,599	kWh	$ 0.12	$ 1,566,192	
	Data/internet Line (for 8 locations)	2,592	months	$ 100.00	$ 259,200	
Consumables	Bag filters, 2 bags per month per system	5,184	bags	$ 15.00	$ 77,760	
	GAC changeout PV-500, first 5 years	4	unit	$ 2,950	$ 11,800	Evoqua quote 8/21/2022
	GAC changeout PV-1000, first 5 years	4	unit	$ 3,550	$ 14,200	Evoqua quote 8/21/2022
	GAC changeout PV-2000, first 5 years	48	unit	$ 4,575	$ 219,600	Evoqua quote 8/21/2022
	GAC changeout PV-500, 0.5 changeout a year, after 5 years	22	unit	$ 2,950	$ 64,900	Evoqua quote 8/21/2022
	GAC changeout PV-1000, 1 changeout a year, after 5 years	22	unit	$ 3,550	$ 78,100	Evoqua quote 8/21/2022
	GAC changeout PV-2000, 1 changeout a year, after 5 years	132	unit	$ 4,575	$ 603,900	Evoqua quote 8/21/2022
Permits/Access	Well Easement, Extraction, Monitor and ISCO Wells	9,261	well	$ 303.00	$ 2,806,083	Fullerton license fee, assumed typical for cities in OC
	Pipeline Easement Fee	275,400	l ft	$ 4.85	$ 1,335,690	Fullerton license fee, assumed typical for cities in OC
	OCSD SPDP Renewal Fee, $795 per 2 years, per permit	126	$/(2 years)	$ 795	$ 100,170	2021-2022 OCSD Fee Schedule
	OCSD Special Purpose Discharge Permit (extraction volume, backwash, well development discharge)	5,051	$/MGal	$ 1,601	$ 8,088,638	2021-2022 OCSD Fee Schedule
ISCO INJECTION	Injection event at a Layer 1 well	108	per injection event	$ 15,802.04	$ 1,706,620	Southern California Contracted Unit Costs[1]
	Injection event at a Layer 2 well	2916	per injection event	$ 15,802.04	$ 46,078,749	Southern California Contracted Unit Costs[1]
	Injection event at a Layer 3 well	972	per injection event	$ 15,802.04	$ 15,359,583	Southern California Contracted Unit Costs[1]
Permits	Initial WDR Permit	1	permit	$ 10,000.00	$ 10,000	
	Annual WDR Permit Costs	26	year	$ 5,000.00	$ 130,000	
	Replenishment Assessment	0	acre-foot (100% extracted volume)	$ 504	$ -	Assessment requirement waived
	Basin Equity Assessment	0	acre-foot (23% extracted volume)	$ 578	$ -	Assessment requirement waived
Routine OMM	Operations Technicial, 1 visit per 2 weeks, 20 hours per visit	14040	hours	$ 100.00	$ 1,404,000	Estimate
Non-Routine OMM	Percent of treatment system cost and well equipment costs	1%	percent	$ 4,249,734	$ 1,147,428	Estimate
Other	Institutional controls/Sealing legacy water supply wells	27	year	$ 50,000.00	$ 1,350,000	Instituational controls/Sealing wells

OPERATION SUBTOTAL A (Not including Permits/Access)			**$ 69,942,032**
Project Management (Sliding scale based on total estimate)	5%	of Operation Subtotal	$ 3,497,102
Scope (15%) and Bid Contingency (15%)	30%	of Operation Subtotal	$ 20,982,610
OPERATION SUBTOTAL B (Permit/Access)			**$ 12,470,581**
OPERATION TOTAL			**$ 106,892,324**

Table D-7a. Alternative 6a - Containment and In Situ Treatment of Relatively High Concentration and Leading-Edge Areas Using Chemical Oxidation with 50-Feet Injection Spacing Combined with Groundwater Extraction and Treatment with discharge to POTW and GWRS

Quick Reference		
PDI Costs	$	3,870,224
Capital Costs	$	17,373,839
OMM Costs	$	122,034,585
Grand Total	$	143,278,648

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
MAINTENANCE						
Development	Extraction well development	370	per day	$ 2,853.50	$ 1,055,795	Southern California Contracted Unit Costs[1]
	ISCO injection well development	810	per day	$ 2,853.50	$ 2,311,335	Southern California Contracted Unit Costs[1]

MAINTENANCE SUBTOTAL			**$ 3,367,130**
Project Management (Sliding scale based on total estimate)	8%	of Maintenance Subtotal	$ 269,370
Construction Management (Sliding scale based on total estimate)	6%	of Maintenance Subtotal	$ 202,028
Scope (15%) and Bid Contingency (15%)	30%	of Maintenance Subtotal	$ 1,010,139
MAINTENANCE TOTAL			**$ 4,848,667**

MONITORING AND REPORTING

Major System	Component	Quantity	Unit	Unit Cost	Cost	Cost Estimate Source
Monitoring	ISCO sampling year 4	132	sample	$ 2,040.00	$ 269,280	Southern California Contracted Unit Costs[1]
	ISCO sampling years 5-8	264	sample	$ 2,040.00	$ 538,560	Southern California Contracted Unit Costs[1]
	ISCO sampling years 9-30	726	sample	$ 2,040.00	$ 1,481,040	Southern California Contracted Unit Costs[1]
	VOC & 1,4-Dioxane sampling year 4	296	sample	$ 1,354.00	$ 400,784	Southern California Contracted Unit Costs[1]
	VOC & 1,4-Dioxane sampling years 5-8	592	sample	$ 1,354.00	$ 801,568	Southern California Contracted Unit Costs[1]
	VOC & 1,4-Dioxane sampling years 9-30	1628	sample	$ 1,354.00	$ 2,204,312	Southern California Contracted Unit Costs[1]
	Sewer discharge semi-annual monitoring per transect, years 4-30	432	sample	$ 500.00	$ 216,000	Southern California laboratory costs
Reporting	Monitoring report year 4	4	report	$ 20,000.00	$ 80,000	ROM estimate
	Monitoring report years 5-8	8	report	$ 20,000.00	$ 160,000	ROM estimate
	Monitoring report years 9-30	22	report	$ 20,000.00	$ 440,000	ROM estimate
	Five-year Remedy Review	5	report	$ 100,000.00	$ 500,000	ROM estimate
	Sewer discharge semi-annual reporting per transect, years 4-30	432	report	$ 1,500.00	$ 648,000	ROM estimate

MONITORING SUBTOTAL			**$ 7,739,544**
Project Management (Sliding scale based on total estimate)	8%	of OMM Subtotal	$ 619,164
Scope (15%) and Bid Contingency (10%)	25%	of OMM Subtotal	$ 1,934,886
MONITORING TOTAL			**$ 10,293,594**

GRAND TOTAL OMM COST	**122,034,585**

Notes:

1. Southern California Contracted Unit Costs reflect actual contracted costs for similar work items at other Southern California environmental investigation/remediation sites.

DCHDPE = Double Contained High Density Polyethylene
gpm = gallons per minute
GWRS = OCWD Groundwater Replenishment System Advanced Wastewater Purification Facility
hp = horsepower
ISCO = In-Situ Chemical Oxidation
kWh = kilowatt hours
l ft = lineal feet
Mgal = Million Gallons
MNA = Monitored Natural Attenuation
OC = Orange County
OCSD = Orange County Sanitation District
OMM = Operations, Maintenance and Monitoring
PDI = Pre-Design Investigation
POTW = Public Owned Treatment Works
PVC = Polyvinyl Chloride
ROM = Rough Order of Magnitude
SPDP = Special Purpose Discharge Permit
SS = Stainless Steel
VOC = Volatile Organic Compound
WDR = Waste Discharge Requirements
WW = Wire Wrap

APPENDIX E
NUMERICAL GROUNDWATER FLOW MODEL DEVELOPMENT, CALIBRATION AND MODELING RESULTS

APPENDIX E, PART I
NUMERICAL GROUNDWATER FLOW MODEL
PART I – DEVELOPMENT AND CALIBRATION

NUMERICAL GROUNDWATER FLOW MODEL
PART I - DEVELOPMENT AND CALIBRATION

South Basin Groundwater Protection Project
Operable Unit 2

Prepared for:

Orange County Water District

18700 Ward Street

Fountain Valley, California

92708

For Internal Use Only

Prepared by:

Engineering Analytics, Inc.

9820 Willow Creek Road, Suite 395
San Diego, California 92131
(858) 221-0264

Project No. 151099

September 2021

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ACRONYMS AND ABBREVIATIONS

Below land surface	bls
Cone-penetrometer tests	CPT
Constant head	CHD
Feasibility Study	FS
Operable Unit 2	OU2
Orange County Water District	OCWD
Orange County Groundwater Basin	Basin
Parameter estimation code	PEST
Principal Aquifer System	PAS
Remedial Investigation/Feasibility Study	RI/FS
Residual sum of squares	RSS
Shallow Aquifer System	SAS
Site Conceptual Hydrogeologic Model	SCHM
South Basin Groundwater Protection Project	SBGPP
Study area of interest	Study Area
U.S. Geological Survey	USGS

1.0 SOUTH BASIN GROUNDWATER PROTECTION PLAN GROUNDWATER FLOW MODELING

This document describes the development and calibration of a numerical groundwater flow model to support the South Basin Groundwater Protection Project (SBGPP) Remedial Investigation/Feasibility Study (RI/FS) being conducted by OCWD to address groundwater contamination in Operable Unit 2 (OU2) in the south-central portion of the Orange County Groundwater Basin (the Basin) in Orange County, California (Study Area) (Figure 1-1). OU2 is groundwater contamination in the Shallow Aquifer System (SAS) off-property of numerous groundwater contamination source sites (source sites) located within the Study Area where groundwater contaminant plumes emanating from individual source sites have migrated and commingled (EA, 2021). The groundwater flow model is being developed to support OCWD's evaluation of remedial alternatives identified in the FS screening process that are intended to address groundwater contamination in OU2 within the SBGPP.

The numerical modeling is based on the current conceptual hydrogeologic model of the regional and local groundwater flow system. The current modeling incorporated aspects of prior modeling conducted by Hargis + Associates, Inc., (H+A). Specifically, the current model used the same model domain along with model layer elevation, hydraulic conductivities, and model boundaries for the upper portion of the Principal Aquifer System (PAS) (Layer 6).

The groundwater flow model is calibrated to transient conditions representative of the low and high potentiometric cycles observed in area monitoring wells. Calibration targets included groundwater levels, groundwater flow directions (estimated from potentiometric surface maps), and vertical hydraulic gradients. The model also includes historical, ongoing, and planned source site remedial system groundwater extraction.

2.0 PURPOSE AND OBJECTIVES

Objectives of the numerical model are to develop a representative simulation of groundwater conditions within the SBGPP Study Area that:

- replicates low and high potentiometric cycles observed in the Shallow Aquifer System;
- incorporates horizontal and vertical aquifer heterogeneity demonstrated from cone penetrometer testing (CPT) characterization and results of available aquifer testing;
- includes ongoing and planned source site remedial system groundwater extraction;
- provides an acceptable calibration to observed water level conditions; and
- is suitable for evaluation of remedial alternatives identified in the FS screening process for addressing OU2 groundwater contamination.

3.0 SITE CONCEPTUAL HYDROGEOLOGIC MODEL

A Conceptual Hydrogeologic Model (CHM) for the Study Area was developed based primarily on RI field investigation results and is focused on the SAS and its relationship to the underlying PAS.

The SAS in the Study Area is characterized by various lenses, layers, interbeds, and mixtures of interfingered fine and coarse-grained material. Based on lithologic evaluation (H+A, 2020), the SAS, with increasing depth, was subdivided into the following four hydrostratigraphic units or layers:

- Layer 1: an uppermost fine-grained unit at and below the water table;
- Layer 2: a generally laterally continuous, predominantly coarse-grained upper sand unit;
- Layer 3: a mixed zone of sands and fine-grained materials; and
- Layer 4: a laterally continuous, relatively coarse-grained basal sand.

The overall thickness of the SAS within the Study Area increases from about 80 feet in the southernmost portion of the Study Area to about 160 feet in the northern portion of the Study Area. The SAS is separated from the upper portions of the underlying PAS by a sequence of predominantly fine-grained material of variable thickness that is laterally continuous across the Study Area and acts as an aquitard between the aquifer systems.

The lower portion of the SAS (Layer 4) is characterized by a basal sand unit of variable thickness that overlies the aquitard and appears to be relatively continuous across the Study Area. This basal sand unit occurs at depths ranging from approximately 67 feet below land surface (bls) in the southern portion of the Study Area to approximately 128 feet bls in the northern portion of the Study Area. The thickness of the basal sand unit ranges from approximately 9 feet in the southern portion of the Study Area, to approximately 62 feet in the northern portion of the Study Area.

The SAS within the Study Area is characterized by very shallow depths to the first occurrence of groundwater. Shallowest groundwater is encountered at depths of a few feet bls at most locations in the Study Area, with near-surface semi-perched groundwater conditions found in portions of the northern Study Area. Groundwater levels, horizontal directions of groundwater flow, and horizontal hydraulic gradients in the upper and lower portions of the SAS within the Study Area have remained fairly consistent over time, with horizontal hydraulic gradients ranging from approximately 0.001 to 0.003 ft/ft. Groundwater flow within the SAS across the Study Area is generally from north-northeast to south-southwest. The potentiometric surface of the uppermost portion of the SAS (Layer 1) for 2008, representing a period of low water level elevations, is shown in Figure 3.1. A potentiometric surface map for the Layer 1 during 2012, representing a period of high water level elevations, is shown on Figure 3.2. A 2016 potentiometric surface map for Layer 1, shown on Figure 3.3, represents a return to low water level conditions. Potentiometric surface maps for 2008, 2012 and 2016 for the lower portion of the SAS (Layer 4) are illustrated as Figures 3.4, 3.5 and 3.6, respectively. Differences in water level elevations between upper and lower portions of the SAS, at specific locations, range from negligible to about 3 to 6 feet overall; with vertical hydraulic gradients generally transitioning from downward in the northern portion of the Study Area to upward in the southern portion of the Study Area.

The overall integrity of the aquitard that separates the SAS from the underlying PAS is indicated by the steep downward vertical hydraulic gradients that are induced across the aquitard as a result of large-scale regional groundwater extraction from below the SAS, with differences in water level elevations between the SAS and the PAS often greater than 100 feet.

Spatial variability in the hydrogeologic properties of the SAS in the Study Area is reflected in the results of hydraulic testing of monitor wells and cone-penetrometer tests (CPTs) conducted as part of the RI field activities. Hydraulic conductivity values are generally lower in the finer-grained materials found near land surface, and relatively much higher in the coarser-grained basal sand unit (Layer 4) of the SAS.

There is an extensive network of drainage channels in and around the Study Area. Although not quantified, local groundwater/surface water interaction along unlined drainages within the Study Area does not appear to be a dominant factor affecting water levels or directions of groundwater flow in the SAS across the Study Area. A relatively small portion of groundwater in the uppermost portion of the SAS (Layer 1) within the Study Area may discharge into surface water channels.

Groundwater within the Study Area is discharged from the SAS through lateral and vertical movement between hydrologic units, to remedial extraction wells, and to surface water bodies and drainages.

Recharge to the SAS within the Study Area is primarily from infiltration of precipitation, lateral and vertical movement of groundwater between the hydrologic units, and leakage from the drainage channels.

4.0 MODEL DEVELOPMENT

4.1 Model Codes

The model code used to simulate flow conditions in and around the South Basin was MODFLOW-SURFACT (HydroGeoLogic Inc., Version 3.0, 1996). MODFLOW-SURFACT is a fully integrated groundwater flow and transport code that numerically solves the groundwater flow equation for a porous medium using a finite difference method. MODFLOW-SURFACT is based on the U.S. Geological Survey (USGS) code MODFLOW (McDonald and Harbaugh 1988). MODFLOW-SURFACT includes additional modules to MODFLOW to improve on the code's robustness and increase its simulation capabilities to include complex saturated-unsaturated subsurface flow analysis. Like MODFLOW, MODFLOW-SURFACT simulates groundwater flow using a block-centered, finite-difference approach that is capable of a wide array of boundary conditions. The code can simulate aquifer conditions as unconfined, confined, or a combination of the two. MODFLOW-SURFACT supports variable thickness layers (i.e. variable aquifer bottom and top elevations). MODFLOW-SURFACT also includes packages (modules) developed by the USGS for later versions of MODFLOW, including MODFLOW-96 (Harbaugh and McDonald, 1996) and MODFLOW-2000 (Harbaugh et al, 2000). Documentation of all aspects of the MODFLOW-SURFACT code is provided in the user manual (HydroGeoLogic Inc., 1996).

The pre/post-processor Groundwater Vistas (Version 7.24), developed by Environmental Simulations, was used to assist with input of model parameters and output of model results. Groundwater Vistas provides an extensive set of tools for developing, modifying, and calibrating numerical models and allows for ease of transition between the groundwater flow and particle tracking codes. Full description of the Groundwater Vistas program is provided in the User’s Guide to Groundwater Vistas, Version 7 (Environmental Simulations, Inc., 2017).

The parameter estimation code PEST (Doherty, 2010) was used to assist in the calibration of the model to observed data. The user's manual for PEST provides description of the methodology and software relevant to the use of the code for parameter estimation.

4.2 Model Domain, Grid and Layering

The model domain encompasses an area of 31,000 feet by 31,000 feet and has cell dimensions ranging from 125 feet by 125 feet within the Study Area up to 500 feet by 500 feet on the model edges. The model consists of 159 rows and 135 columns. The Study Area is located in the central portion of the model domain, as shown on Figure 4.1. Projection of the southwest corner of the model is at 6,059,720 feet Easting and 2,188,680 feet Northing, NAD 1983 State Plane California VI FIPS 0406. The model domain was extended a distance of over one mile in all directions from the Study Area boundaries to minimize impacts of exterior boundary conditions on the model solution in the area of interest.

The model consists of six layers. The model layers within the study area were developed from cross sections presented in the Supplemental Remedial Investigation Report (H+A., 2020). The four uppermost layers simulate the SAS. Layer 1 generally represents the shallowest occurrence of groundwater (that is not perched) within the Study Area. Layer 4 represents the basal sand unit that is the lowest portion of the SAS. Layers 2 and 3 represent intermediate hydrostratigraphic units between the uppermost and lowermost units of the SAS. Layer 5 simulates the aquitard between the SAS and the PAS. Layer 6 represents the upper portion of the PAS. Figures 4.2 and 4.3 are north-south and west-east cross sections, respectively, through the center of the model that demonstrate the variable thickness of the layers.

The top of the model is consistent with the current topographic surface, as illustrated in Figure 4.4. The elevation of the base of Layers 1 through 5 are shown on Figures 4.5 through 4.9, respectively. The bottom of the model is 100 feet below the base of the aquitard (layer 5) that lies between the SAS and the PAS. The thickness of model Layers 1 through 5 are illustrated in Figures 4.10 through 4.14.

The overall thickness of the SAS (Layers 1 through 4) decreases toward the south end of the model domain. In some locations, the SAS may be entirely absent, or only a few feet thick. These areas have been identified as "mergence zones", where groundwater from the SAS may flow into or mix with groundwater in the PAS. The mergence zones are located in the southwest corner and south central boundary of the model domain. The thinning of the SAS was represented within the SBGPP model by gradually reducing the thickness of Layers 1 through 4 south of the Study Area to a minimal value of 2 feet per layer.

4.3 Simulation Period

The SBGPP model was used to simulate groundwater flow conditions from February 15, 2007 to July 1, 2017, a duration of 3,788 days. This time period encompasses high and low potentiometric cycles observed in water level elevation data from Study Area monitoring wells. The model simulation was divided into 23 stress periods, ranging from 91 to 244 days in length. Table 4-1 summarizes the stress periods of the model. Boundary conditions around the perimeter of the model domain, discussed in the following section, were adjusted to simulate the observed fluctuation in potentiometric cycles.

4.4 Boundary Conditions

Boundary conditions imposed on a numerical model define the external geometry of the groundwater flow system being studied as well as internal water sources and sinks. Boundary conditions assigned in the model were based on observed/measured conditions including water level and ground surface elevations and documented remedial well extraction rates. Descriptions of the types of boundary conditions that can be implemented with the MODFLOW and MODFLOW-SURFACT codes are found in McDonald and Harbaugh (1988), Harbaugh and McDonald (1996), and HydroGeoLogic Inc. (1996). Boundary conditions used to represent hydrologic conditions within the South Basin included the transient constant head (CHD), river, well, and areal recharge packages of MODFLOW and MODFLOW-SURFACT. The locations of those boundary conditions within the model are illustrated on Figure 4-15. Discussion of the placement and values for these boundary conditions is provided below.

The conceptualization of hydrologic conditions within the Study Area is that groundwater flow in the SAS is generally to the south-southwest. The CHD module is used to simulate groundwater flow into and out of the model domain along the edges of the model domain (Figure 4.15). The CHD module was used to simulate variability in water level conditions over time within the Study Area. CHD values for the SAS were projected from potentiometric surface maps (Figures 3.1 through 3.6) representing low and high water level conditions from 2008 (low), 2012 (high) and 2016 (low) data. The 2008, 2012 and 2016 potentiometric data are represented in model stress periods 3, 12 and 21, respectively. CHD values were interpolated for the stress periods between those low and high cycles.

Groundwater flow in the upper portion of PAS (Layer 6 of the SBGPP model) is consistent with the simulation developed by OCWD for the Basin Model, generally to the south-southwest across the model domain.

The MODFLOW river module was used to represent the system of drainage channels that are present within the model domain (Figure 4.15). Parameters used to define the river cells in the model include elevation of the river stage (head) and bed, length and width of the river, and the thickness and hydraulic conductivity of the river bed. The river bed elevation was set equal to land surface and the stage of the river cells was set at 0.5 feet above the river bed. MODFLOW uses a conductance term to simulate the response of the river cell with the surrounding aquifer system. The conductance term is the product of the river cell length and width, and the thickness and hydraulic conductivity of the river bed. The conductance of the river cell was used as a variable in the calibration of the model.

The MODFLOW-SURFACT well package was implemented to represent source site SAS remedial extraction wells that were operating during the modeled time period (from early 2007 through mid 2017). Approximately 70 source site remedial extraction wells were identified from the California State Water Resources Board Control Geotracker website (https://geotracker.waterboards.ca.gov) and the California Department of Toxic Substances Control Envirostor website (https://dtsc.ca.gov/your-envirostor) and are summarized in Appendix 4-1. In some cases, the spacing between extraction wells was smaller than the minimum model cell width (125 feet). In other cases, the total extraction rate for several wells within a remedial groundwater extraction system was very small. For those conditions, multiple remedial wells were simulated as a single extraction well. Table 4-2 summarizes the wells and extraction rates that are utilized in the SBGPP model. Figure 4.15 indicates the locations of wells simulated in the SBGPP model. No PAS production wells were simulated in the SBGPP model.

Infiltration of precipitation to groundwater is represented using the recharge module of MODFLOW. Recharge is only applied to the uppermost active layer of the model. The SBGPP model utilized the same distribution of recharge that was incorporated in the OCWD Basin Model. Four zones of recharge were utilized, with rates ranging from 8.48

E-05 to 3.16 E-04 feet/day (Figure 4.16). The recharge values were not changed in the calibration of the SBGPP model from the original values developed from the Basin Model.

4.5 Aquifer Properties

Input parameters used in the model to simulate aquifer properties are consistent with data derived from the source sites, where available. Key parameters utilized in the modeling to simulate aquifer properties included top and bottom elevation of the hydrologic units, hydraulic conductivity, storativity and porosity. Top and bottom elevations of the model layers were previously described in Section 4.2.

Zones of hydraulic conductivity were developed to calibrate the model. The zone delineation within the Study Area was based on the distribution of hydraulic conductivity estimated from hydraulic tests and CPT results. The locations of hydraulic tests and CPTs used for estimating the SBGPP model hydraulic conductivity are shown on Figure 4.17. Hydraulic conductivity values within the Study Area were assigned for Layers 1 through 4 that were within the general range estimated from hydraulic tests and CPTs. Hydraulic conductivity is calculated by dividing the transmissivity by the saturated thickness. Transmissivity is estimated directly from hydraulic test results.

Initial estimates of the distribution of hydraulic conductivity within the Study Area for model layers 1 through 4 are shown on Figures 4.18 through 4.21. In general, within the SAS, hydraulic conductivity values are lower for Layer 1, and higher for Layer 4 with more intermediate values in Layers 2 and 3.

Hydraulic conductivity zones outside of the Study Area, but within the model domain, were generally based on the OCWD Basin Model. Additionally, a buffer zone (approximately 600 feet wide) was placed between the zones estimated from the hydraulic test/CPT data and the zones carried over from the Basin Model to provide for a gradual transition of hydraulic conductivity values between the Study Area and surrounding model domain.

Hydraulic conductivity was the primary variable used to calibrate the model. The distribution and values for hydraulic conductivity were adjusted during the calibration process. The final calibrated hydraulic conductivity zonation and values for Layers 1 through 4 are shown in Figures 4.22 through 4.25, respectively. In general, the calibrated hydraulic conductivity zones were on the lower end of the range of values initially estimated inside the Study Area.

The hydraulic conductivity of the aquitard between the SAS and the PAS (Layer 5) was unchanged from the OCWD Basin model with the exception of the mergence zones in the south central boundary of the model domain (Figure 4.26). Hydraulic conductivity of Layer 5 in the vicinity of the mergence zone was increased to enhance flow between the SAS and the PAS, consistent with the recent conceptualization presented by OCWD that is based on the recently completed East Newport Mesa Groundwater Investigation (OCWD 2020). Hydraulic conductivity zones and values for Layer 6 (PAS) were generally based on the Basin Model and were not adjusted during calibration (Figure 4.27).

Specific storage is a measure of the water released from storage due to compaction of the aquifer and expansion of water in response to a decline in head. Specific storage is the storage term used for confined aquifers, where lowering of the potentiometric surface in response to pumping does not result in physical dewatering of the aquifer. Specific storage multiplied by the saturated thickness is referred to as storativity or storage coefficient. MODFLOW-SURFACT requires the input of specific storage, and calculates the storativity.

The SBGPP model includes porosity and specific yield values. Porosity is the percentage of void space within the total soil or rock volume. Porosity is used by the model codes in the calculation of groundwater velocity. Specific yield refers to drainable porosity and cannot be higher than the total porosity. Specific yield is the storage term utilized for unconfined groundwater systems, when lowering of the potentiometric surface results in physical dewatering of the aquifer.

The distribution of specific storage, specific yield and porosity for Layers 1 through 4 are shown on Figure 4.28. For Layer 6, the distribution of these parameters is shown on Figure 4.29. For Layer 5, the following values were used throughout the model domain; specific storage of 1 E-06, specific yield of 1 E-02, and porosity of 3 E-01.

5.0 MODEL CALIBRATION

Model calibration is an integral component of groundwater modeling applications. Calibration of a numerical groundwater flow model is the process of adjusting model parameters to obtain a reasonable match between field measured (observed) values and model predicted (simulated) values of heads and fluxes (Woessner and Anderson, 1992). The calibration procedure is generally performed by varying the estimates of model parameters (hydraulic properties) and/or boundary condition values from a set of initial estimates until an acceptable match of simulated and observed water levels and/or fluxes are achieved. Calibration can be accomplished using trial and error methods or automated techniques (often referred to as inverse modeling). Both methods were employed in the calibration of the SBGPP model.

The SBGPP model was calibrated to water level elevations measured at key wells within and around the Study Area during the modeled time period (early 2007 to middle 2017). The adequacy of model calibration is judged by examining model residuals. A residual, as defined for use in this report, is the difference between the observed water level elevation at a specific well and time and the water elevation simulated by the model for the equivalent well and time. The objective of model calibration is the minimization of key calibration statistics including the residual mean, residual standard deviation, and residual sum of squares (RSS) (Duffield et al., 1990). The mean residual is the arithmetic average of all the differences between observed and simulated water levels. A positive residual indicates that the model has underpredicted the observed water level elevation level and a negative residual indicates overprediction. The residual standard deviation quantifies the spread of the differences between observed and predicted water level elevation around the mean residual. The ratio of residual standard deviation to the total head change across the model domain should be small, indicating the residual errors are only a small part of the overall model response (Woessner and Anderson 1992). The RSS is computed by adding the square of each residual and is another measure of overall variability. The overall objective during the calibration process is to minimize the residuals and the statistics based on the residual while maintaining hydraulic properties within the range of reasonably expected values.

The calibration statistics provide a quantitative assessment of the calibration effort. Additional methods were used to evaluate the calibration that are more qualitative in nature. These include demonstration that the model adequately replicates the potentiometric surface, in terms of flow direction and gradient, the transient nature of the potentiometric cycles, and the vertical hydraulic gradients that exist between the various hydrostratigraphic units.

5.1 Calibration Targets

The model was calibrated to water level elevations measured from February 2007 to July 2017 at wells located within and around the Study Area. Water level measurements from 56 wells were used as calibration targets with 46 of those wells being located within the Study Area. The number of observations (water level measurements) per well ranged from

1 to 22. Some wells had multiple water level measurements within a single model stress period. In those cases, only the measurement that was closest to the start of a stress period was used in the calibration. A total of 888 observations were used as calibration targets. Appendix A-2 summarizes the wells used for calibration, the corresponding model layers where the wells are located, the observed and simulated water level elevations and model residuals. Several of the calibration targets located in the south portion of the study area are synthetic values that were derived from projections of potentiometric maps.

5.2 Calibration Process

Initial calibration was conducted through trial and error methods to match the observed water levels to simulated values. Calibration was assisted through the use of PEST, a parameter estimation software that is commonly used in calibrating groundwater models (Doherty et al., 2010). The user's manual for PEST provides description of the methodology and software relevant to the use of the code for parameter estimation.

The objective function used to guide the calibration process was the successive reduction of the RSS. Lowering the RSS during the calibration process generally represents an overall improvement in the match between observed and simulated heads throughout the model.

Calibration was primarily accomplished by varying the hydraulic conductivity zone values within model layers 1, 2, 3 and 4. Both horizontal and vertical values were adjusted during calibration. However, the hydraulic conductivity values were maintained within the range of reasonably expected values throughout the calibration process. No adjustments were made to either Layer 5 or 6 hydraulic conductivity zones, with the exception of the area along the south central portion of the model that represents the mergence zone. In that area, the aquitard (Layer 5) was assigned relatively higher hydraulic conductivity values to provide a preferential pathway for groundwater in the SAS to move into the upper PAS.

Some adjustments were made to the river conductance values, but those adjustments had minimal impacts on the overall model calibration.

5.3 Calibration Simulation Results

As previously described, the model was constructed to simulate low water level conditions in 2008 and 2016, and high water level conditions in 2012. Results of the calibration simulation for the 2008 potentiometric surfaces are provided for model layers 1, 2, 3, 4, and 6 as Figures 5.1 through 5.5, respectively. Layer 5 represents the aquitard between the SAS and the PAS and is not shown. The simulated 2012 potentiometric surfaces for layers 1 through 4 and 6 are shown on Figures 5.6 through 5.10. Figures 5.7 through 5.15 depict the simulated 2016 potentiometric surfaces for those same layers.

The potentiometric surface maps for each model layer are consistent with the conceptual model of groundwater flow across the Study Area, demonstrating a general decrease in water level elevation moving from north-northeast to south-southwest.

Each of the potentiometric surface figures include the model residuals for applicable calibration targets. Water level elevations were not available for each stress period in the model for every well. In general, there were less calibration targets available in the earlier modeled time. Some of the calibration targets in the southern portion of the Study Area are based on synthetic water level elevations derived from projections of the potentiometric surface. Those calibration targets are indicated with an asterisk.

A plot of observed versus simulated water level elevations for all of the calibration targets is presented in Figure 5.16. Results of the calibration simulation indicate an acceptable fit between the observed and simulated data. The red line on the figure represents the projection a "perfect fit", i.e. where the residual between the observed and simulated values would all equal zero. The tight clustering and even distribution of points around the line of equal observed/simulated groundwater level elevations indicate that the model reasonably reproduces the calibration targets without consistently overpredicting or underpredicting the observed values.

A plot of observed water level elevations versus the residual for all of the calibration targets is presented in Figure 5.17. A negative residual indicates that the model has overpredicted the water level elevation for a calibration target, whereas a positive residual indicates the model has underpredicted the water level elevation. The redline on the plot highlights the zero residual value. The figure indicates a generally even distribution of model residuals across the model domain, relative to the zero residual line, indicating that the model is not overly biased toward overprediction or underprediction.

A plot of observed versus simulated water level elevations for Layer 1 is shown on Figure 5.18. A plot of observed water level elevations versus the residual for Layer 1 is shown on Figure 5.19. Similar plots are shown for Layer 2 (Figures 5.20 and 5.21), Layer 3 (Figures 5.22 and 5.23), Layer 4 (Figures 5.24 and 5.25), and Layer 6 (Figures 5.26 and 5.27).

The calibration statistics for the SBGPP model are presented in Table 5-1. The table breaks down the statistics for the entire model, and for individual layers. The residual mean, and absolute residual mean for the entire model and for layers 2, 3 and 4 have values less than 1.0 and 2.0 feet, respectively. These calibration statistics for Layers 1 and 6 are higher, but are still reasonable. Multiple factors could be affecting the quality of the calibration statistics of Layer 1 including: calibration targets from this layer may be from wells that are completed in perched systems that are not connected or continuous throughout the study area; may be from wells that are screened across multiple layers; or water levels at the wells used as calibration targets may be affected by localized remedial groundwater extraction systems. Regarding the calibration statistics for Layer 6, the focus of the SBGPP model is on the SAS, which comprises layers 1 through 4. No attempt was made to adjust the aquifer parameters associated with Layer 6 during the calibration process. However, the simulated potentiometric surface of Layer 6 is consistent with the conceptual hydrologic model.

Calibration was also assessed specifically for the Study Area. Calibration statistics for the calibration targets from wells located within the Study Area are presented in Table 5-2. These statistics exclude wells outside of the Study Area and all synthetic values.

Essentially, non-synthetic calibration targets within the Study Area were assigned a weighting factor of 1, whereas all other targets were assigned a weighting factor of 0. The calibration statistics were improved for Layers 2, 3 and 4, but showed little change for Layer 1.

The calibration of the model was further assessed by comparing the simulated and observed horizontal hydraulic gradients across the Study Area for the upper and lower SAS. The hydraulic gradients were calculated from potentiometric surface maps. Figure 5.28 shows the location of the upgradient (A) and downgradient (B) locations used to calculate the horizontal hydraulic gradient from both the simulated and observed potentiometric surfaces. The observed potentiometric surfaces of the upper SAS for 2008 (Figure 3.1), 2012 (Figure 3.2), and 2016 (Figure 3.3) were compared to the simulated potentiometric surface for Layer 1 for the same time periods (Figures 5.1, 5.6 and 5.11, respectively). The horizontal hydraulic gradient calculated from the simulated potentiometric surfaces range from 0.0021 to 0.0023 ft/ft, compared to 0.0022 to 0.0023 ft/ft for the observed data, as summarized in Table 5-3. Similarly, the observed potentiometric surfaces of the lower SAS for 2008 (Figure 3.4), 2012 (Figure 3.5), and 2016 (Figure 3.6) were compared to the simulated potentiometric surface for Layer 4 for the same time periods (Figures 5.4, 5.9 and 5.15, respectively). The horizontal hydraulic gradient calculated from the simulated potentiometric surfaces of Layer 4 range from 0.0016 to 0.0020 ft/ft, compared to 0.0016 to 0.0019 ft/ft for the observed data (Table 5-3).

Calibration of the model was also assessed qualitatively through the use of hydrographs for key wells (Figure 5.28). The hydrographs were used to verify that the model simulates the general fluctuations observed in the potentiometric cycles and the relative vertical gradients that exist between the hydrostratigraphic units (Layers) within the SAS. The conceptual hydrologic model includes a generally downward vertical hydraulic gradient in the northern portion of the Study Area that transitions to a more neutral to slightly upward gradient to the south. Figure 5.29 illustrates hydrographs of the observed and simulated water level elevations for wells 2SAM2-1 (screened in Layer 2) and 2SAM2-2 (screened in Layer 4). These wells are located in the northern portion of the Study Area. The figure demonstrates that the water level elevations in the shallower well (2SAM2-1) are consistently higher than the levels for the deeper well (2SAM2-2) for both the observed and simulated values. Figure 5.30 shows a similar relationship for wells 2SAM6-1 (screened in Layer 2) and 2SAM6-2 (screened in Layer 4) which are located slightly southwest of the 2SAM2 series wells. The vertical hydraulic gradient is downward throughout the modeled time period. Moving further south, there is a gradual transition to a more neutral and then slightly upward vertical gradient, as seen in the hydrographs for the 2SAM7 and 2SAM8 series wells (Figures 5.31 and 5.32, respectively). Wells 2SAM7A and 2SAM8A are screened in Layer 2, whereas 2SAM7D and 2SAM8D are screened in Layer 4. These wells had not yet been installed during the modeled time period and the comparison is between simulated and synthetic data. The synthetic data were developed from projections of potentiometric surface maps through the Study Area.

6.0 SUMMARY AND CONCLUSIONS

A numerical groundwater flow model was developed to support the SBGPP RI/FS being conducted by OCWD to address groundwater contamination in OU2 in the south-central portion of the Basin in Orange County, California. The numerical modeling is based on the current hydrogeologic conceptual model of the regional and local groundwater flow system. The SBGPP model was generally based on the Basin Model previously developed by OCWD. Key modifications included the following:

- the SAS was divided into four Layers;
- the simulation period was 3,789 days, from February 15, 2007 to July 1, 2017;
- hydraulic conductivity values within the Study Area were based on data from aquifer tests and CPTs;
- Constant Head Boundaries along the model perimeter were derived from projection of potentiometric surfaces in the upper and lower portions of the SAS during low and high water level conditions observed in 2008 (low), 2012 (high) and 2016(low);
- simulation of extraction rates from remedial actions;
- incorporation of a “mergence zone” between the SAS and the PAS in the southwest corner and south central boundary of the model domain.

Model calibration was focused mainly on adjusting hydraulic conductivity values within the Study Area in the SAS. A total of 888 water level elevations from 56 wells were used as calibration targets.

The calibration of the SBGPP model appears reasonable across the simulated range of low and high potentiometric conditions. The simulated potentiometric surfaces reasonably reflect observed horizontal and vertical gradients and directions of groundwater flow within and between subunits of the SAS.

Based on the calibration results and simulated potentiometric conditions, the SBGPP model is suitable for the purpose of evaluating FS remedial alternatives to address OU2 groundwater contamination within the SAS

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TABLES

Table 4-1. Simulation Time and Stress Periods, SBGPP Groundwater Model

StressPeriod	Length (days)	Start (days from start of simulation)	End (cumulative days from start of simulation)	Start Date	End Date
1	213	0	213	2/15/2007	9/16/2007
2	213	213	426	9/16/2007	4/16/2008
3	183	426	609	4/16/2008	10/16/2008
4	151	609	760	10/16/2008	3/16/2009
5	184	760	944	3/16/2009	9/16/2009
6	181	944	1125	9/16/2009	3/16/2010
7	184	1125	1309	3/16/2010	9/16/2010
8	122	1309	1431	9/16/2010	1/16/2011
9	120	1431	1551	1/16/2011	5/16/2011
10	123	1551	1674	5/16/2011	9/16/2011
11	152	1674	1826	9/16/2011	2/15/2012
12	91	1826	1917	2/15/2012	5/16/2012
13	153	1917	2070	5/16/2012	10/16/2012
14	151	2070	2221	10/16/2012	3/16/2013
15	214	2221	2435	3/16/2013	10/16/2013
16	151	2435	2586	10/16/2013	3/16/2014
17	184	2586	2770	3/16/2014	9/16/2014
18	212	2770	2982	9/16/2014	4/16/2015
19	183	2982	3165	4/16/2015	10/16/2015
20	122	3165	3287	10/16/2015	2/15/2016
21	244	3287	3531	2/15/2016	10/16/2016
22	151	3531	3682	10/16/2016	3/16/2017
23	107	3682	3789	3/16/2017	7/1/2017

Table 4-2: Remedial Extraction Rates, by Stress Period, SBGPP Groundwater Model

Extraction Well	X*	Y*	Layer	SP1	SP2	SP3	SP4	SP5	SP6	SP7
E-13	6073607.54	2208917.8	1	134.37	373.08	465.68	399.07	247.57	423.33	540.95
HEW-6	6074352.35	2208275.09	1	0.00	0.00	0.00	25.03	25.03	0.00	0.00
CEI-6	6077063.9	2206327.39	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EX-2	6076907.82	2206343.93	1	847.04	1155.06	0.00	0.00	0.00	847.04	837.61
W-2	6075079.7	2208914.65	1	751.94	39.08	411.78	809.31	833.95	712.09	770.04
GWX-1	6077952.15	2210066.25	1	2161.12	1965.53	0.00	1516.40	2035.99	1847.33	2070.25
MW-19B	6077833.69	2209940.17	1	0.00	320.72	0.00	692.84	988.15	923.66	1035.13
MW-26B	6077841.94	2209838.5	1	0.00	320.72	0.00	692.84	988.15	923.66	1035.13
OW-2B	6077917.41	2209836.26	1	0.00	641.25	0.00	1385.49	1976.12	1847.33	2070.25
SSA-PZ1	6073489.56	2206760	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MW-22B	6077419.73	2207574.1	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trench	6077428.88	2207590.97	1	0.00	0.00	30.80	25.60	22.72	7.51	11.55
MW-24	6073732.07	2208911.19	2	9.63	26.57	33.30	28.49	17.71	30.22	38.69
EX-1	6075243.92	2202606.19	2	1653.66	1351.04	1424.57	1386.07	1090.95	606.41	1183.94
GWX-6	6077519.02	2209119.13	2	0.00	325.92	0.00	692.84	988.15	923.66	1035.13
MW-23B	6077741.52	2209639.18	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MW-25C	6077624.35	2209512.32	2	0.00	325.92	0.00	692.84	988.15	923.66	1035.13
RW-1	6073031.2	2203985.97	2	0.00	0.00	0.00	1925.10	1925.10	1925.10	1925.10
RW-2	6073270.44	2203949.61	2	0.00	0.00	0.00	1232.06	1232.06	1232.06	1232.06
RW-3	6073139.98	2203967.04	2	0.00	0.00	0.00	6064.07	6064.07	6064.07	6064.07
RMW-4D	6072371.14	2201261.32	2	703.43	632.78	715.37	806.23	779.86	730.38	375.20

ft^3/d - cubic feet per day

Table 4-2: Remedial Extraction Rates, by Stress Period, SBGPP Groundwater Model

Extraction Well	SP8	SP9	SP10	SP11	SP12	SP13	SP14	SP15	SP16	SP17	SP18
E-13	360.38	451.05	561.74	544.03	581.96	677.44	531.91	673.98	640.67	721.14	494.17
HEW-6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CEI-6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.55	6.74	6.74
EX-2	1232.06	1221.67	1296.75	1074.78	1129.26	1095.96	1122.53	1110.98	1134.46	1076.71	1041.67
W-2	770.04	770.04	770.04	770.04	770.04	385.02	0.00	0.00	0.00	0.00	0.00
GWX-1	1875.05	2238.31	2143.98	2181.33	2104.33	2113.76	2095.86	2127.62	2624.10	1635.56	1627.86
MW-19B	937.52	1119.25	1071.90	1090.76	1052.26	1056.88	1048.02	1063.81	1093.26	0.00	0.00
MW-26B	937.52	1119.25	1071.90	1090.76	1052.26	1056.88	1048.02	1063.81	1530.65	1635.56	1627.86
OW-2B	1875.05	2238.31	2143.98	2181.33	2104.33	2113.76	2095.86	2127.62	2624.10	1635.56	1627.86
SSA-PZ1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	84.70	0.00	0.00	0.00
MW-22B	0.00	0.00	0.00	0.00	0.00	0.00	1774.94	1884.67	1890.45	2057.93	2096.43
Trench	10.40	17.13	95.10	91.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MW-24	25.80	32.15	40.04	38.89	41.58	48.32	37.92	48.13	45.82	51.59	35.23
EX-1	1294.63	1168.54	1767.24	1617.08	2169.01	1959.75	1848.10	1832.89	1460.96	1599.57	1611.69
GWX-6	937.52	1119.25	1071.90	1090.76	1052.26	1056.88	1048.02	1063.81	1530.65	1635.56	1627.86
MW-23B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MW-25C	937.52	1119.25	1071.90	1090.76	1052.26	1056.88	1048.02	1063.81	1530.65	1635.56	1627.86
RW-1	1925.10	1902.38	1828.85	2079.11	1809.59	2003.45	2051.19	2136.86	1895.65	1927.60	1904.89
RW-2	1232.06	1303.68	1347.96	1065.16	673.79	218.31	520.35	404.27	184.42	244.49	281.06
RW-3	6064.07	5822.85	4732.47	6750.75	7767.78	7691.74	8156.07	8566.70	8346.85	8882.99	8460.81
RMW-4D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

ft^3/d - cubic feet per day

Table 4-2: Remedial Extraction Rates, by Stress Period, SBGPP Groundwater Model

Extraction Well	SP19	SP20	SP21	SP22	SP23
E-13	254.31	304.17	284.14	0.00	0.00
HEW-6	0.00	0.00	0.00	0.00	0.00
CEI-6	4.04	5.78	5.78	12.51	19.25
EX-2	874.00	789.87	795.07	803.34	771.97
W-2	0.00	0.00	0.00	0.00	0.00
GWX-1	2847.99	2751.55	2808.91	1143.51	1416.49
MW-19B	0.00	0.00	0.00	0.00	0.00
MW-26B	1503.12	1316.00	1426.88	1143.51	1416.49
OW-2B	1503.12	1316.00	505.72	0.00	0.00
SSA-PZ1	0.00	0.00	0.00	0.00	0.00
MW-22B	2119.54	2113.76	2113.76	1925.10	2111.83
Trench	0.00	0.00	0.00	0.00	0.00
MW-24	18.10	21.75	20.21	0.00	0.00
EX-1	997.78	972.18	1045.91	900.95	1400.51
GWX-6	1581.85	0.00	0.00	0.00	0.00
MW-23B	1582.24	1316.00	1426.88	1143.51	1416.49
MW-25C	1503.12	1316.00	1426.88	1143.51	1416.49
RW-1	1936.46	1907.77	1742.41	1595.14	1580.51
RW-2	368.85	359.03	311.87	293.58	192.51
RW-3	8279.28	7761.04	6706.09	6476.04	6868.76
RMW-4D	0.00	0.00	0.00	0.00	0.00

ft^3/d - cubic feet per day

Table 5-1. Calibration Statistics, SBGPP Groundwater Model

Calibration Statistic	All Layers	Layer 1	Layer 2	Layer3	Layer 4	Layer 6
Residual Mean (ft)	0.75	3.38	-0.13	0.90	0.16	2.39
Absolute Residual Mean (ft)	1.75	3.64	1.06	1.24	1.67	3.10
Residual Std. Deviation (ft)	2.36	2.46	1.28	1.66	2.24	3.28
Sum of Squares (ft^2)	5454.95	1502.75	431.42	586.04	1421.23	1513.51
Residual Mean Squared Error	2.48	4.18	1.28	1.88	2.24	4.06
Min. Residual (ft)	-8.97	-7.10	-3.10	-2.94	-8.97	-4.19
Max. Residual (ft)	12.94	9.98	3.22	10.78	7.74	12.94
Number of Observations	888	86	262	165	283	92
Range in Observations (ft)	62.72	33.64	23.38	41.61	39.79	45.15
Scaled Residual Std. Deviation (ft)	0.038	0.073	0.055	0.040	0.056	0.073
Scaled Absolute Residual Mean (ft	0.028	0.108	0.045	0.030	0.042	0.069
Scaled RMS Error (ft)	0.040	0.124	0.055	0.045	0.056	0.090
Scaled Residual Mean (ft)	0.012	0.101	-0.005	0.022	0.004	0.053

ft - feet
ft^2 - feet squared

Table 5-2. Calibration Statistics, Study Area, SBGPP Groundwater Model

Calibration Statistic	All Layers	Layer 1	Layer 2	Layer 3	Layer 4
Residual Mean (ft)	0.39	3.39	0.00	0.40	-0.04
Absolute Residual Mean (ft)	0.92	3.47	0.79	0.64	0.72
Residual Std. Deviation (ft)	1.61	2.27	1.12	1.14	1.26
Sum of Squares (ft^2)	2450.04	1432.27	329.59	239.89	448.30
Residual Mean Squared Error	1.66	4.08	1.12	1.21	1.26
Min. Residual (ft)	-5.12	-1.56	-3.10	-2.94	-5.12
Max. Residual (ft)	9.98	9.98	3.22	4.32	3.35
Number of Observations	487	80	193	71	143
Range in Observations (ft)	62.72	33.64	23.38	41.61	39.79
Scaled Residual Std. Deviation (ft)	0.026	0.067	0.048	0.027	0.032
Scaled Absolute Residual Mean (ft)	0.015	0.103	0.034	0.015	0.018
Scaled RMS Error (ft)	0.026	0.121	0.048	0.029	0.032
Scaled Residual Mean (ft)	0.006	0.101	0.000	0.010	-0.001

ft - feet
ft^2 - feet squared

Table 5-3. Comparison of Observed vs Simulated Horizontal Hydraulic Gradients, Study Area, SBGPP Groundwater Model

	Observed Potentiometric Surfaces						
	2008 Upper SAS	2012 Upper SAS	2016 Upper SAS		2008 Lower SAS	2012 Lower SAS	2016 Lower SAS
Distance- A to B (ft)	16270	16270	16270		16270	16270	16270
Obs Head at A (ft amsl)	63.10	60.72	55.75		55.86	56.76	50.47
Obs Head at B (ft amsl)	25.70	24.55	20.75		29.96	28.46	20.20
Obs Head Diff (ft)	37.40	36.17	35.00		25.90	28.30	30.27
Obs Hyd Grad(ft/ft)	0.0023	0.0022	0.0022		0.0016	0.0017	0.0019
	Simulated Potentiometric Surfaces						
	2008 Layer 1	2012 Layer 1	2016 Layer 1		2008 Layer 4	2012 Layer 4	2016 Layer 4
Distance- A to B (ft)	16270	16270	16270		16270	16270	16270
Sim Head at A (ft amsl)	59.36	57.12	53.29		53.53	54.81	46.41
Sim Head at B (ft amsl)	21.83	22.30	19.69		21.67	22.35	19.57
Sim Head Diff (ft)	37.53	34.82	33.60		31.86	32.46	26.84
Sim Hyd Grad (ft/ft)	0.0023	0.0021	0.0021		0.0020	0.0020	0.0016

Points A and B are shown on Figure 5.28
Obs - observed
Sim - simulated
Head Diff - head difference between points A and B
Hyd Grad - hydraulic gradient between points A and B
ft amsl - feet above mean sea level
ft - feet
ft/ft - feet per foot
SAS - shallow aquifer system

FIGURES

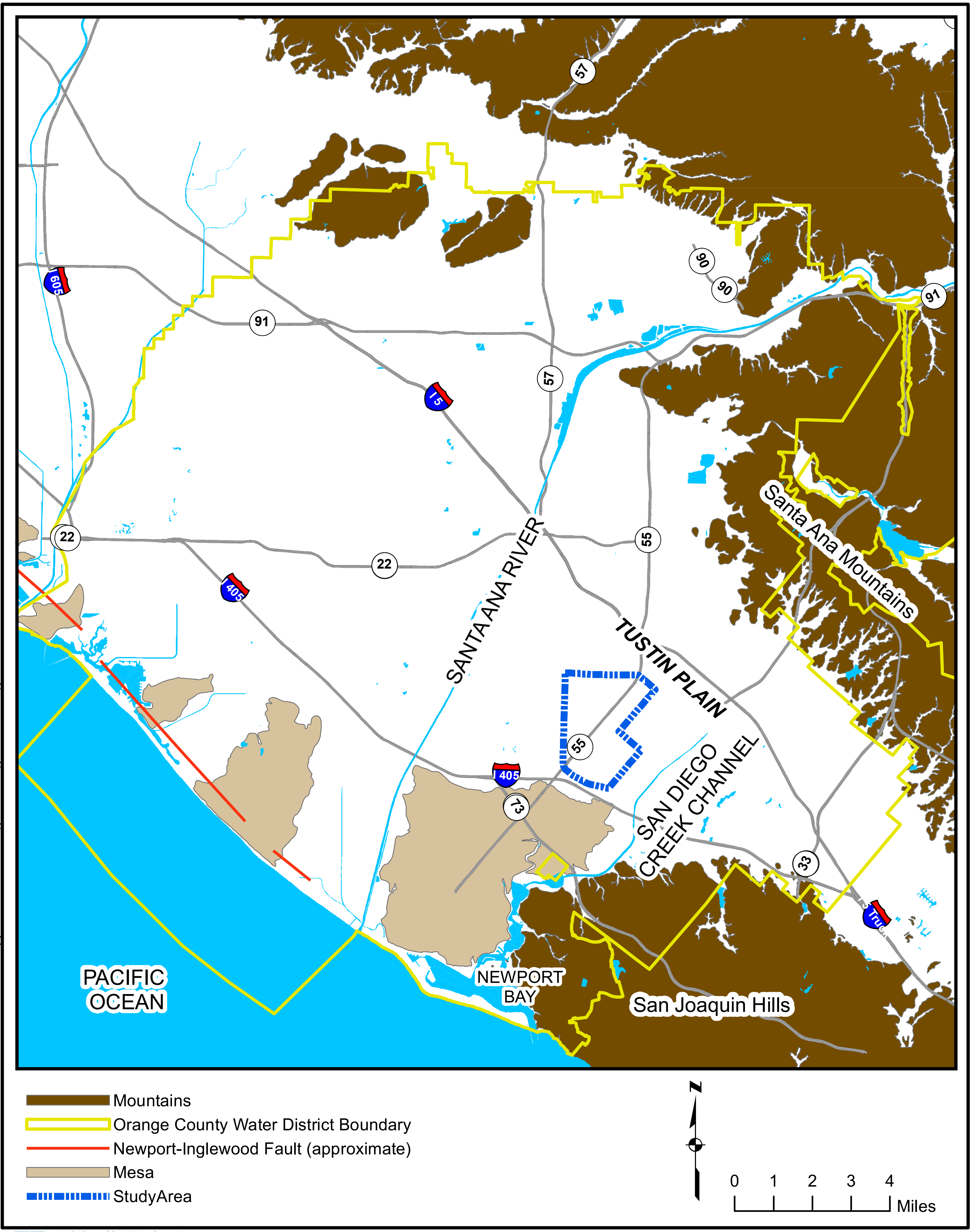

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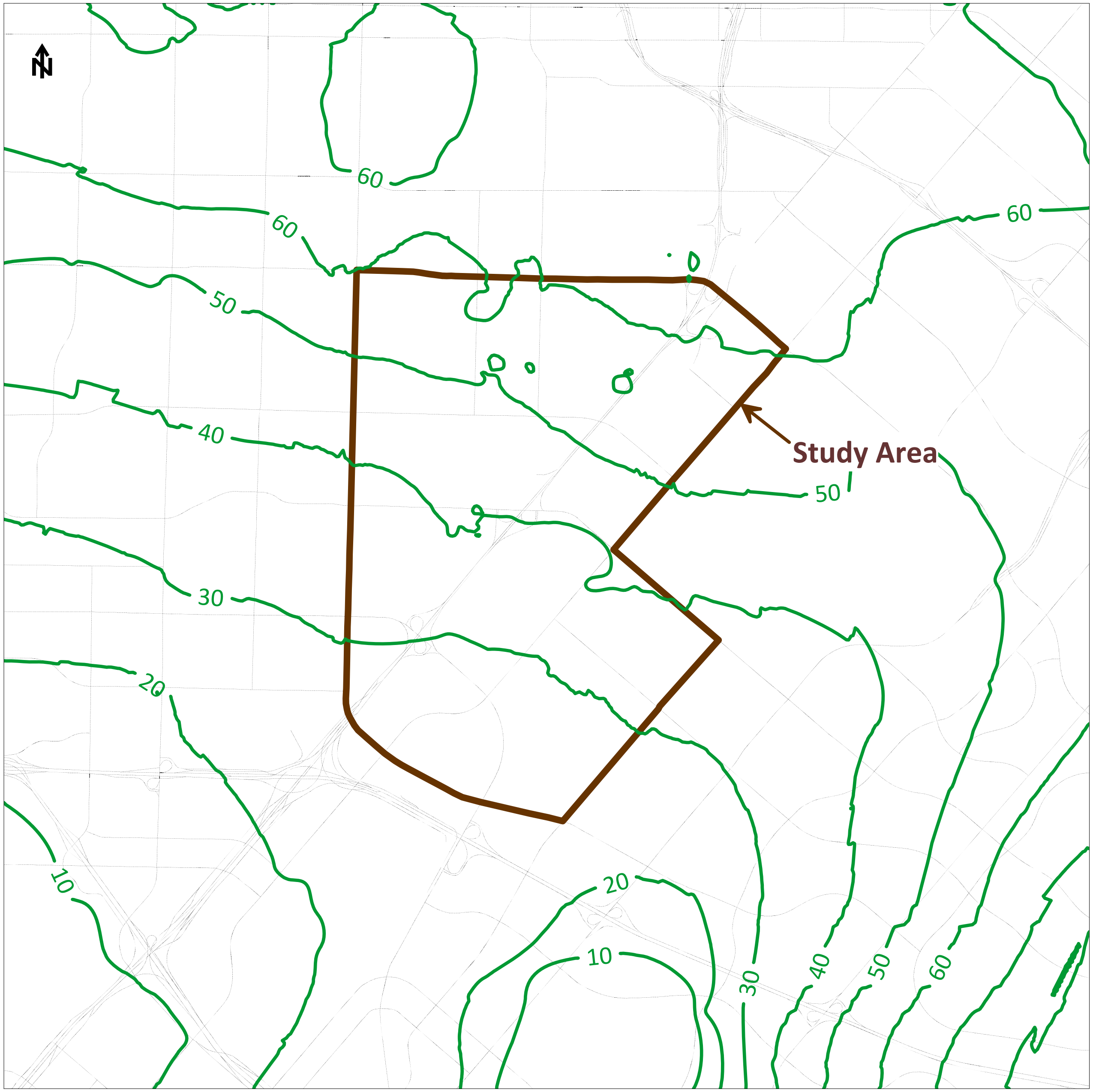
FIGURE 1-1. PROJECT STUDY AREA



Potentiometric surface (feet above mean sea level) (contour interval is 10 feet)

0 5000 10000
feet

* Simulated as Layer 1 of the SBGPP Model

Project No. 151099

SBGPP_Potsurf_UpperSAS_2008.srf (04/12/21)

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Figure 3.1. Potentiometric Surface - 2008 Upper Shallow Alluvial Aquifer System*

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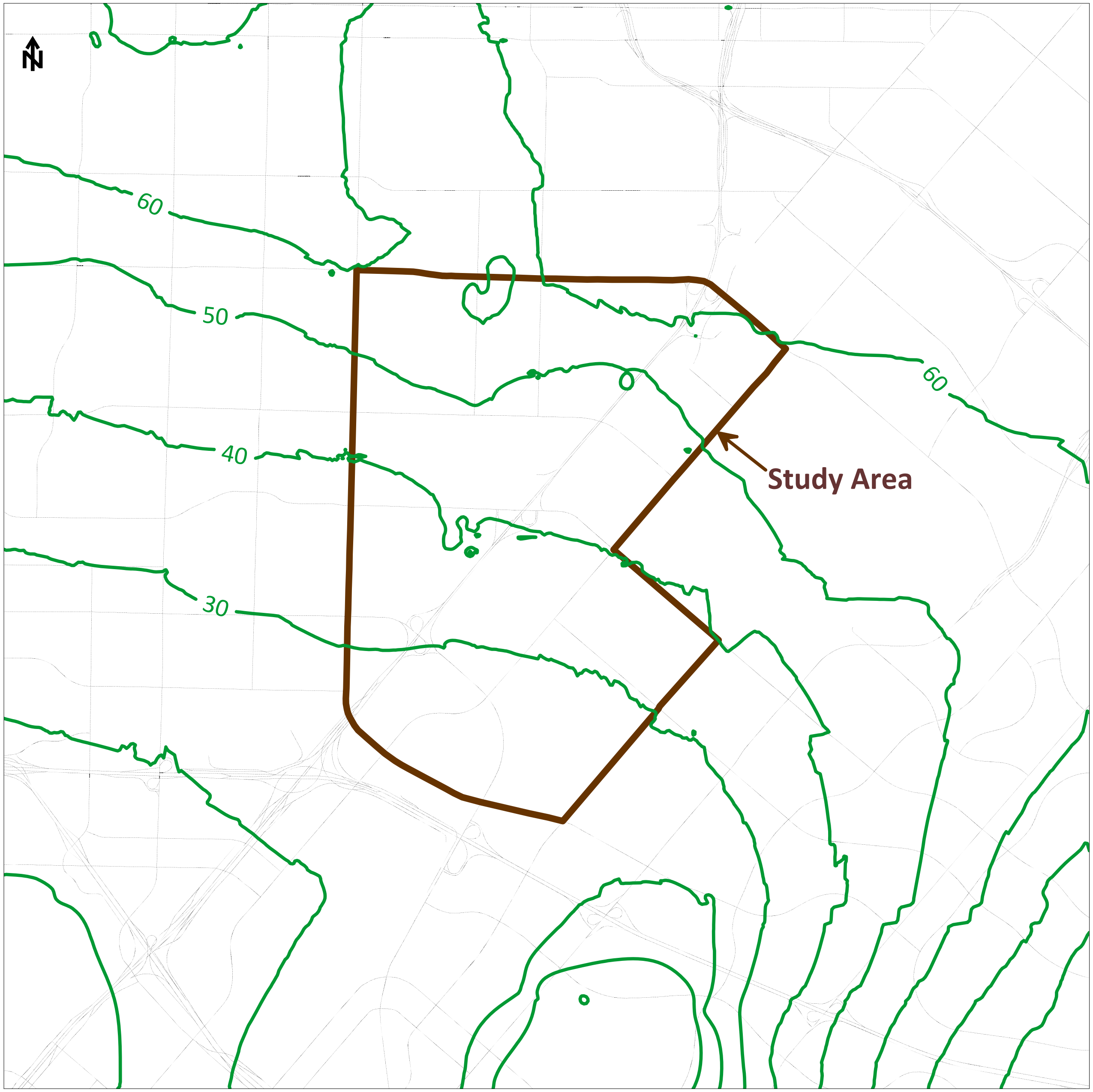
South Basin Groundwater Protection Plan

Project No. 151099



Potentiometric surface (feet above mean sea level)
(contour interval is 10 feet)

0 5000 10000
feet

* Simulated as Layer 1 of the SBGPP Model

SBGPP_Potsurf_UpperSAS_2012.srf (04/12/21)

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Figure 3.2. Potentiometric Surface - 2012
Upper Shallow Alluvial Aquifer System*

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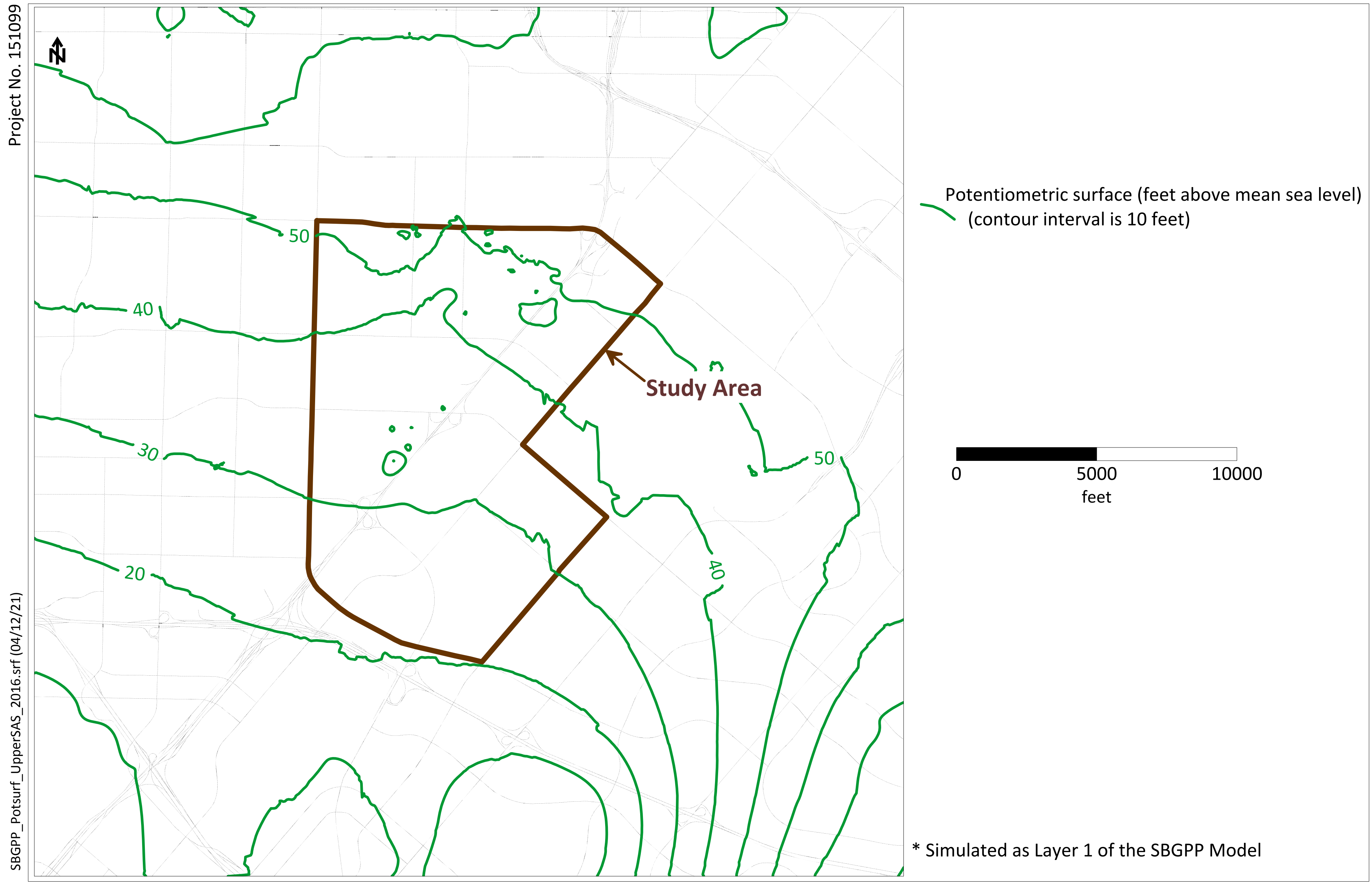

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Figure 3.3. Potentiometric Surface - 2016
Upper Shallow Alluvial Aquifer System*

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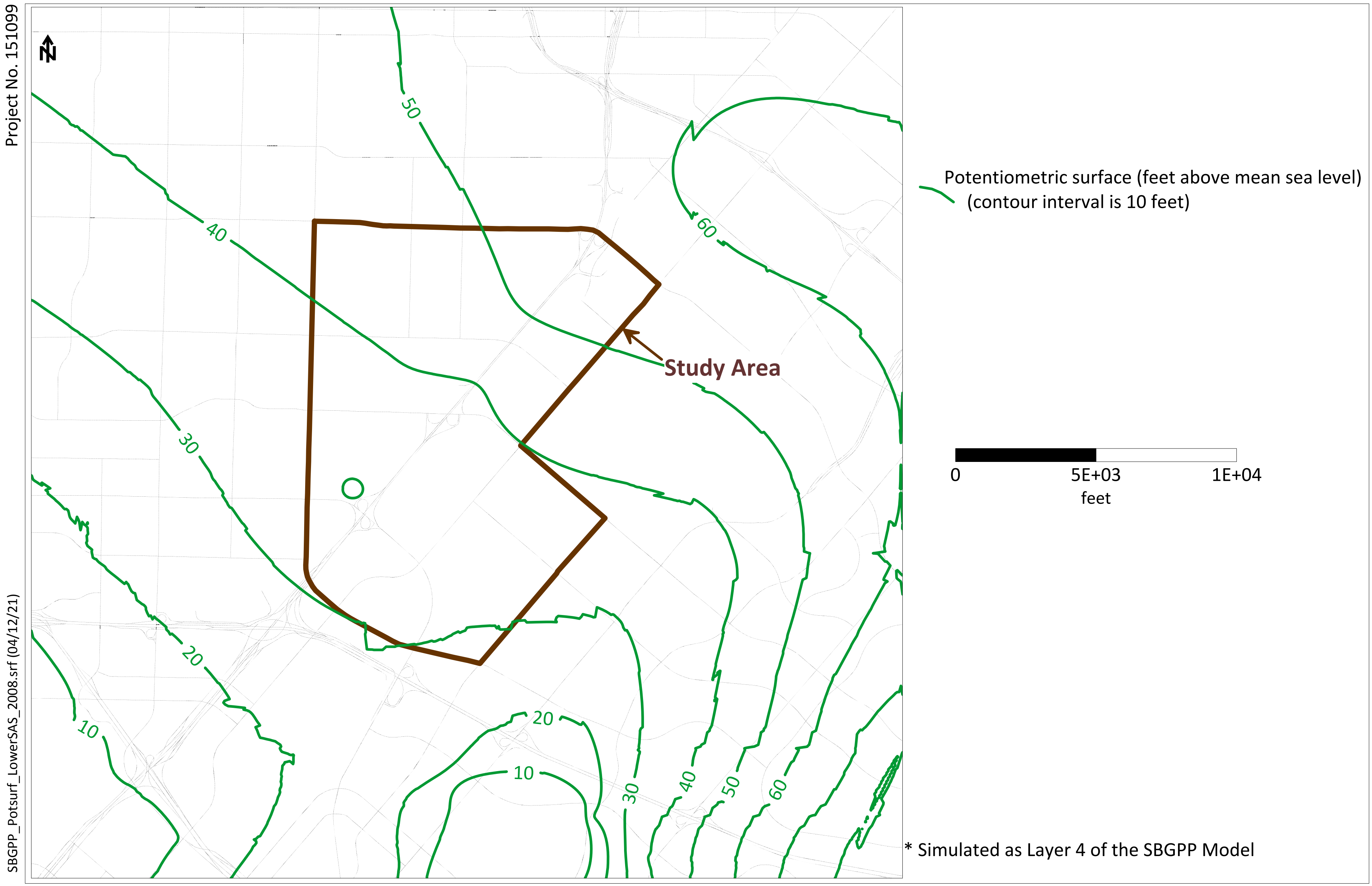

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Figure 3.4. Potentiometric Surface - 2008
Lower Shallow Alluvial Aquifer System*

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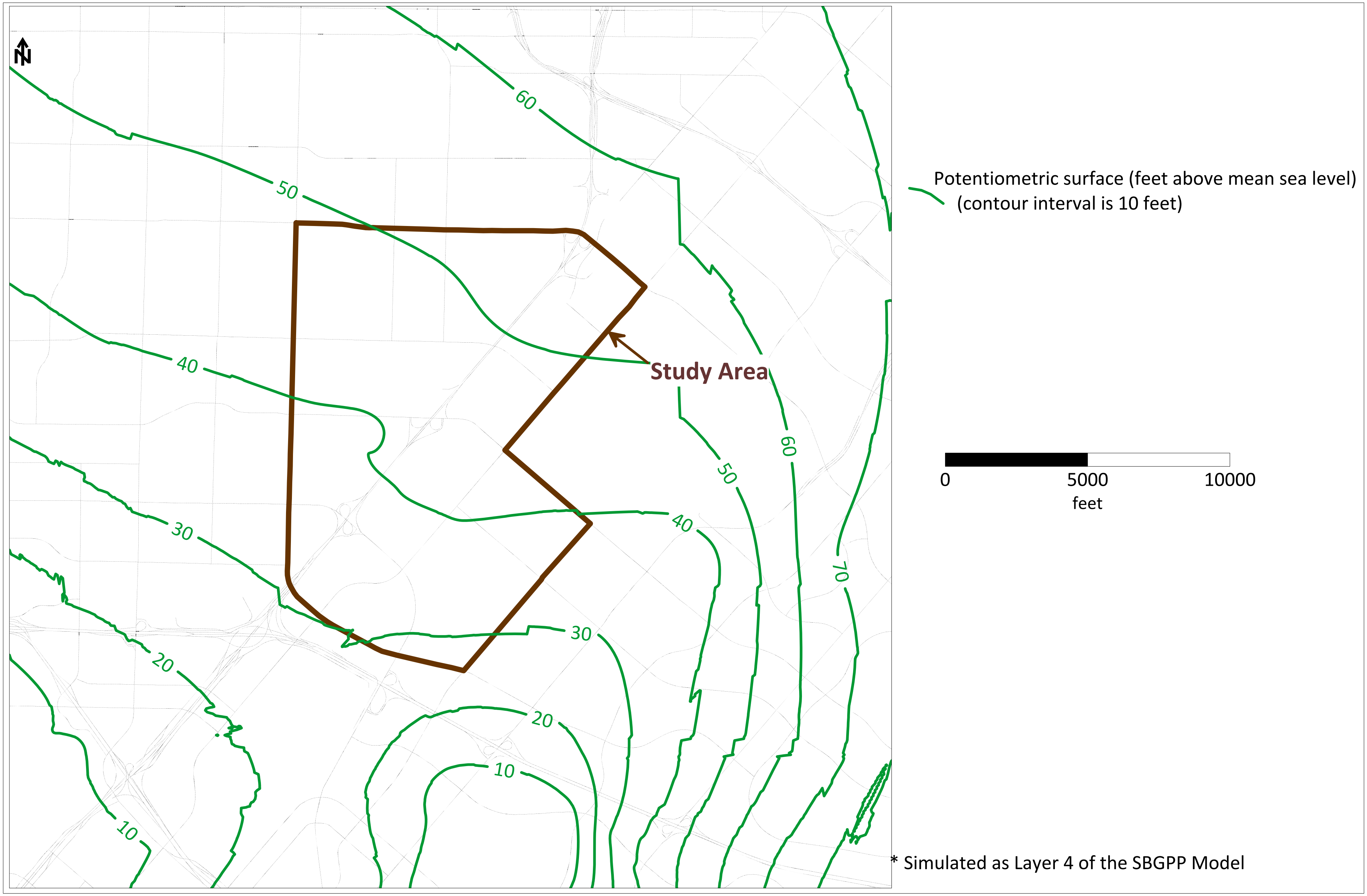

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Figure 3.5. Potentiometric Surface - 2012
Lower Shallow Alluvial Aquifer System*

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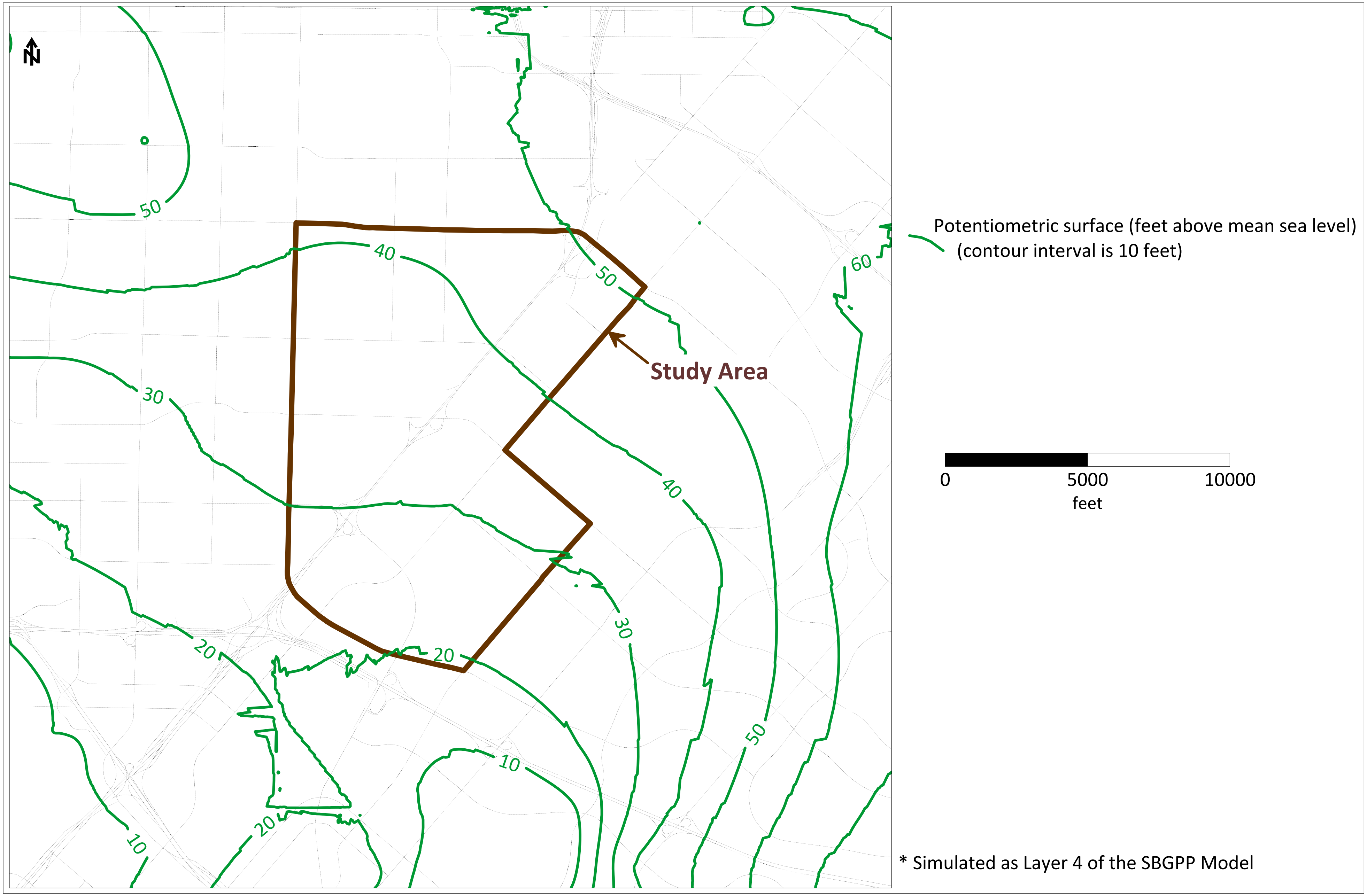

SBGPP_Potsurf_LowerSAS_2016.srf (04/12/21)

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Figure 3.6. Potentiometric Surface - 2016
Lower Shallow Alluvial Aquifer System*

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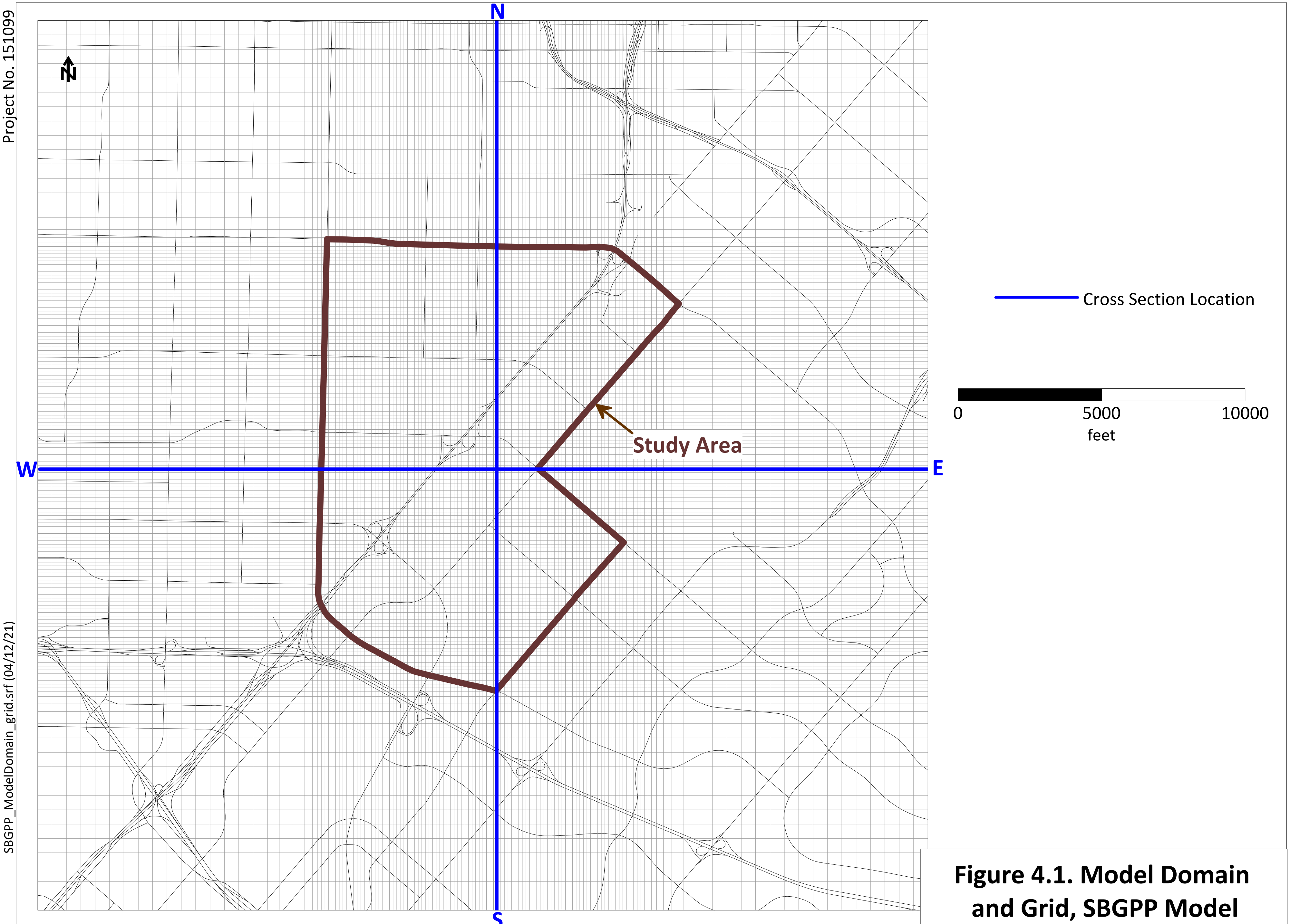

Project No. 151099

SBGPP_ModelDomain_grid.srf (04/12/21)

Figure 4.1. Model Domain and Grid, SBGPP Model

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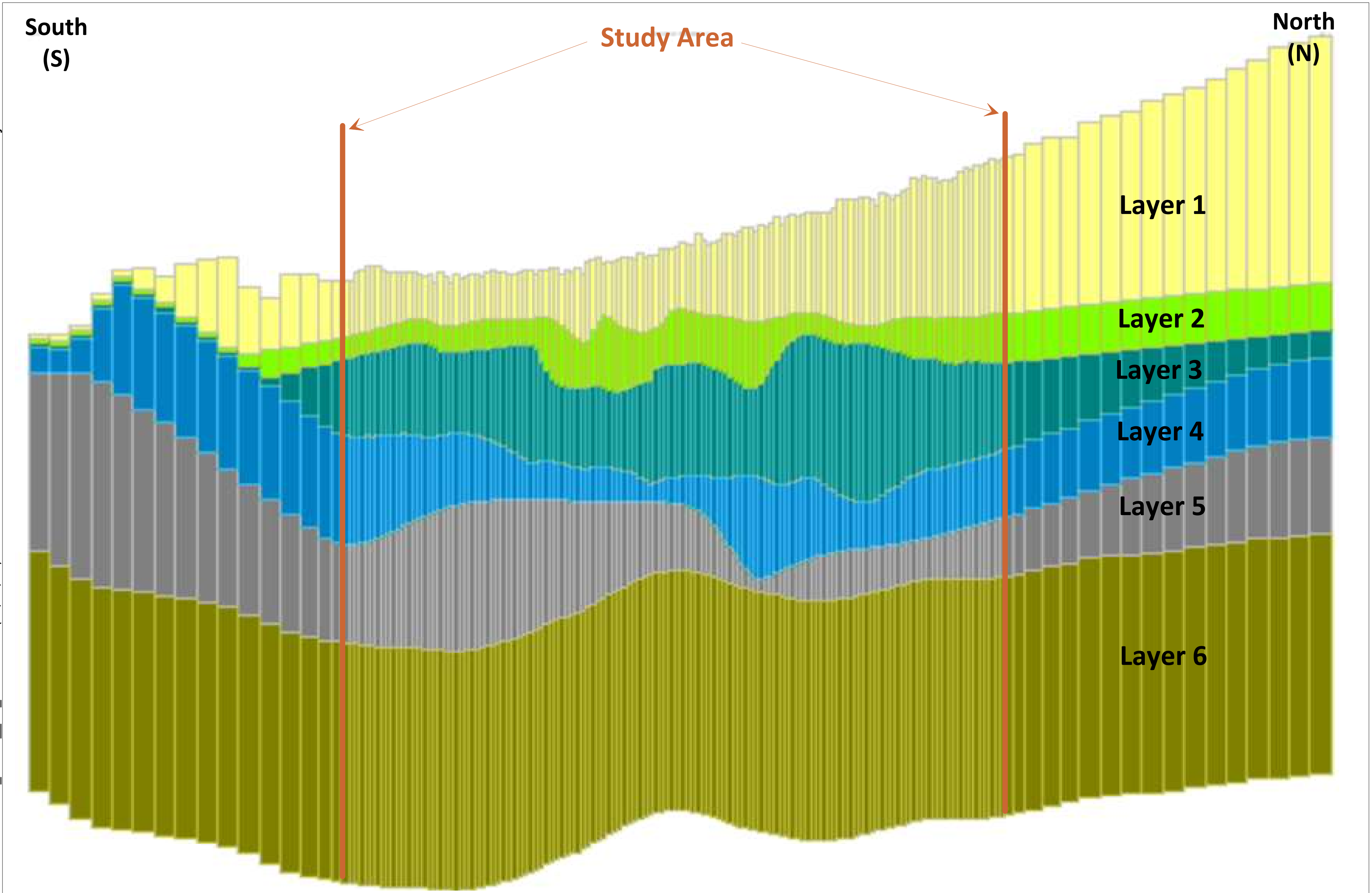

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Figure 4.2. North-South Cross Section SBGPP Model

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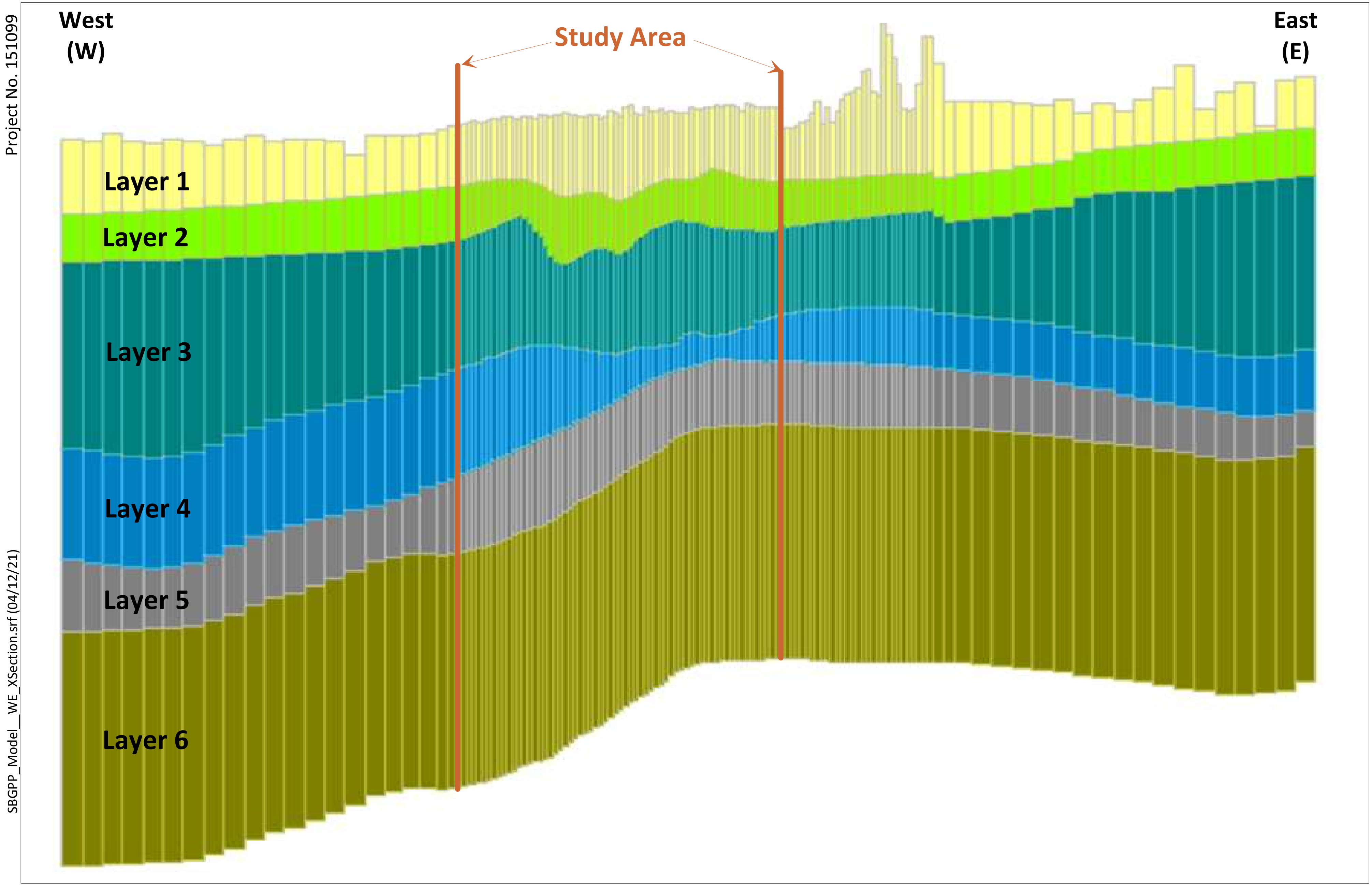

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Figure 4.3. West-East Cross Section SBGPP Model

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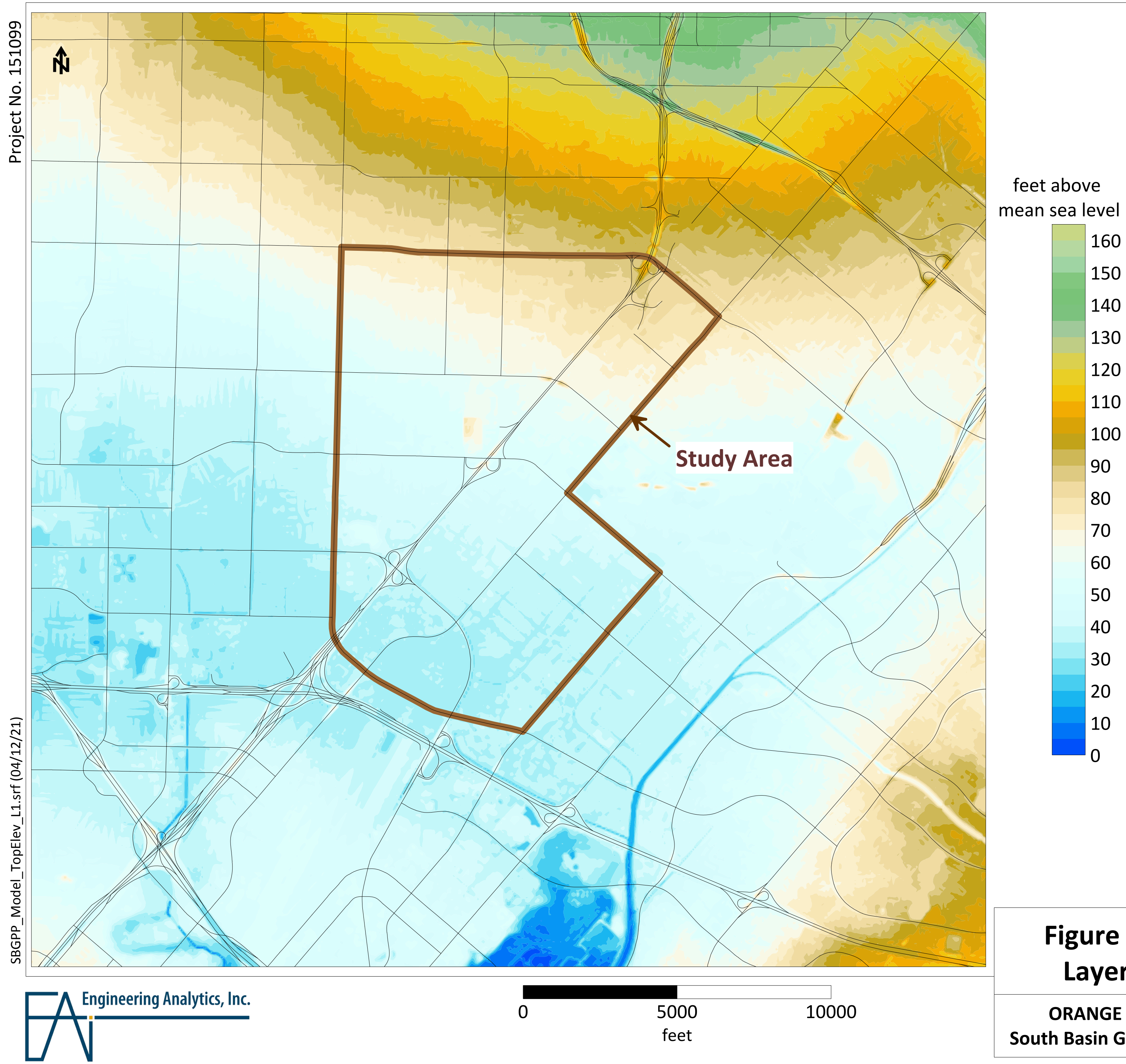

Figure 4.4. Top Elevation Layer 1-SBGPP Model

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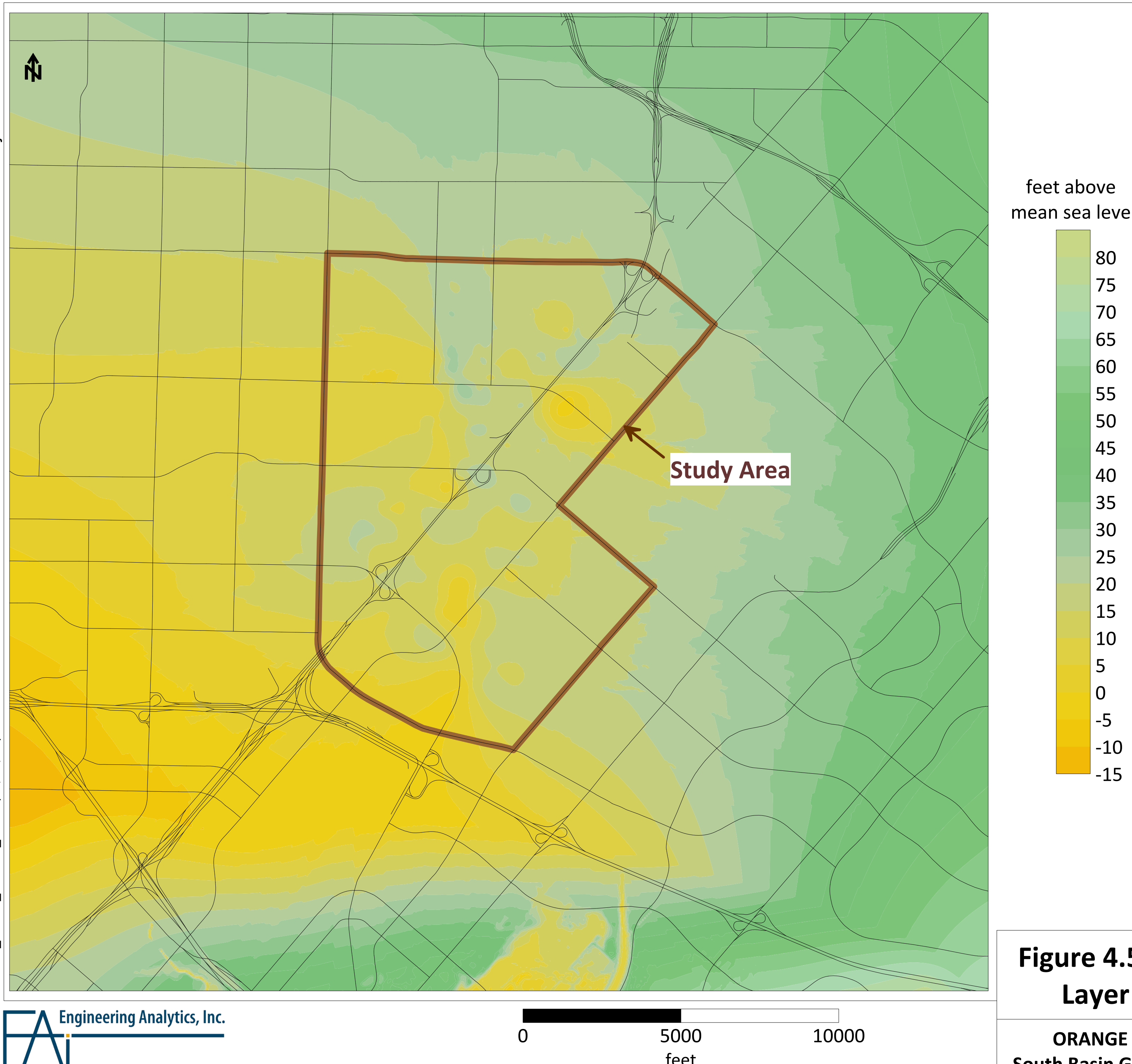

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Figure 4.5. Bottom Elevation Layer 1-SBGPP Model

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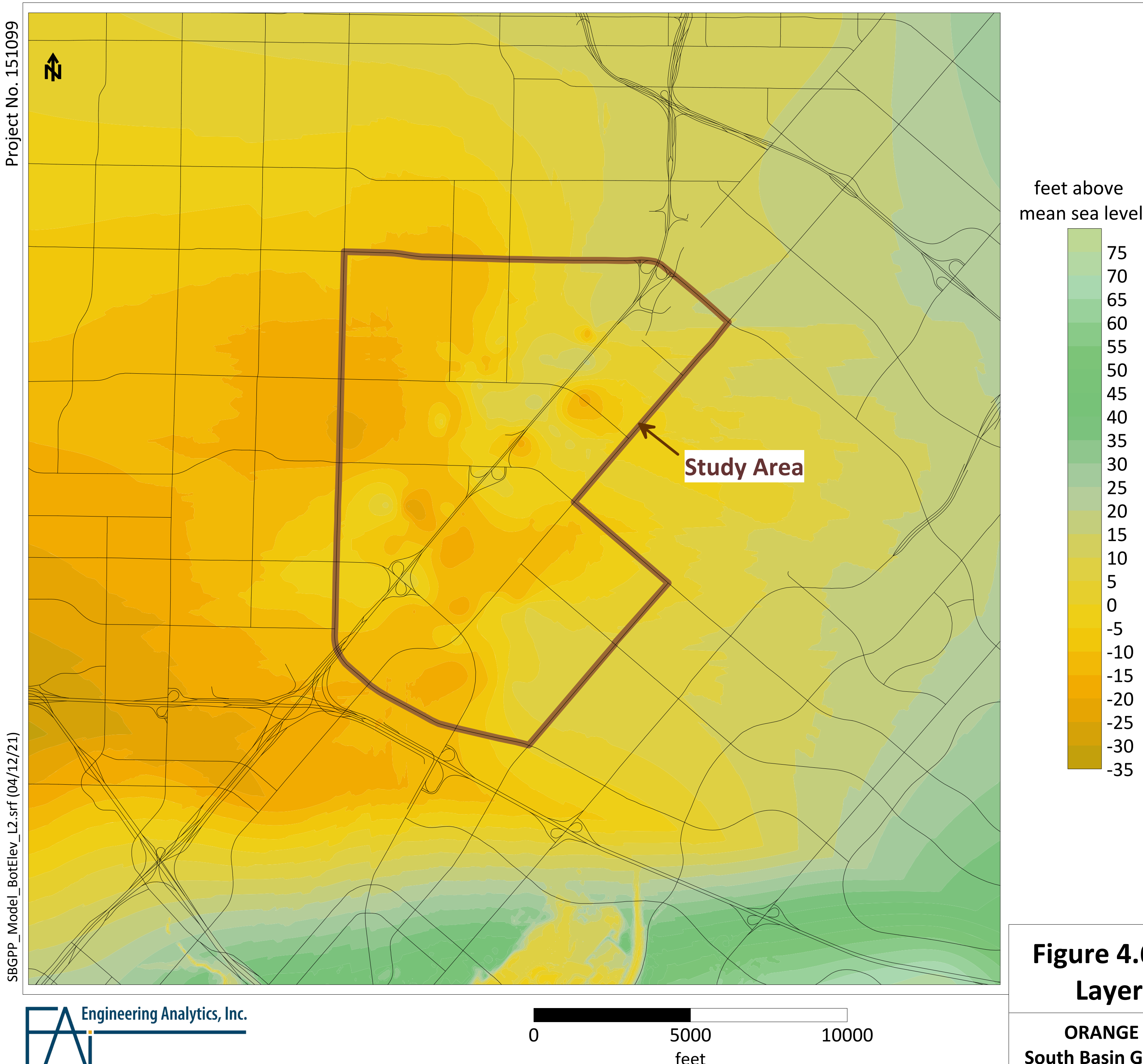

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Figure 4.6. Bottom Elevation Layer 2-SBGPP Model

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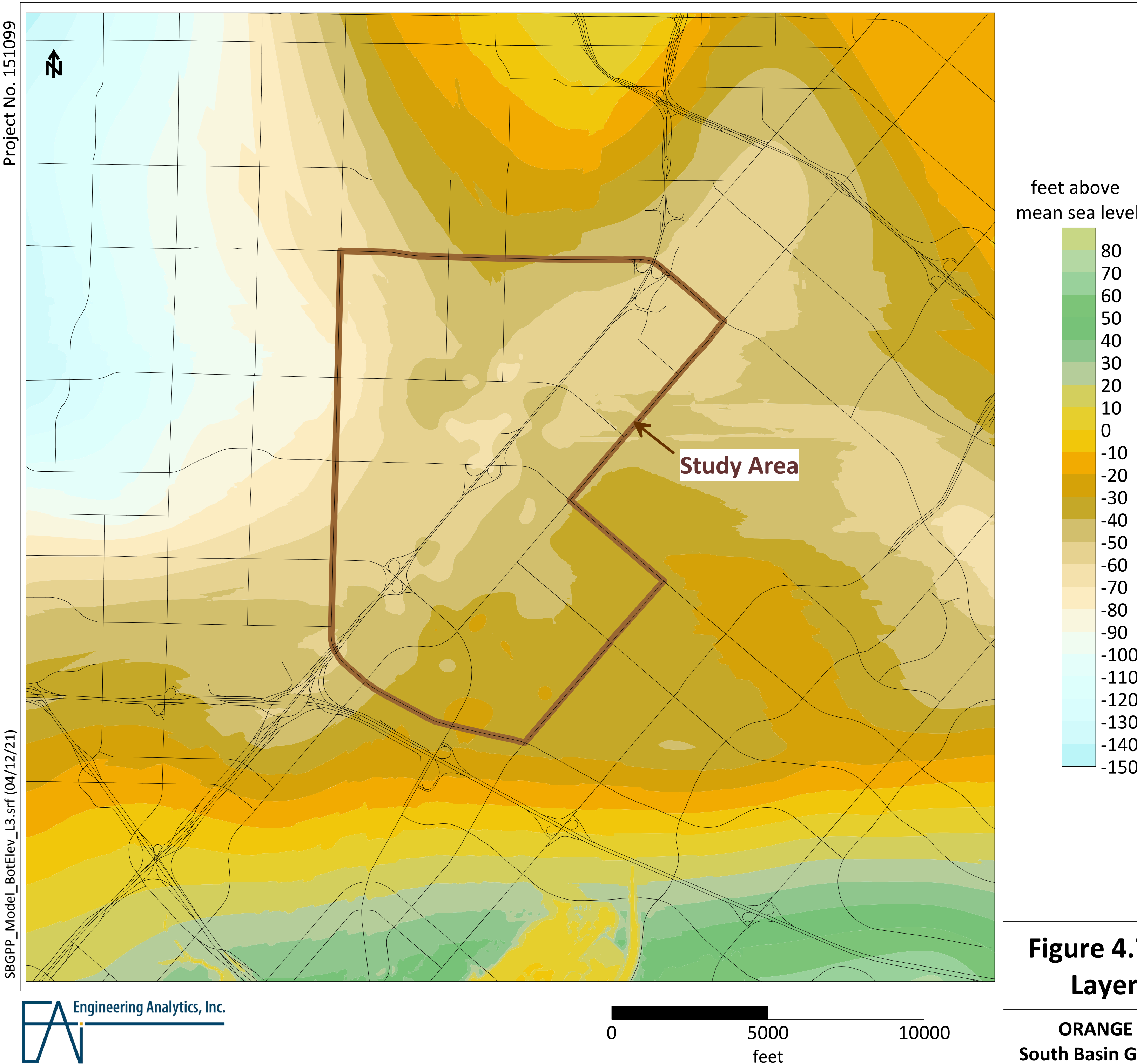

Figure 4.7. Bottom Elevation Layer 3-SBGPP Model

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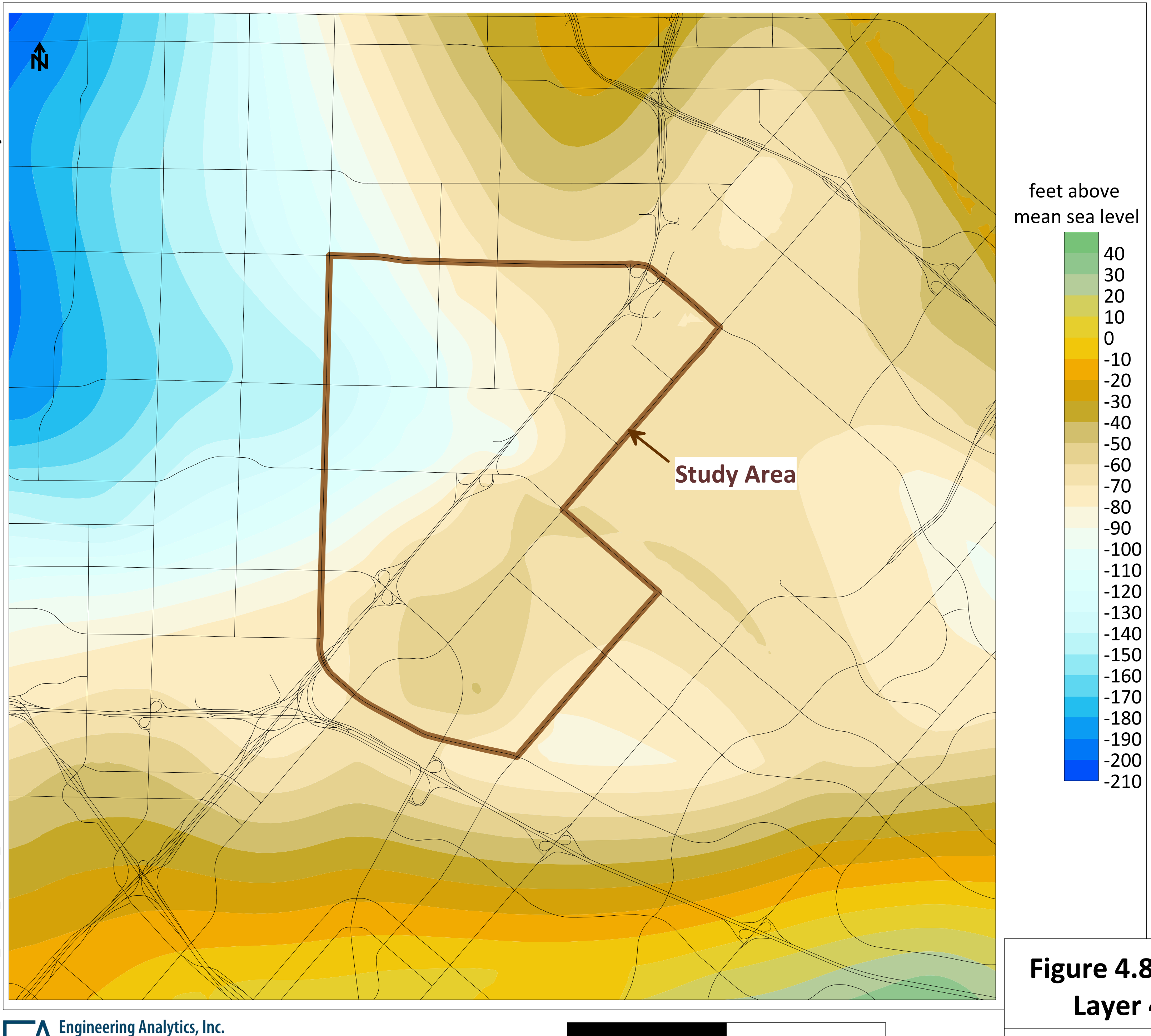
South Basin Groundwater Protection Project

Project No. 151099



SBGPP_Model_BotElev_L4.srf (04/12/21)

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Figure 4.8. Bottom Elevation Layer 4-SBGPP Model

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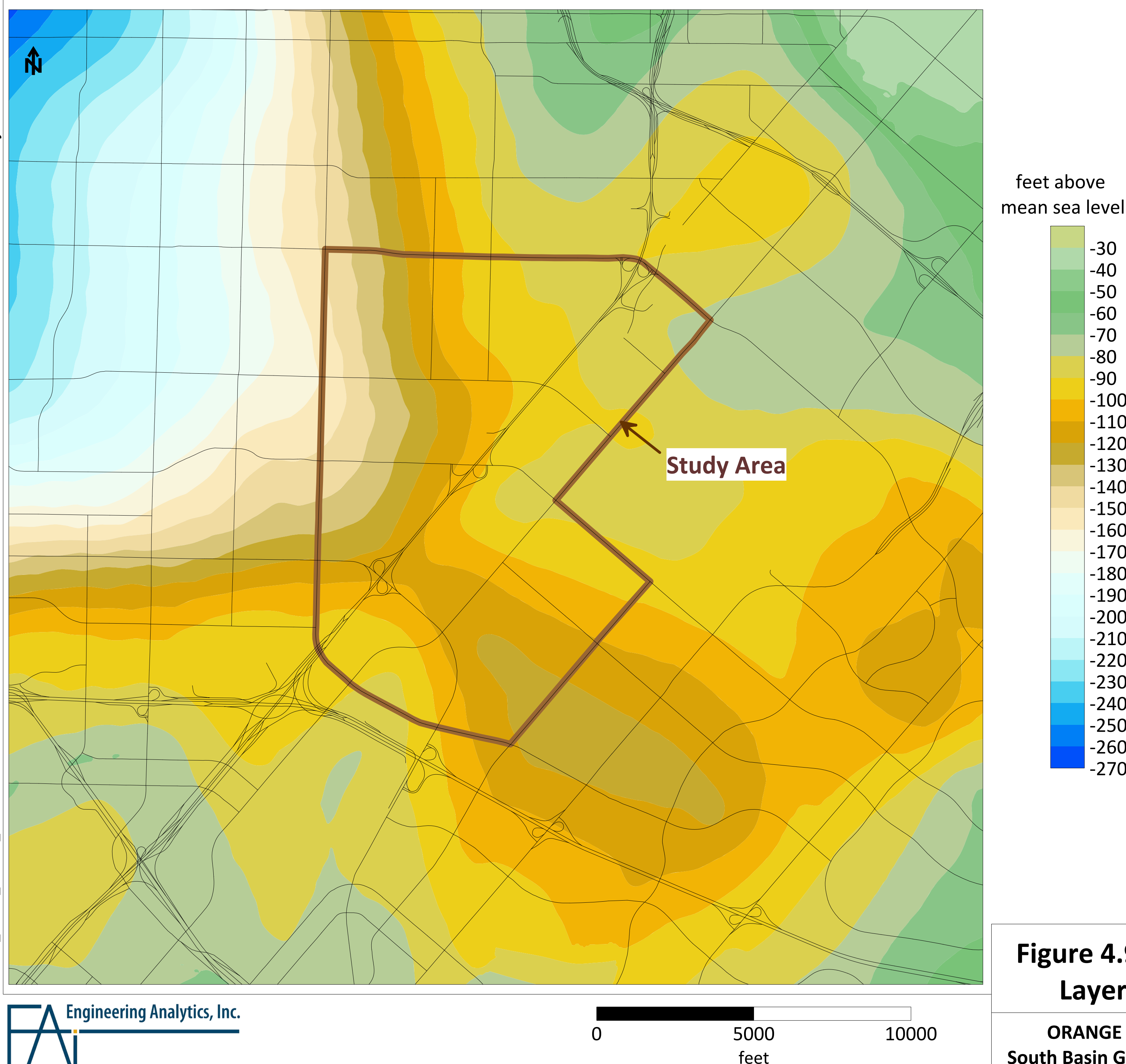
Project No. 151099



SBGPP_Model_BotElev_L5.srf (04/12/21)

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Figure 4.9. Bottom Elevation Layer 5-SBGPP Model

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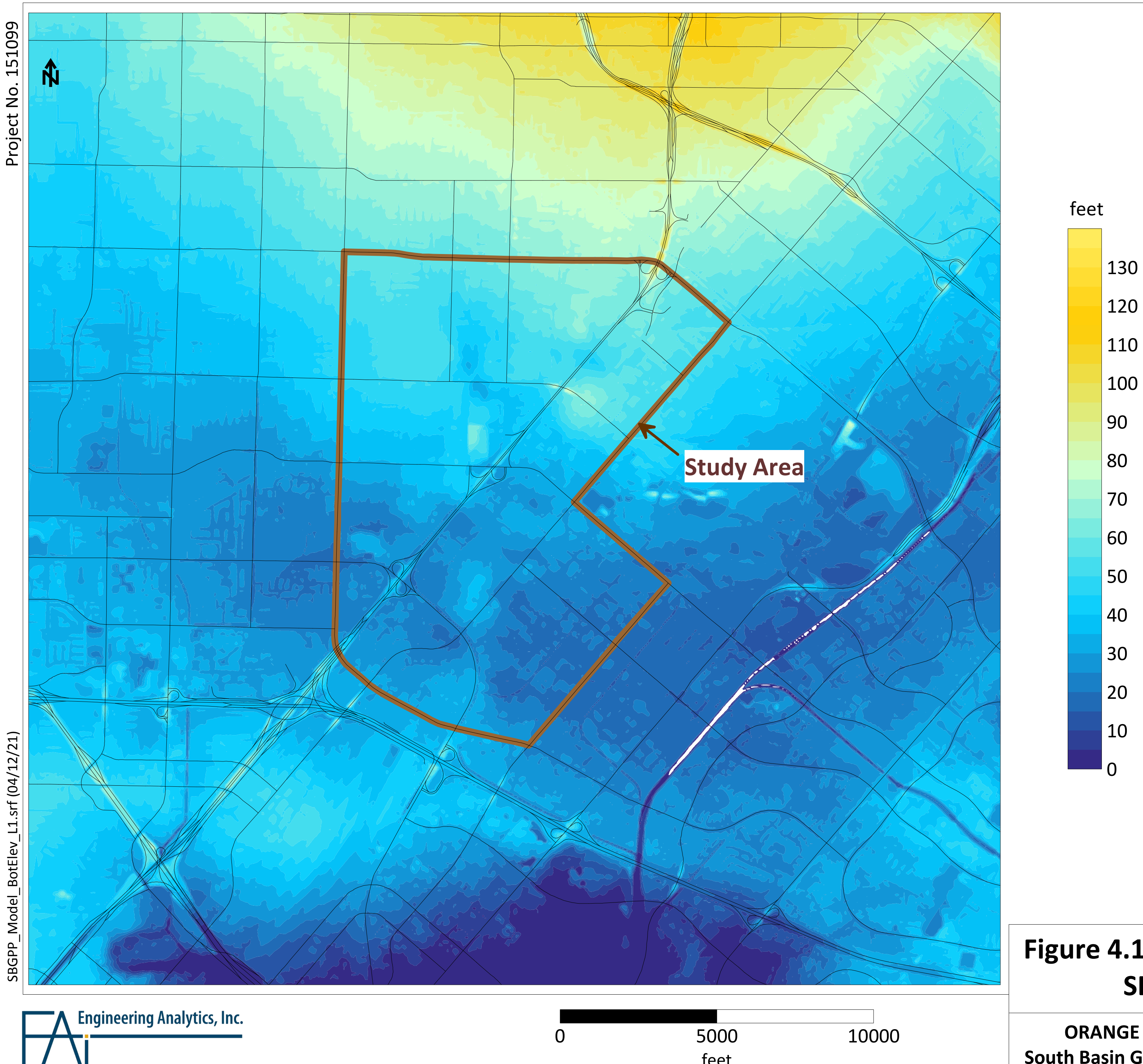

Figure 4.10. Layer 1 Thickness SBGPP Model

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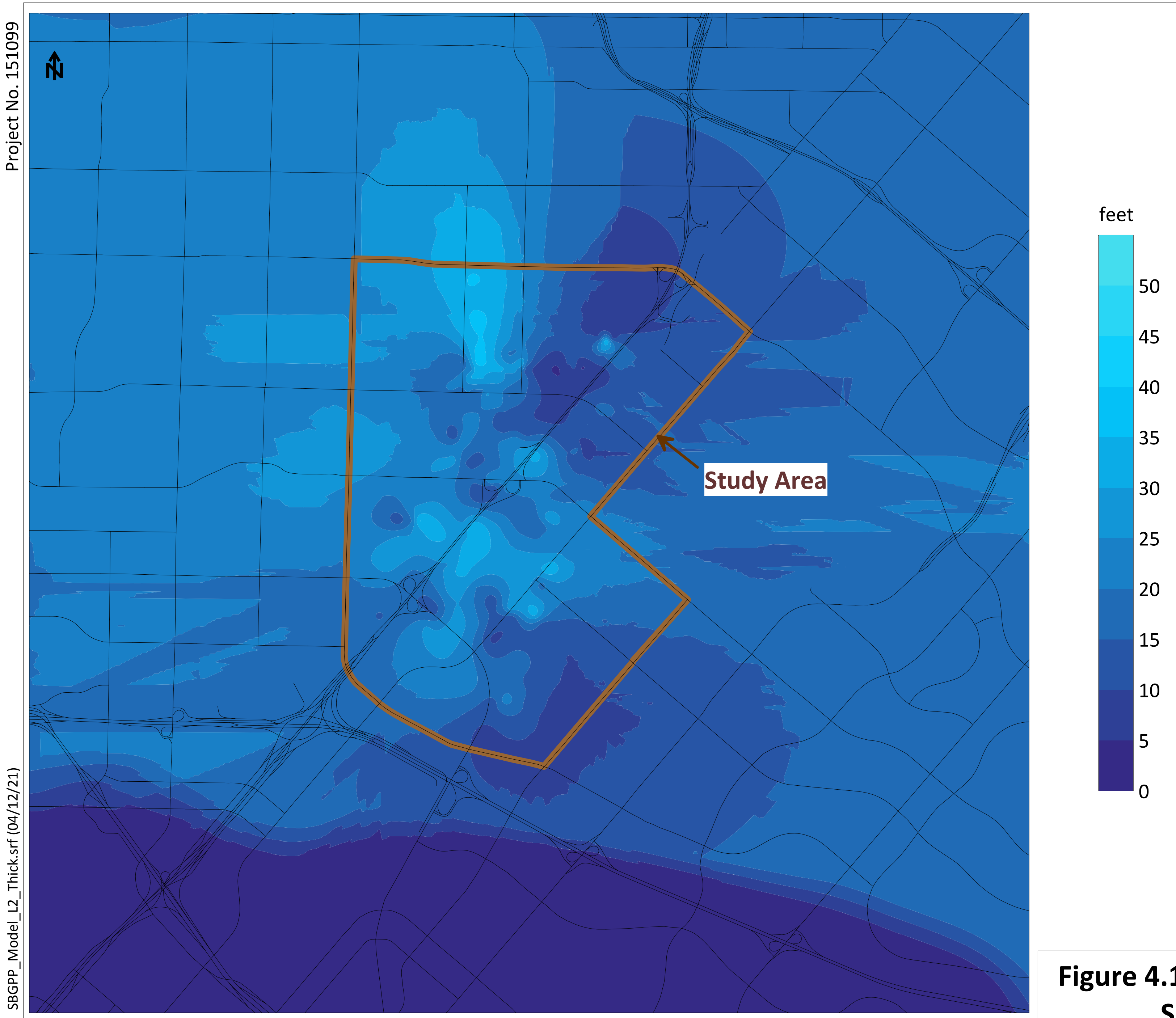

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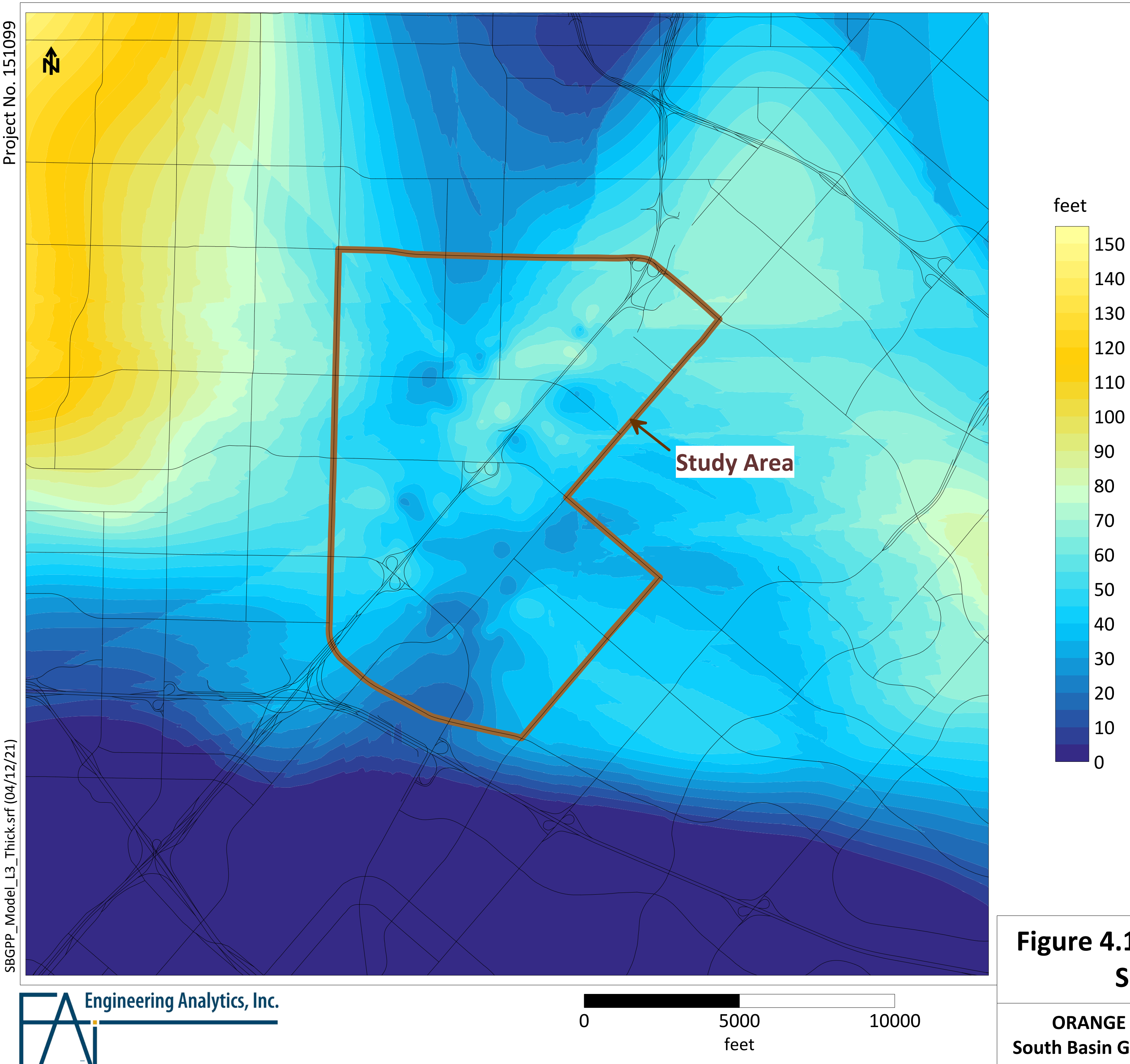
Figure 4.11. Layer 2 Thickness SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project



Engineering Analytics, Inc.

Figure 4.12. Layer 3 Thickness SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

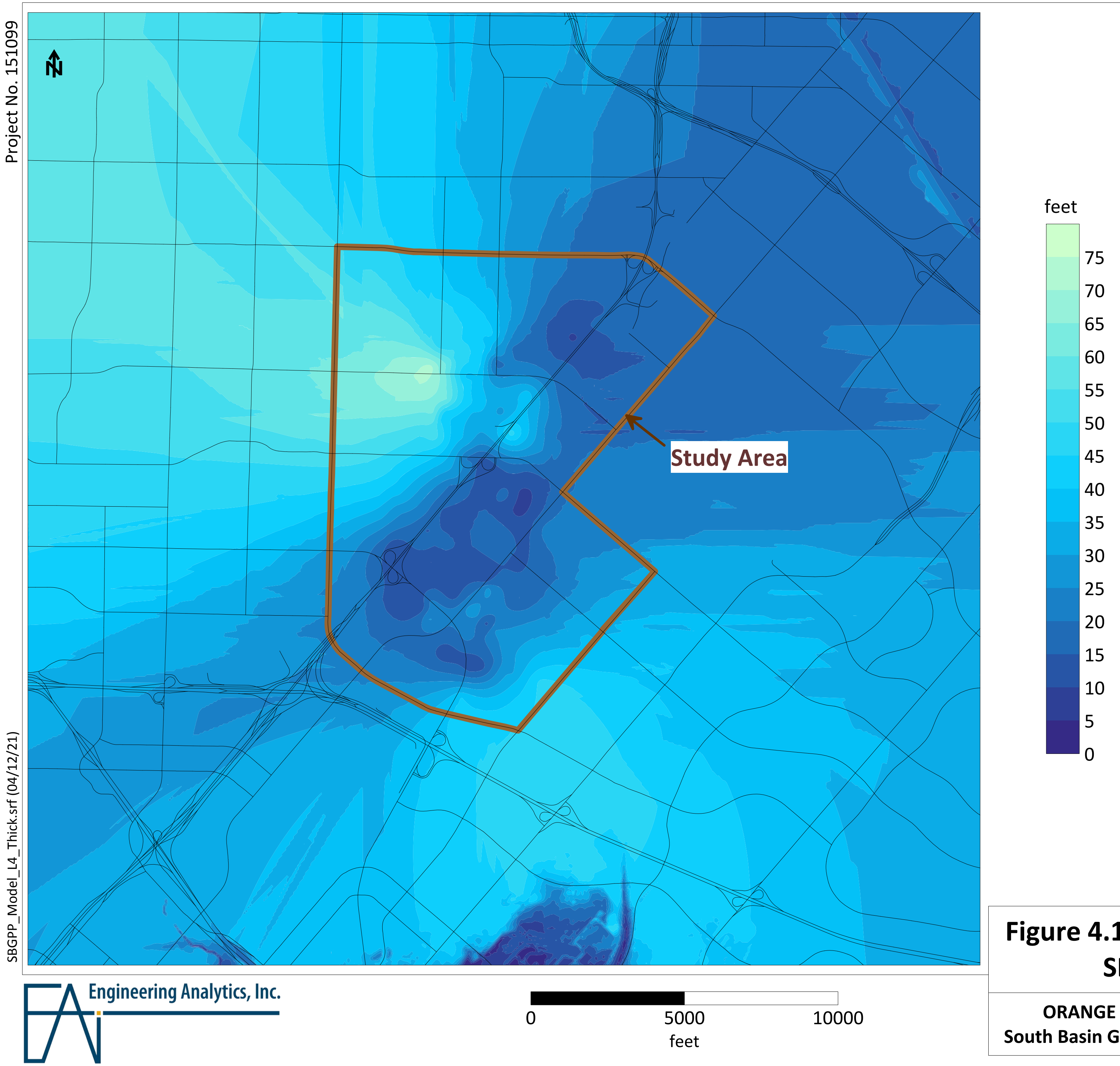


Figure 4.13. Layer 4 Thickness SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

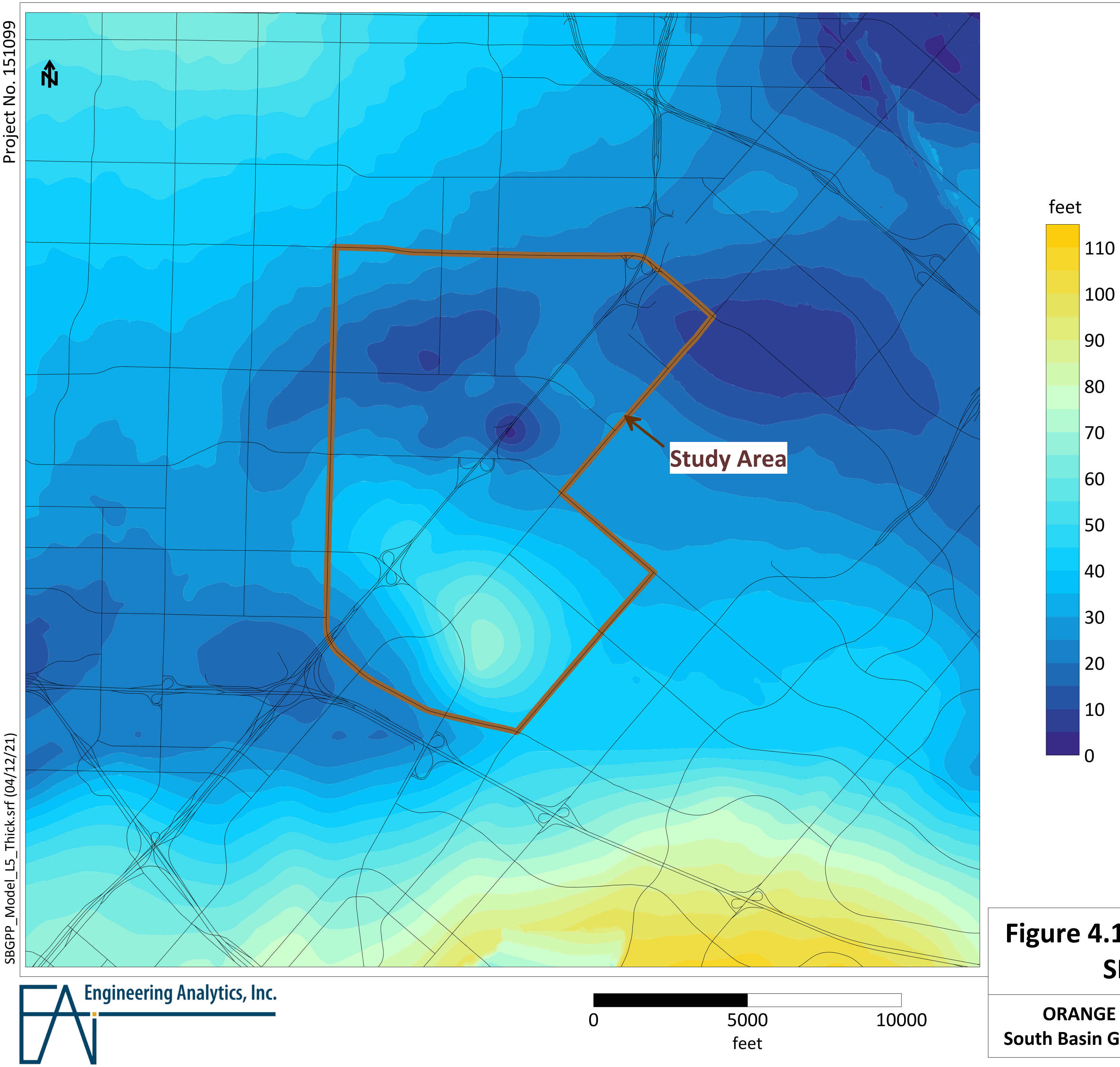
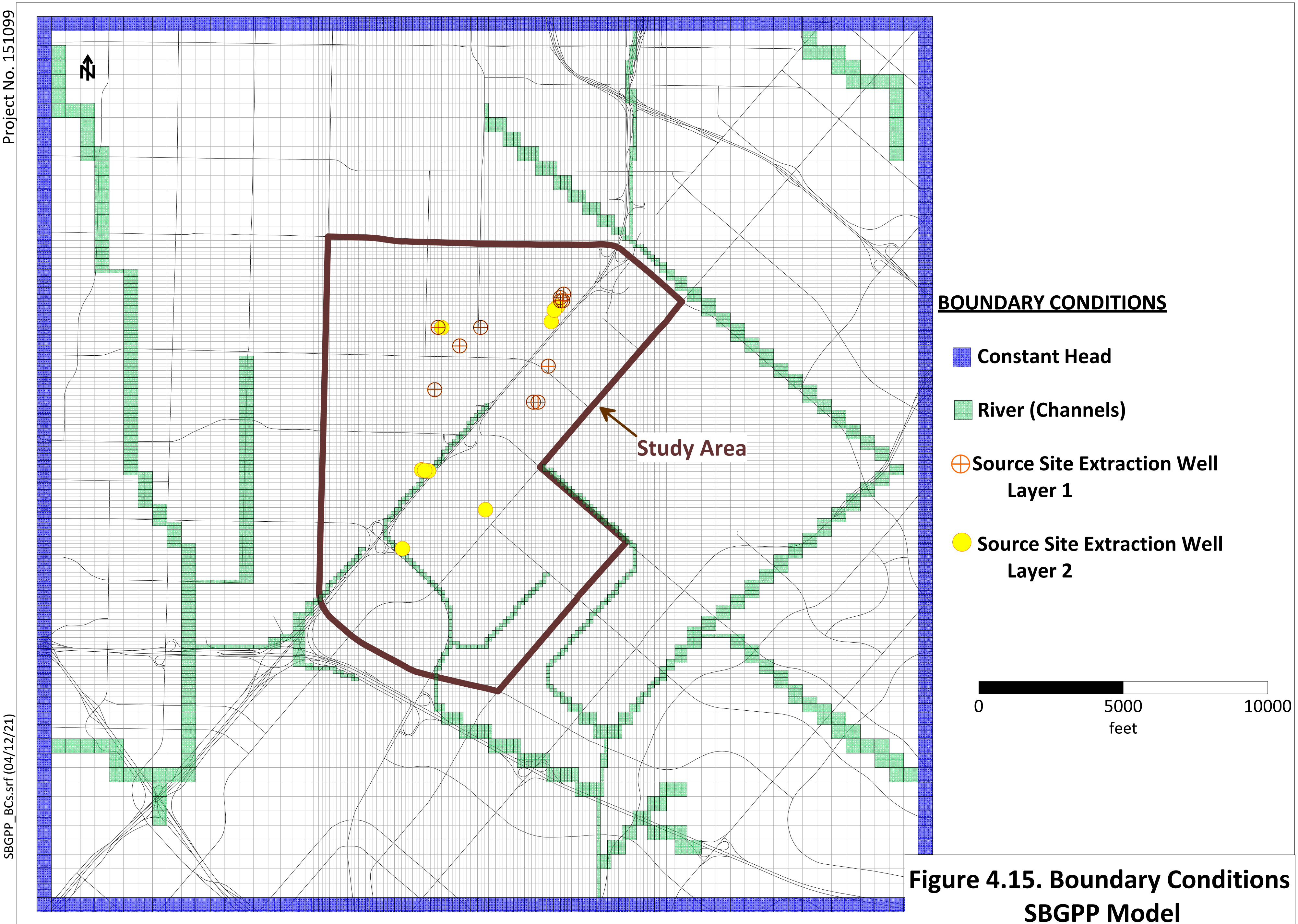


Figure 4.14. Layer 5 Thickness SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099

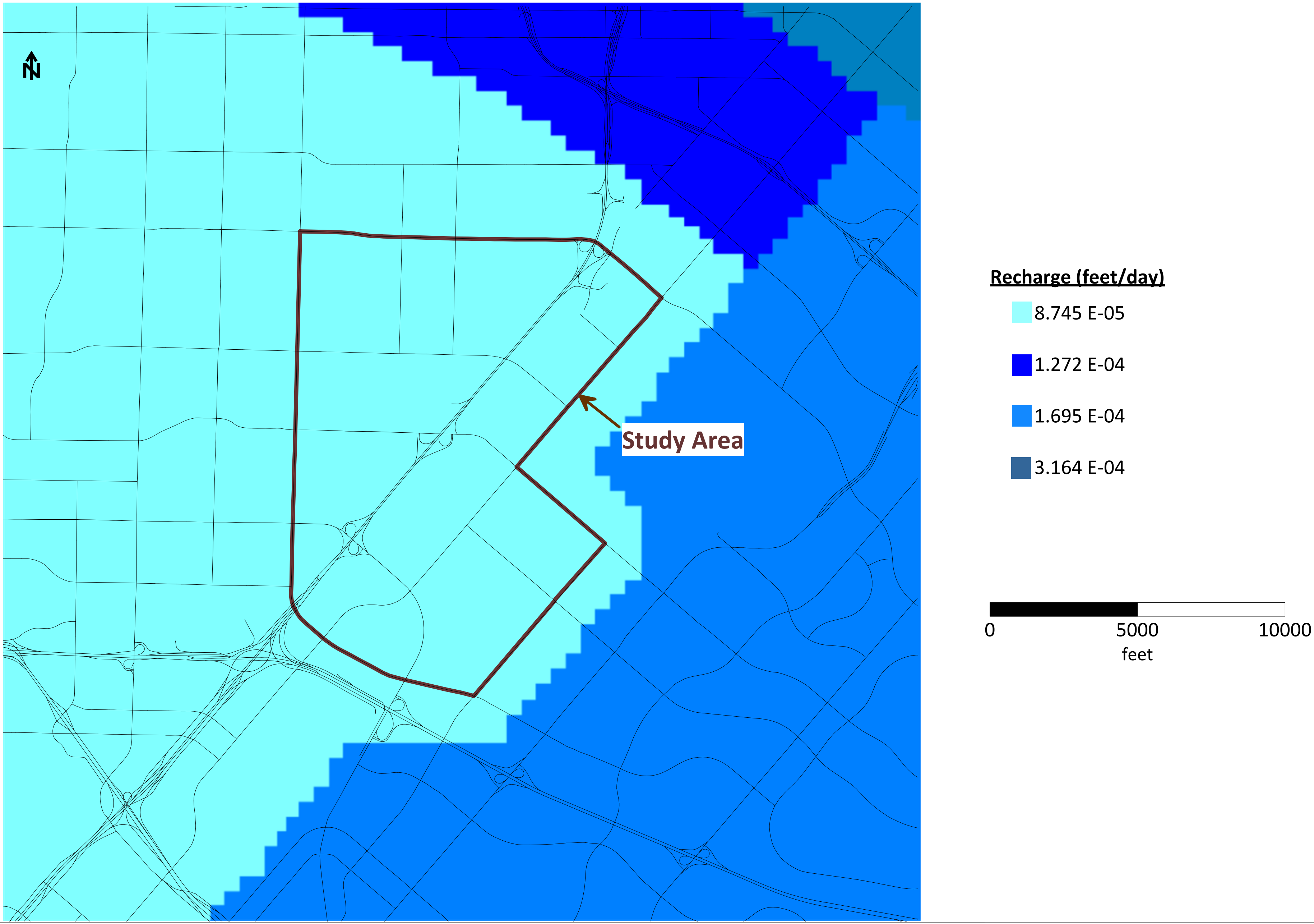


SBGPP_BCs.srf (04/12/21)

Figure 4.15. Boundary Conditions SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Engineering Analytics, Inc.



Project No. 151099

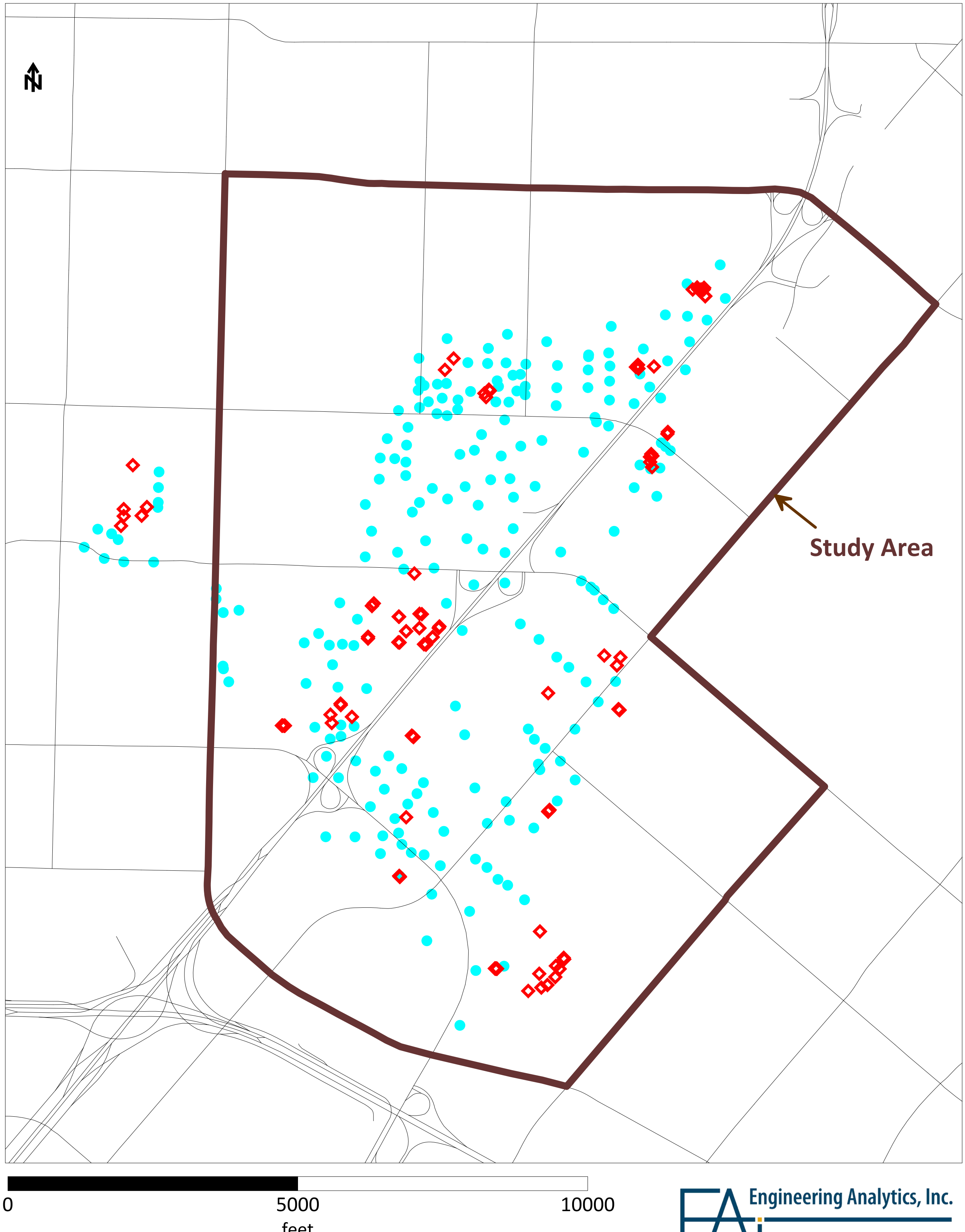
SBGPP_RechargeZones.srf (04/12/21)

Engineering Analytics, Inc.

Figure 4.16. Recharge Zones SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



SBGPP_AT_CPT_Locations.srf (04/12/21)

Engineering Analytics, Inc.

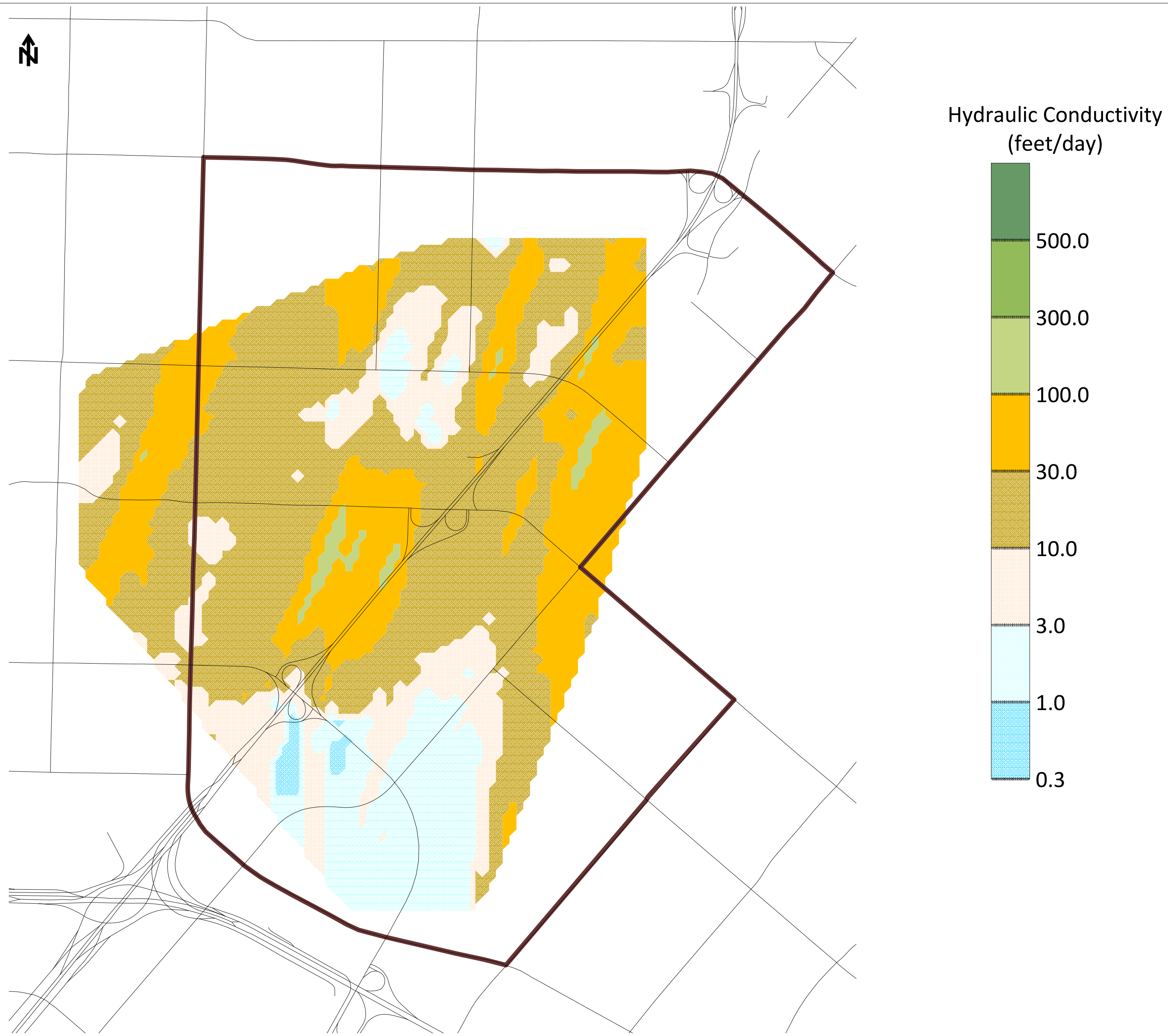
◇ Hydrologic Test Location

● Cone Penetrometer Test Location

Figure 4.17. Location of Hydrologic Tests and Cone Penetrometer Tests , SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



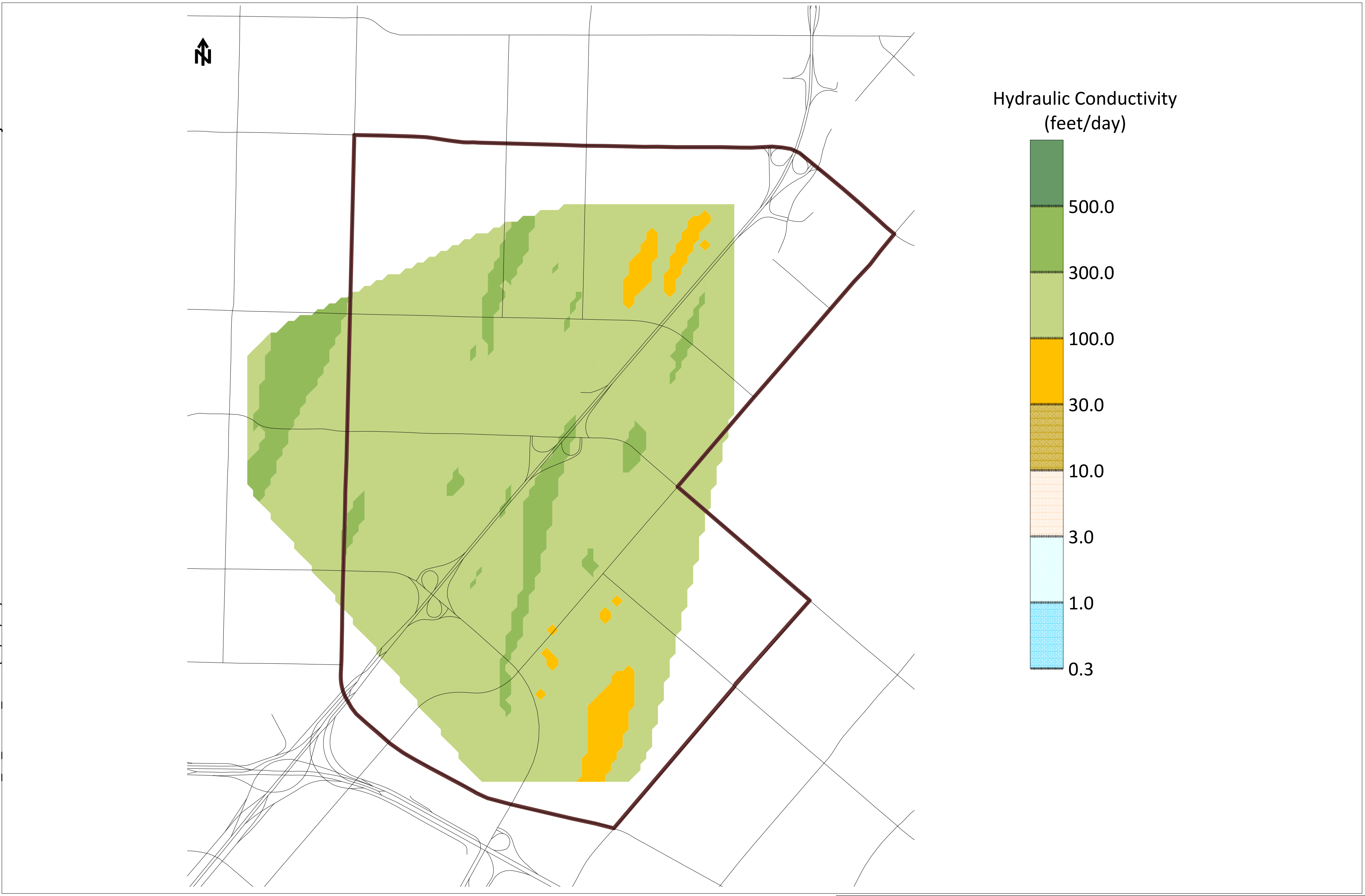
SBGPP_Ini_KZones_L1.srf (04/12/21)

Engineering Analytics, Inc.

Figure 4.18. Initial Estimate of Hydraulic Conductivity, Layer 1, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099

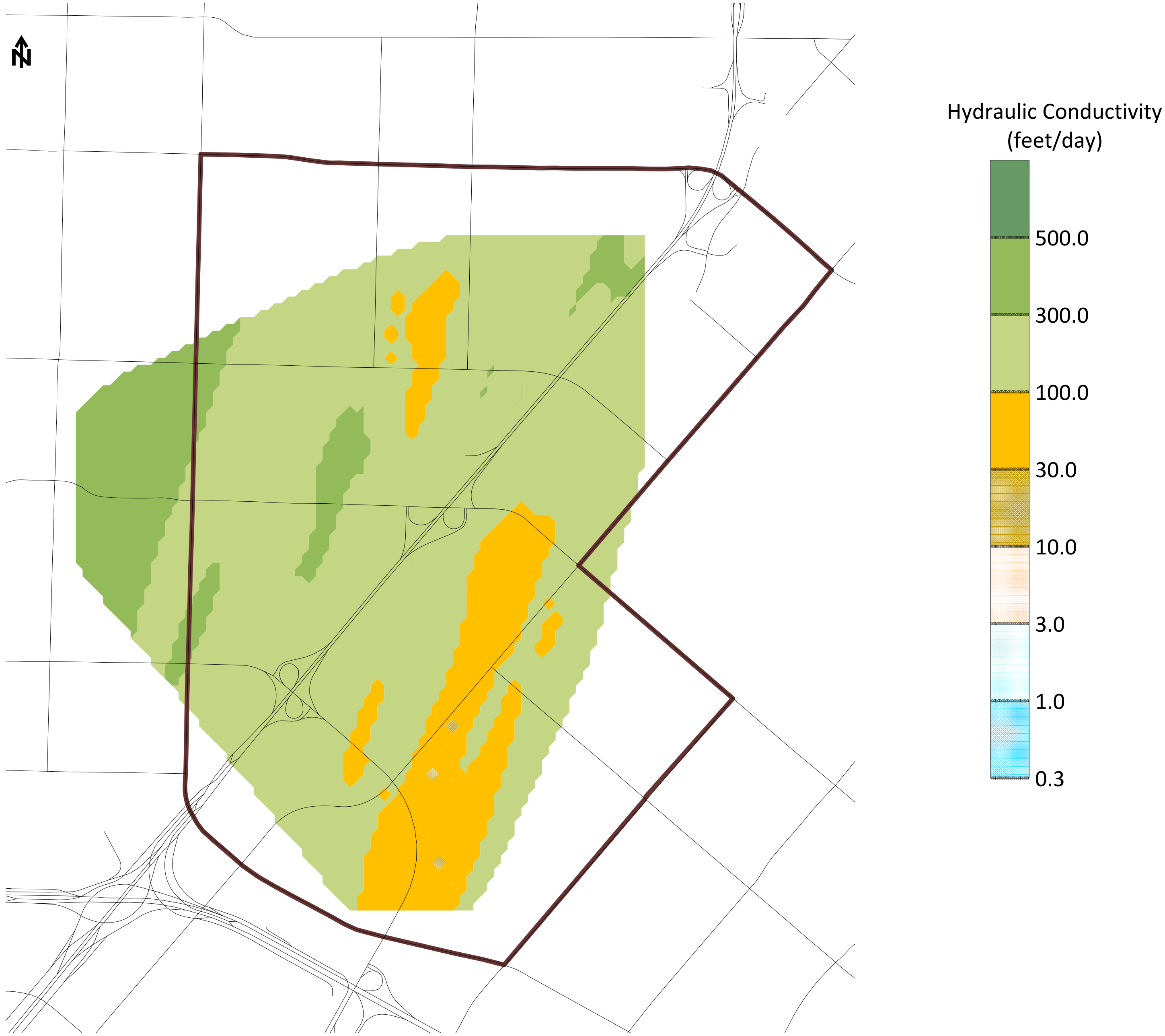


SBGPP_Ini_KZones_L1.srf (04/12/21)

Engineering Analytics, Inc.

Figure 4.19. Initial Estimate of Hydraulic Conductivity, Layer 2, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project



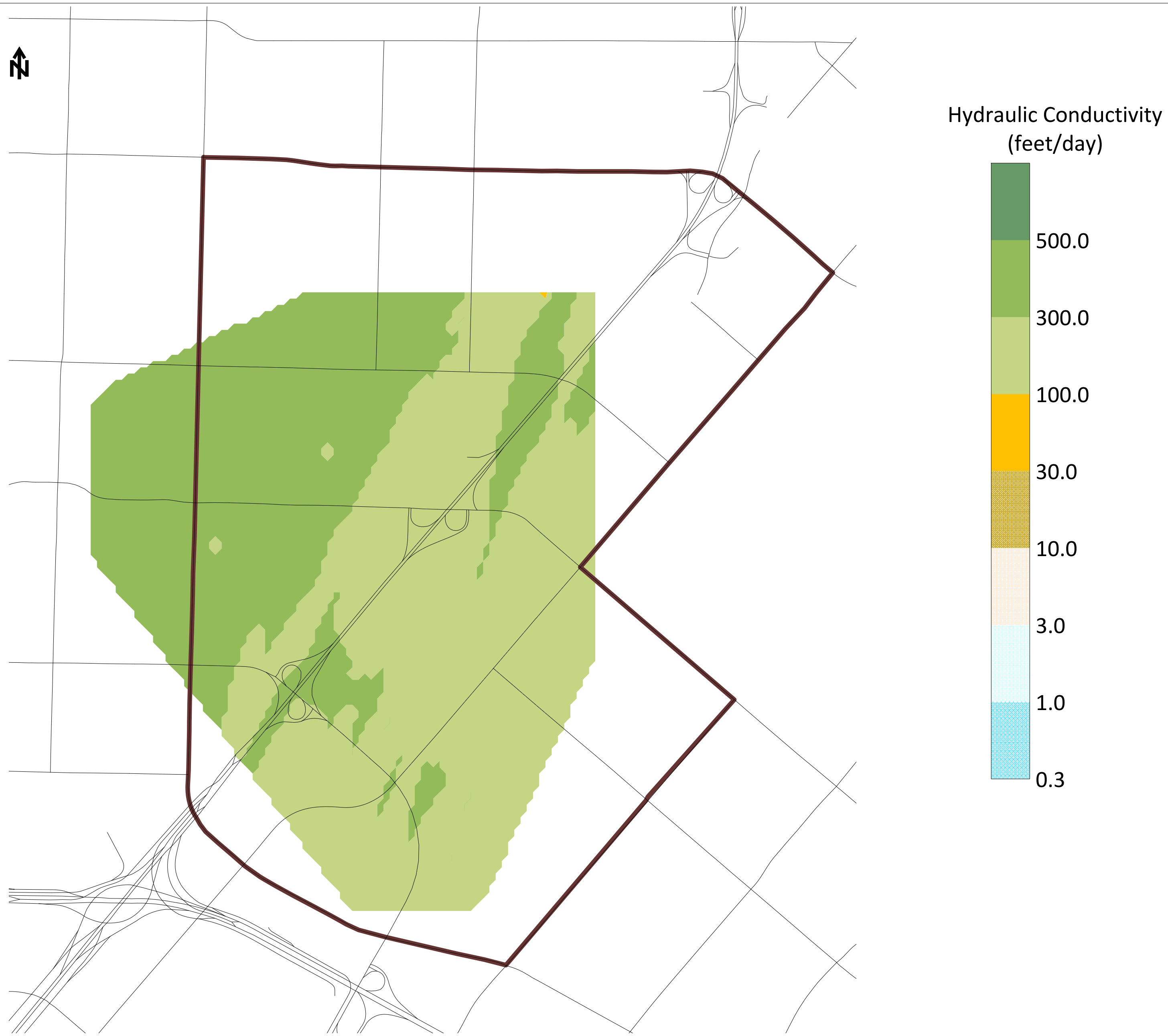
SBGPP_Ini_KZones_L3.srf (04/12/21)

Engineering Analytics, Inc.

Figure 4.20. Initial Estimate of Hydraulic Conductivity, Layer 3, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099

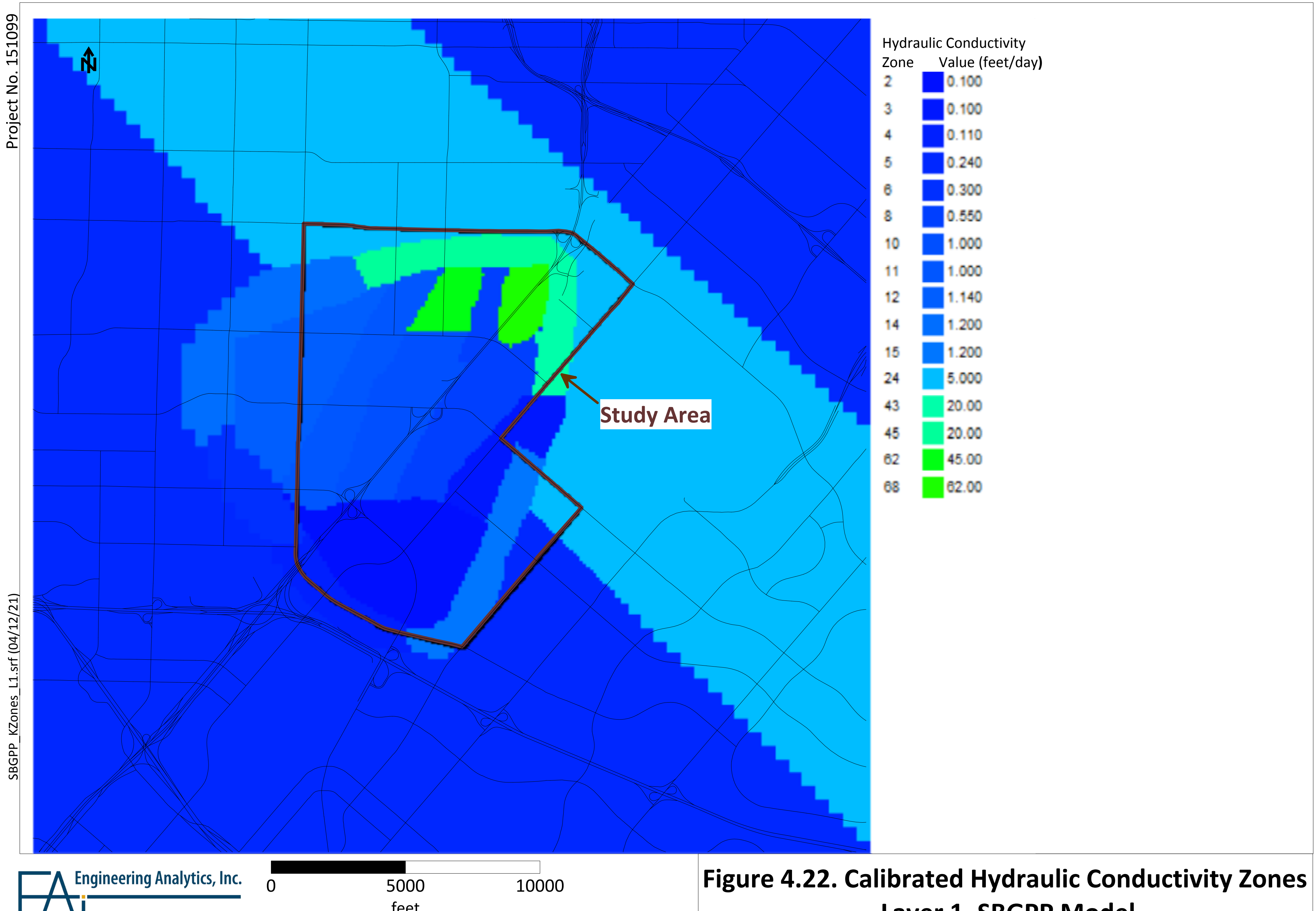


SBGPP_Ini_KZones_L4.srf (04/12/21)

Engineering Analytics, Inc.

Figure 4.21. Initial Estimate of Hydraulic Conductivity, Layer 4, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project



Engineering Analytics, Inc.

Figure 4.22. Calibrated Hydraulic Conductivity Zones Layer 1, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

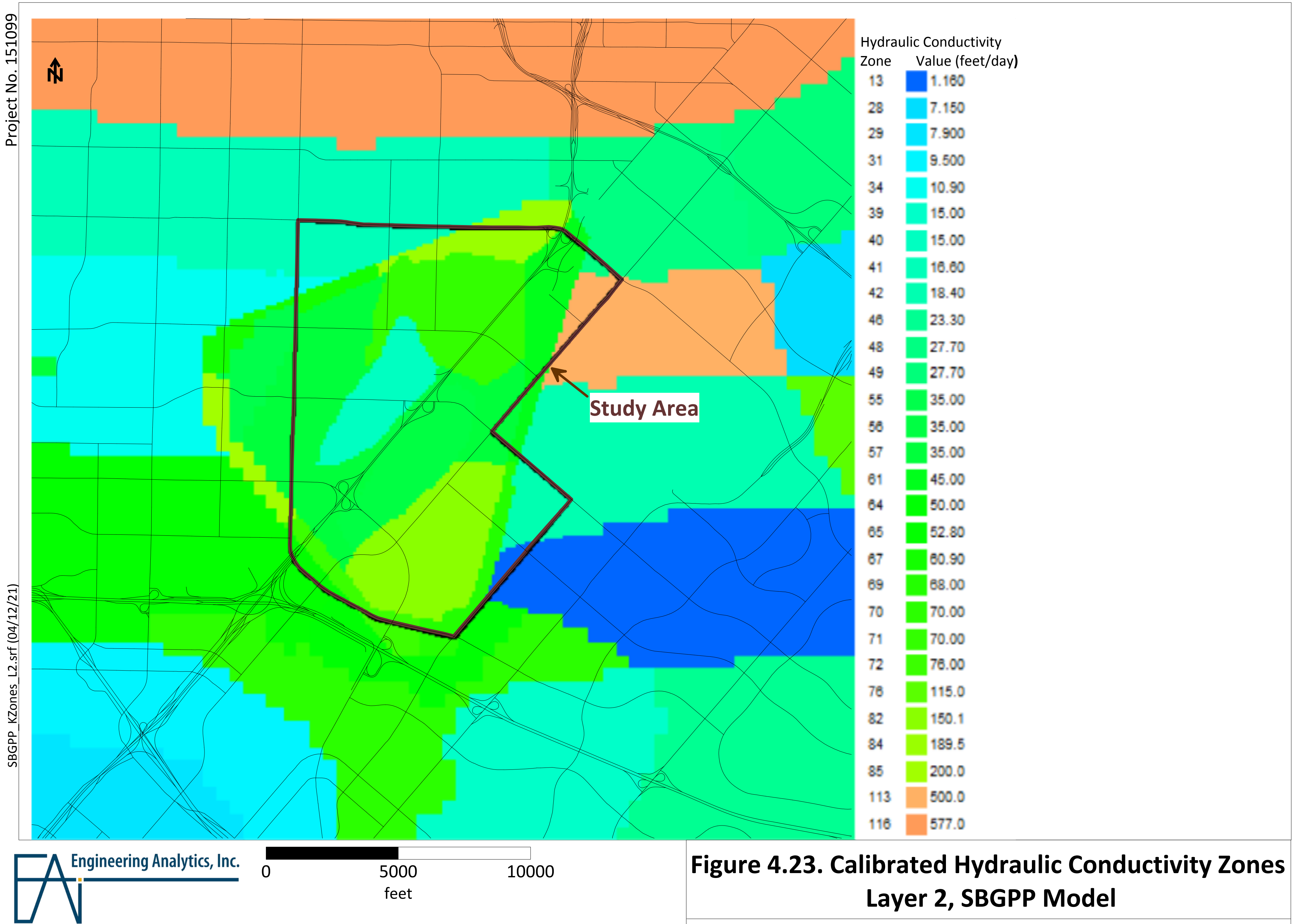
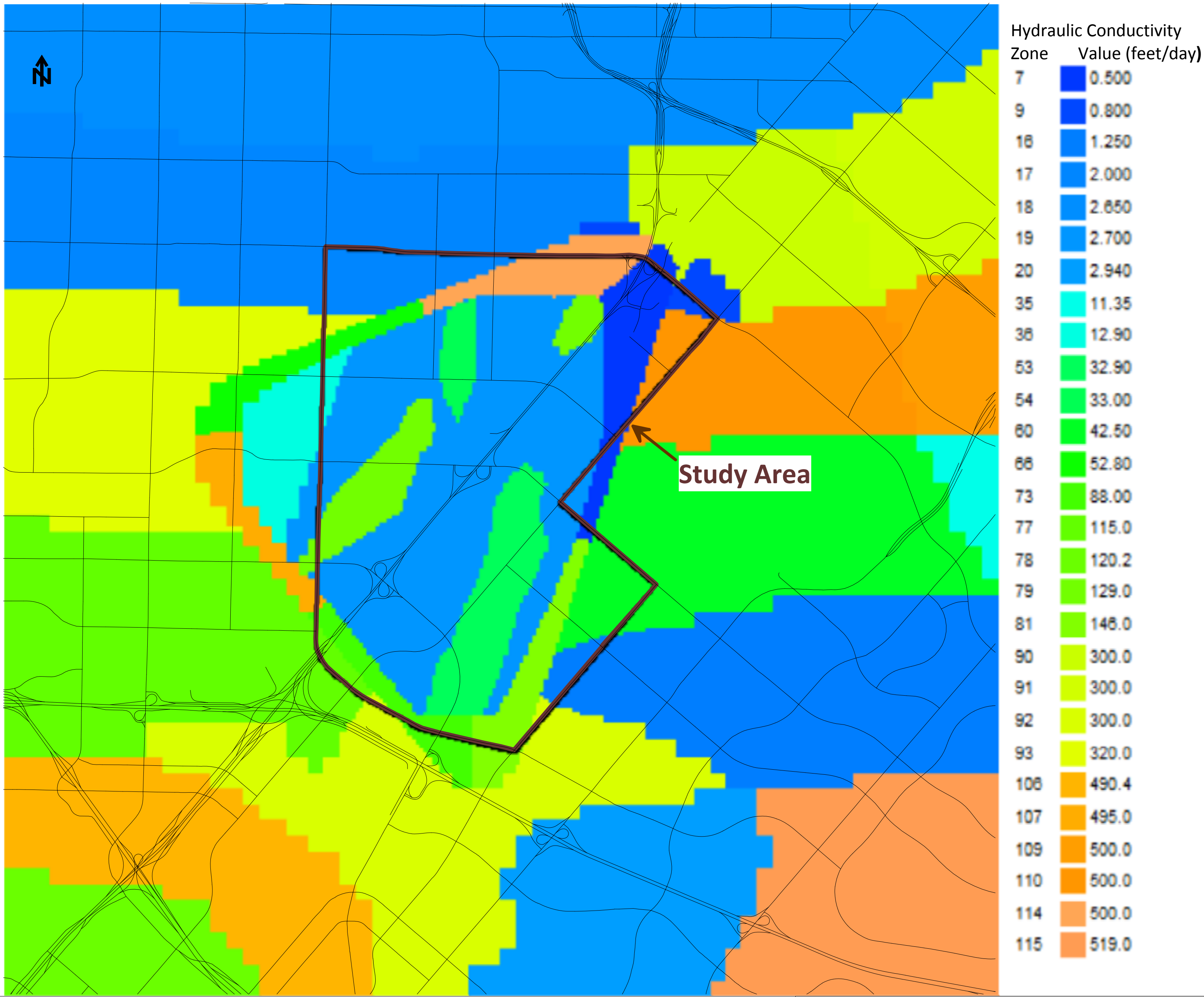


Figure 4.23. Calibrated Hydraulic Conductivity Zones Layer 2, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project



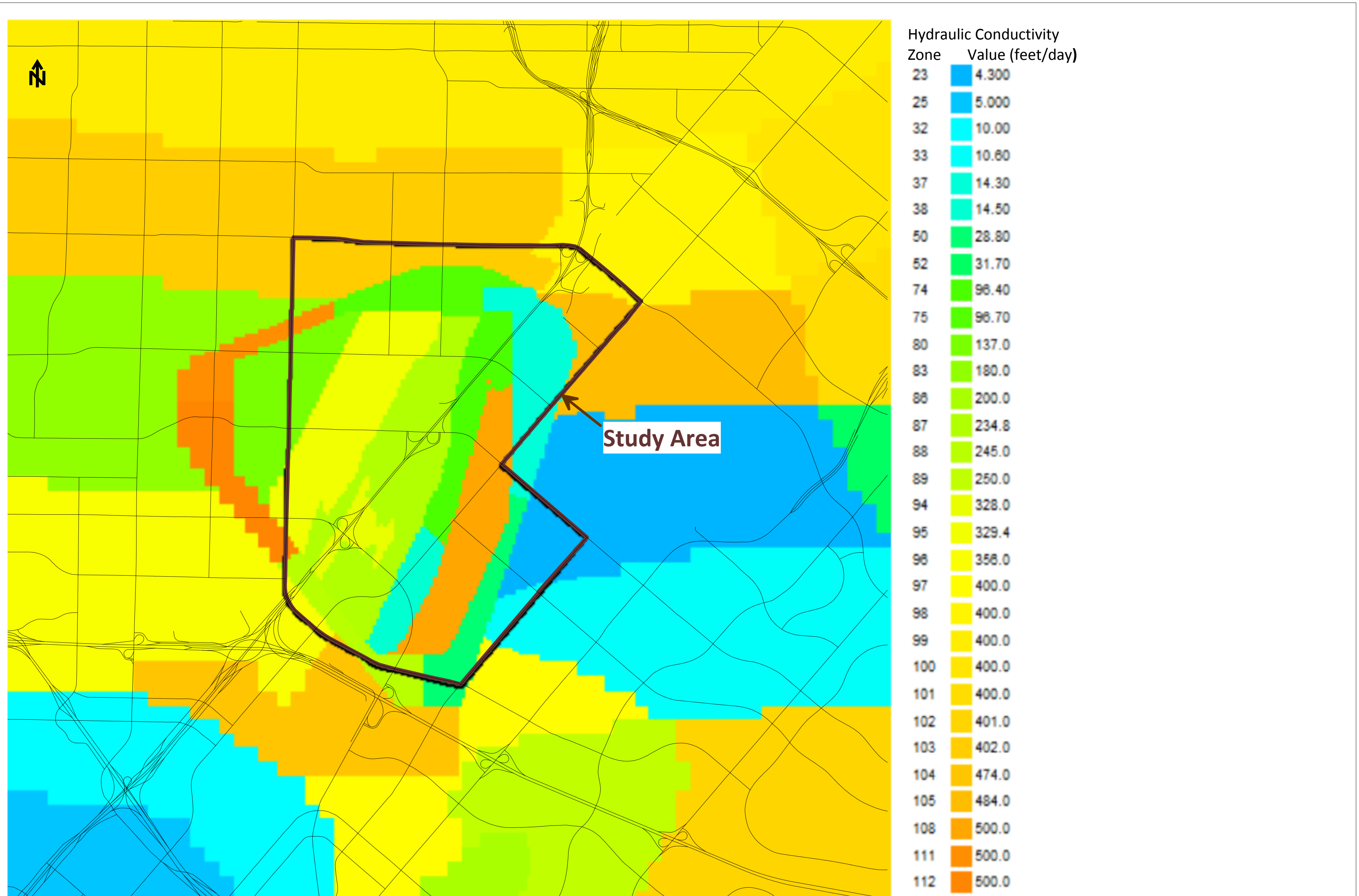
SBGPP_KZones_L3.srf (04/12/21)

Engineering Analytics, Inc.

Figure 4.24. Calibrated Hydraulic Conductivity Zones Layer 3, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



SBGPP_KZones_L5.srf (04/12/21)

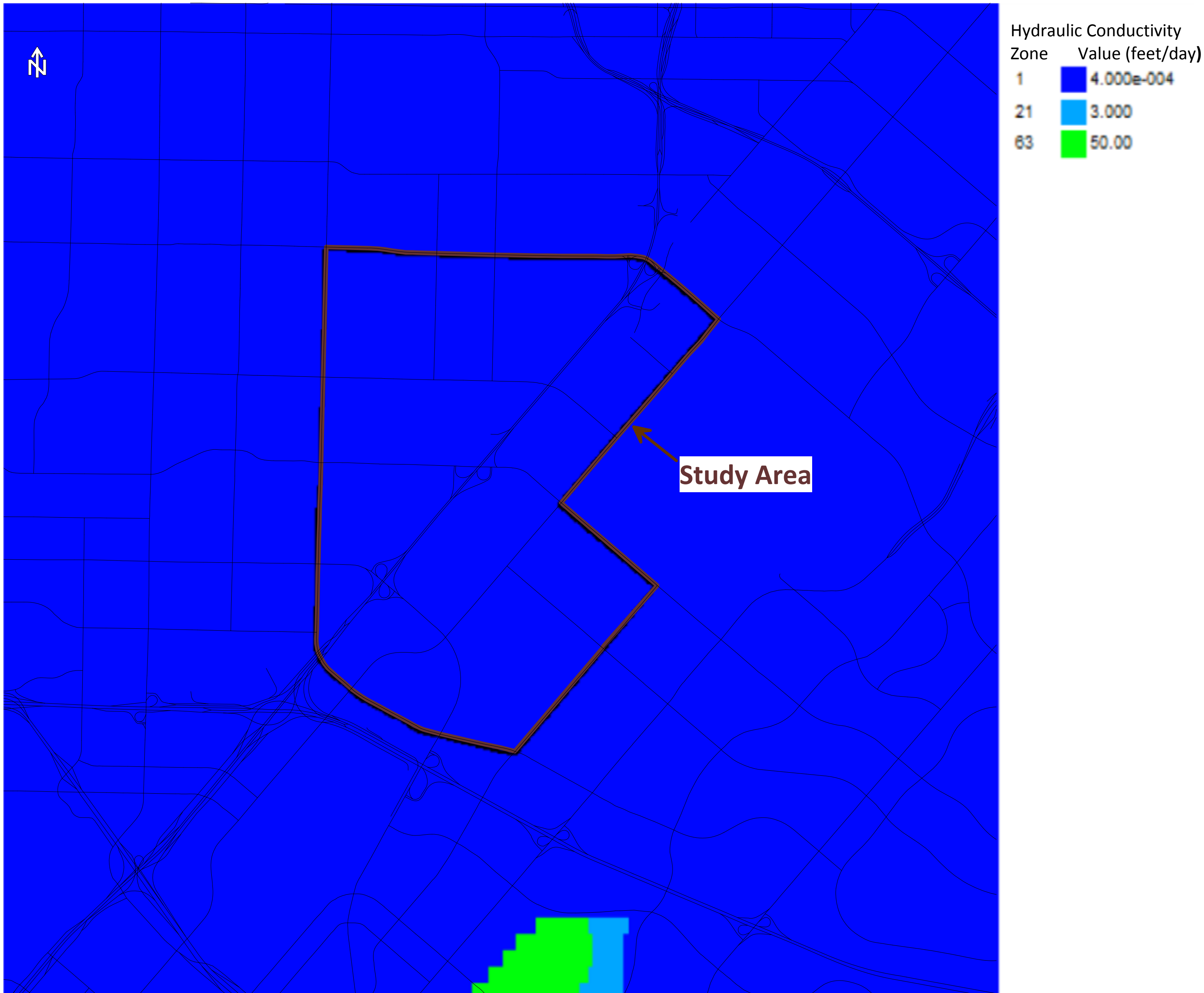
Engineering Analytics, Inc.

0 5000 10000
feet

Figure 4.25. Calibrated Hydraulic Conductivity Zones Layer 4, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



SBGPP_KZones_L5.srf (04/12/21)

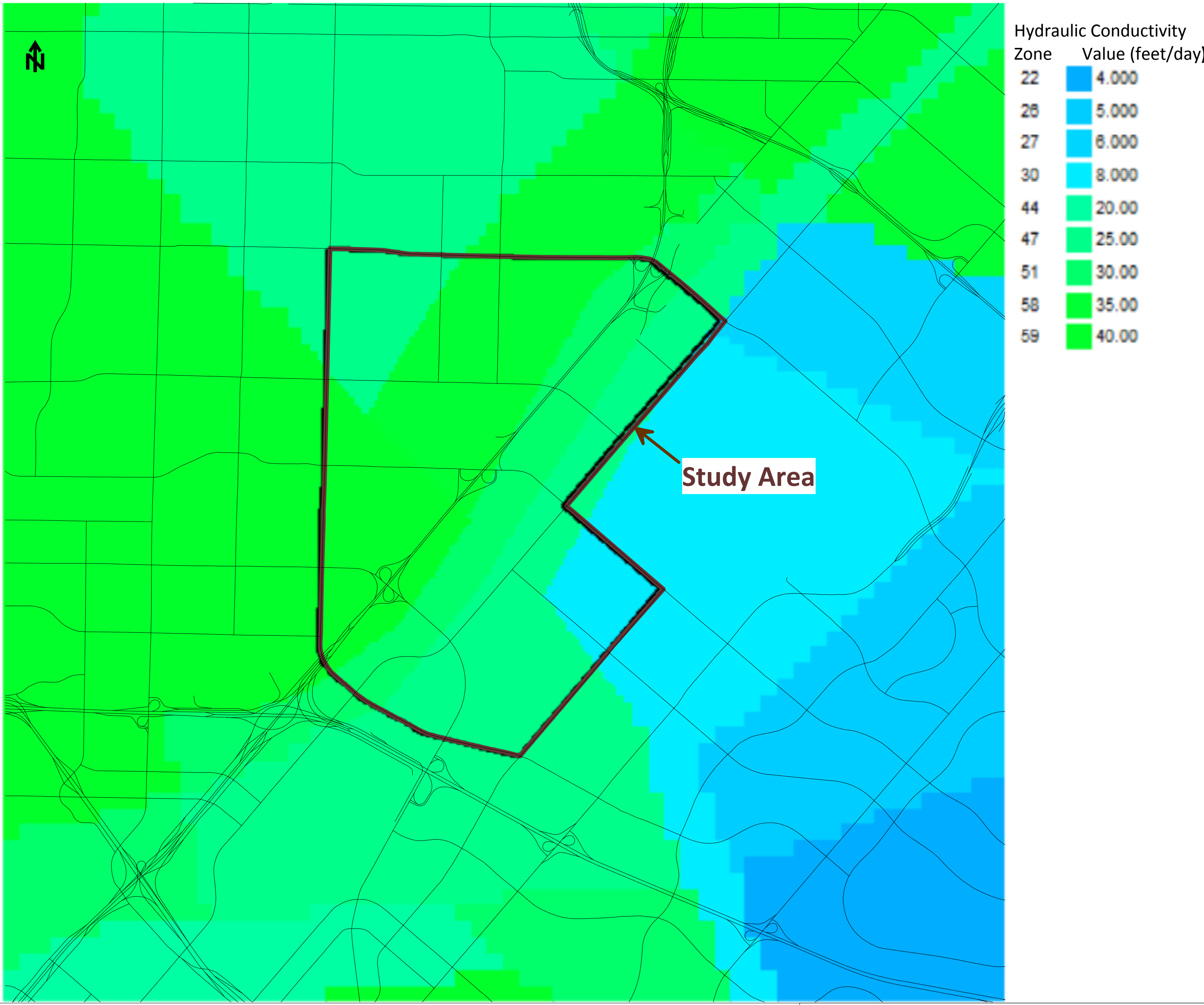
Engineering Analytics, Inc.

0 5000 10000
feet

Figure 4.26. Calibrated Hydraulic Conductivity Zones Layer 5, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



SBGPP_KZones_L6.srf (04/12/21)

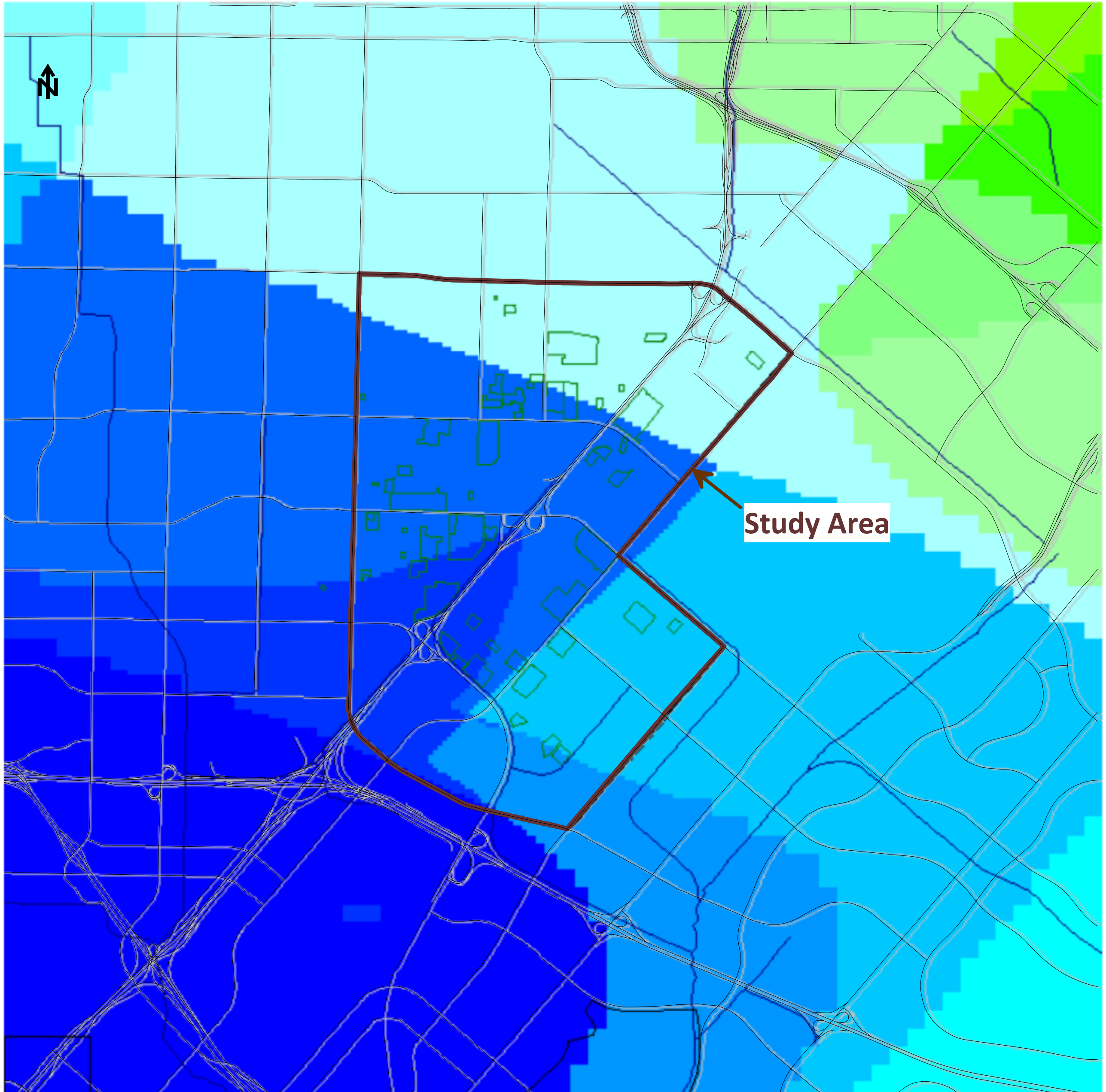
Engineering Analytics, Inc.

0 5000 10000
feet

Figure 4.27. Calibrated Hydraulic Conductivity Zones Layer 6, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



Zone	Specific Storage	Specific Yield	Porosity
1	3.0E-5	1.0E-1	3.0E-1
2	4.0E-5	1.0E-1	3.0E-1
3	4.0E-5	1.2E-1	3.0E-1
4	5.0E-5	1.0E-1	3.0E-1
5	5.0E-5	1.2E-1	3.0E-1
6	6.0E-5	1.2E-1	3.0E-1
7	1.0E-5	1.2E-1	3.0E-1
8	2.0E-5	1.2E-1	3.0E-1
9	2.0E-5	1.4E-1	3.0E-1
10	2.0E-5	1.5E-1	3.0E-1
11	4.0E-5	1.4E-1	3.0E-1
12	4.0E-5	1.5E-1	3.0E-1

SBGPP_SSZones.srf (04/12/21)

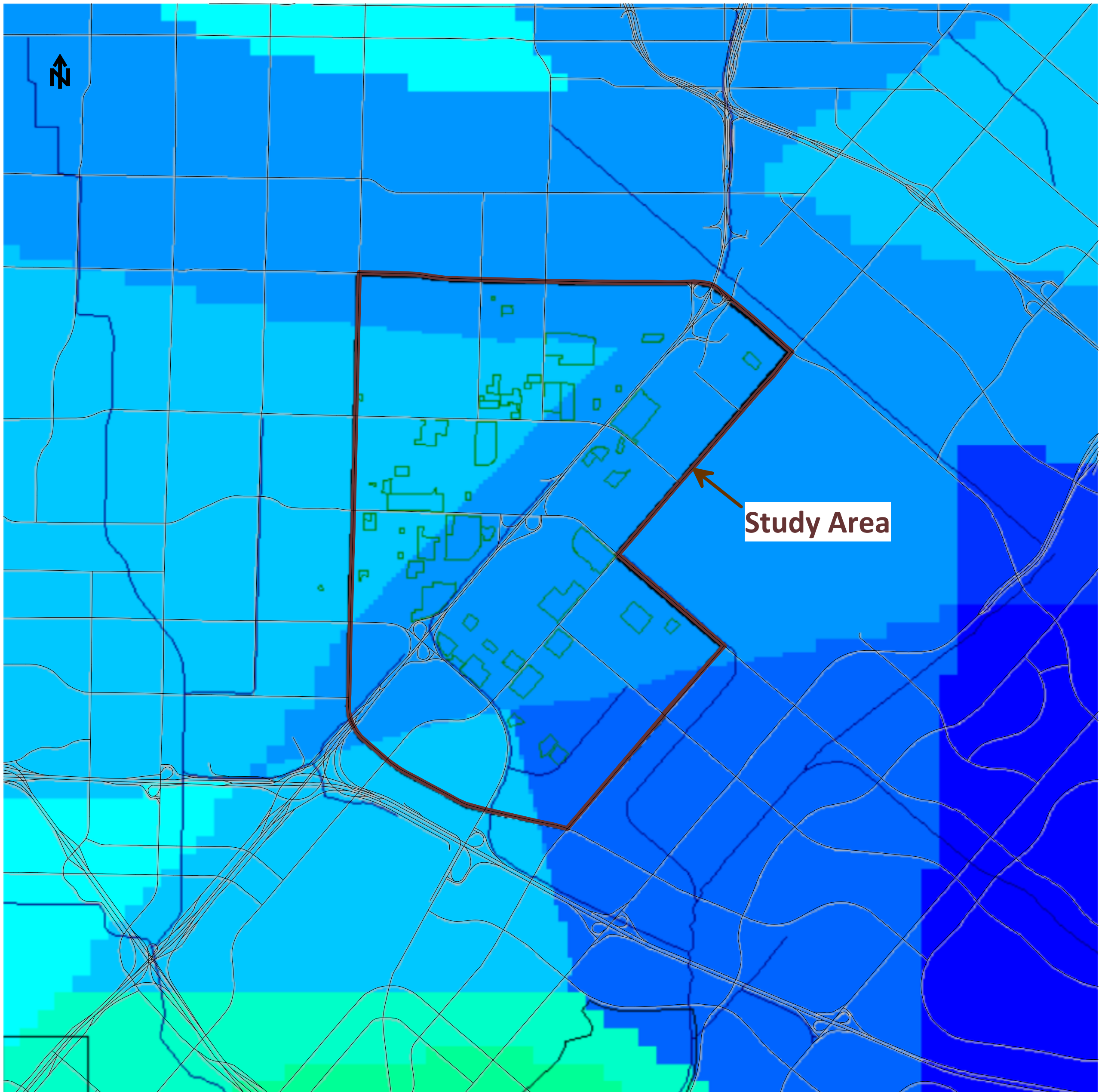
Engineering Analytics, Inc.

0 5000 10000
feet

Figure 4.28. Specific Storage, Specific Yield and Porosity, Layer 1, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



Zone	Specific Storage	Specific Yield	Porosity
13	1.0E-8	6.0E-2	3.0E-1
14	5.0E-8	6.0E-2	3.0E-1
15	5.0E-7	6.0E-2	3.0E-1
16	2.0E-6	6.0E-2	3.0E-1
17	3.0E-6	6.0E-2	3.0E-1
18	4.0E-6	6.0E-2	3.0E-1
19	5.0E-6	6.0E-2	3.0E-1
20	5.0E-5	6.0E-2	3.0E-1

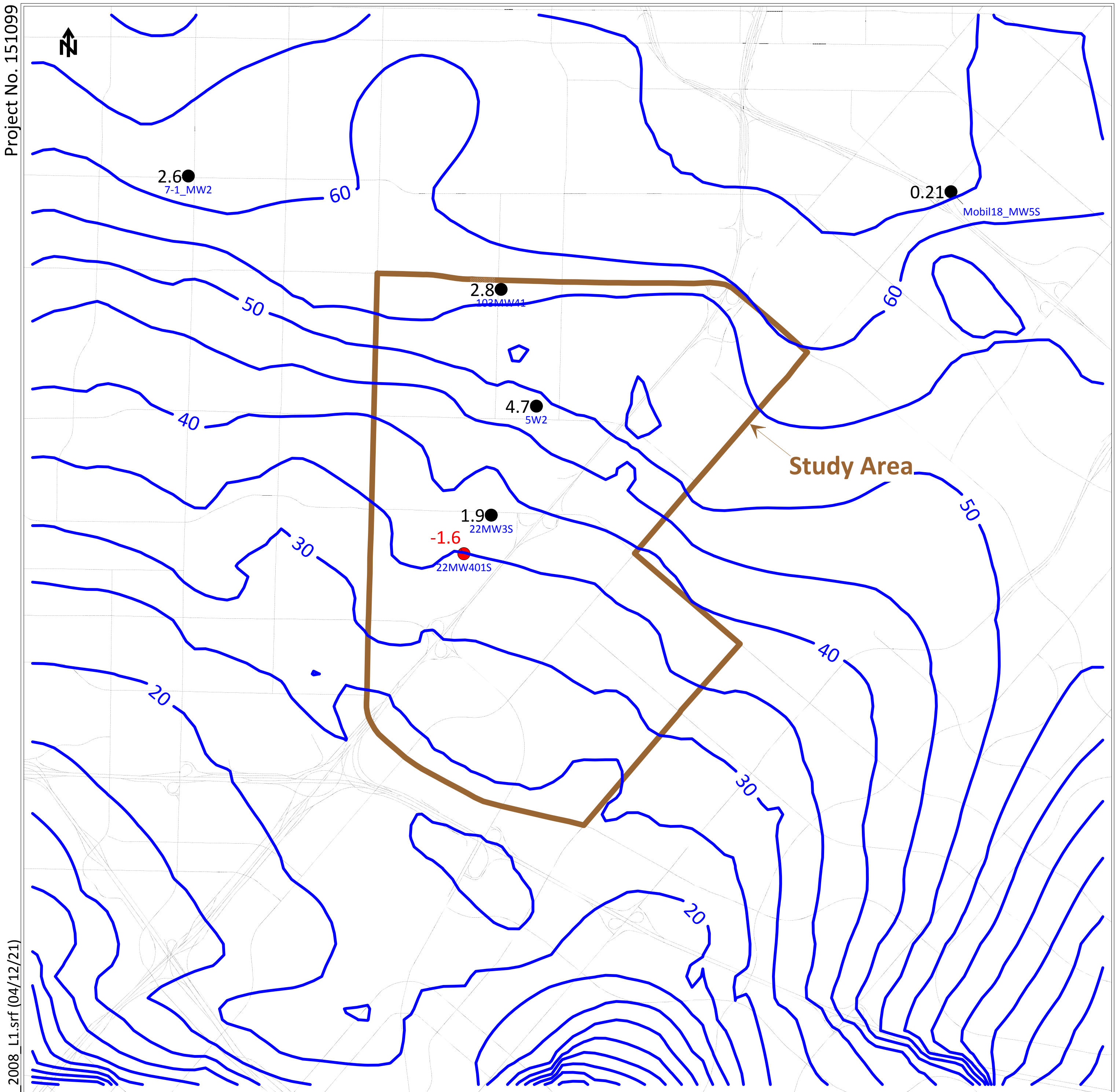
SBGPP_SSZonesL6.srf (04/12/21)

Engineering Analytics, Inc.

0 5000 10000
feet

Figure 4.29. Specific Storage, Specific Yield and Porosity, Layer 6, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project



● Model Target with Positive Residual (feet) (indicates head is underpredicted)

● Model Target with Negative Residual (feet) (indicates head is overpredicted)

* Residual is from synthetic head value

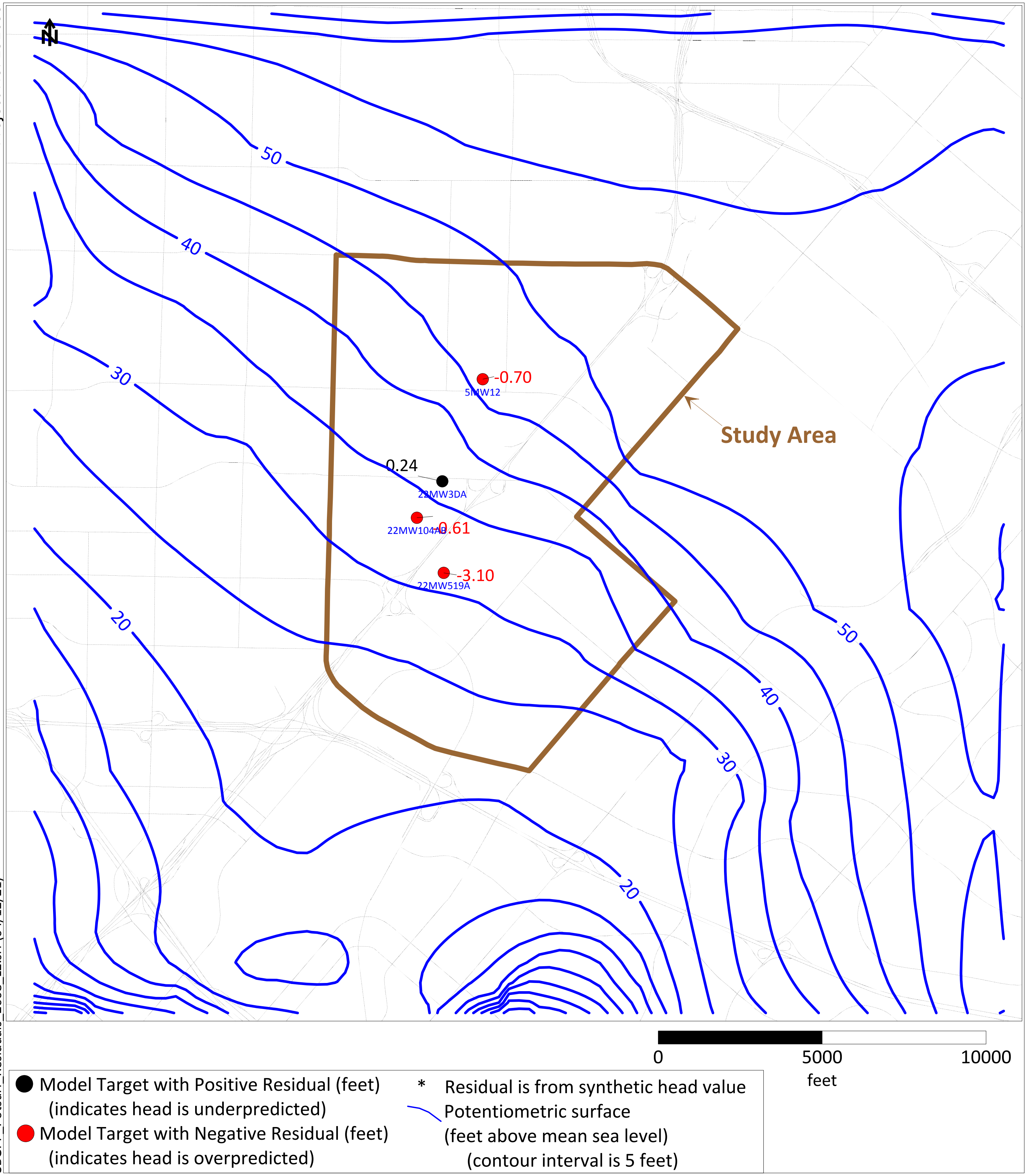
Potentiometric surface (feet above mean sea level) (contour interval is 5 feet)

Engineering Analytics, Inc.

Figure 5.1. Simulated 2008 Potentiometric Surface and Calibration Residuals, Layer 1-SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Plan

Project No. 151099

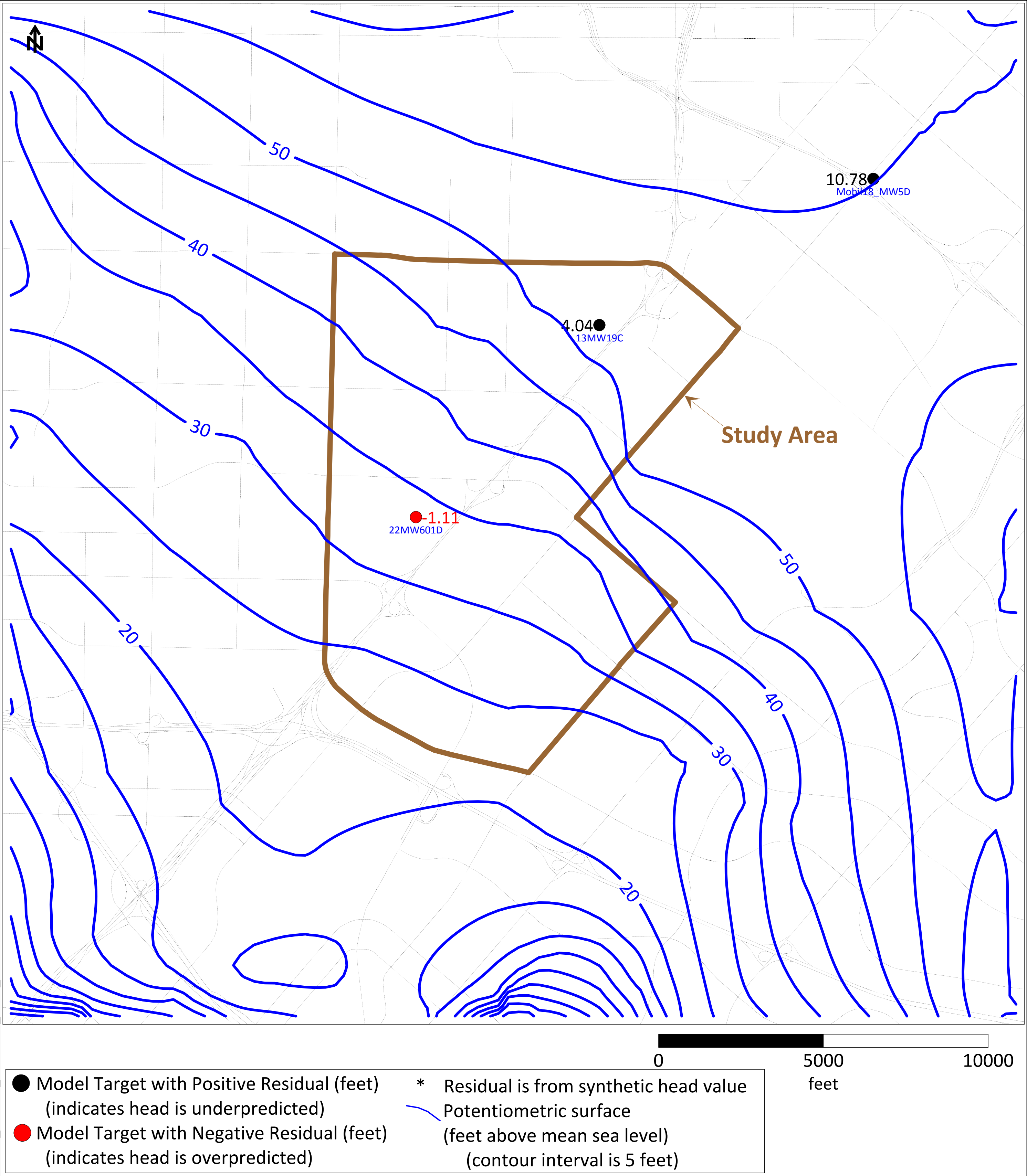


SBGPP_Potsurf_Residuals_2008_L2.srf (04/12/21)

Engineering Analytics, Inc.

Figure 5.2. Simulated 2008 Potentiometric Surface and Calibration Residuals, Layer 2-SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Plan

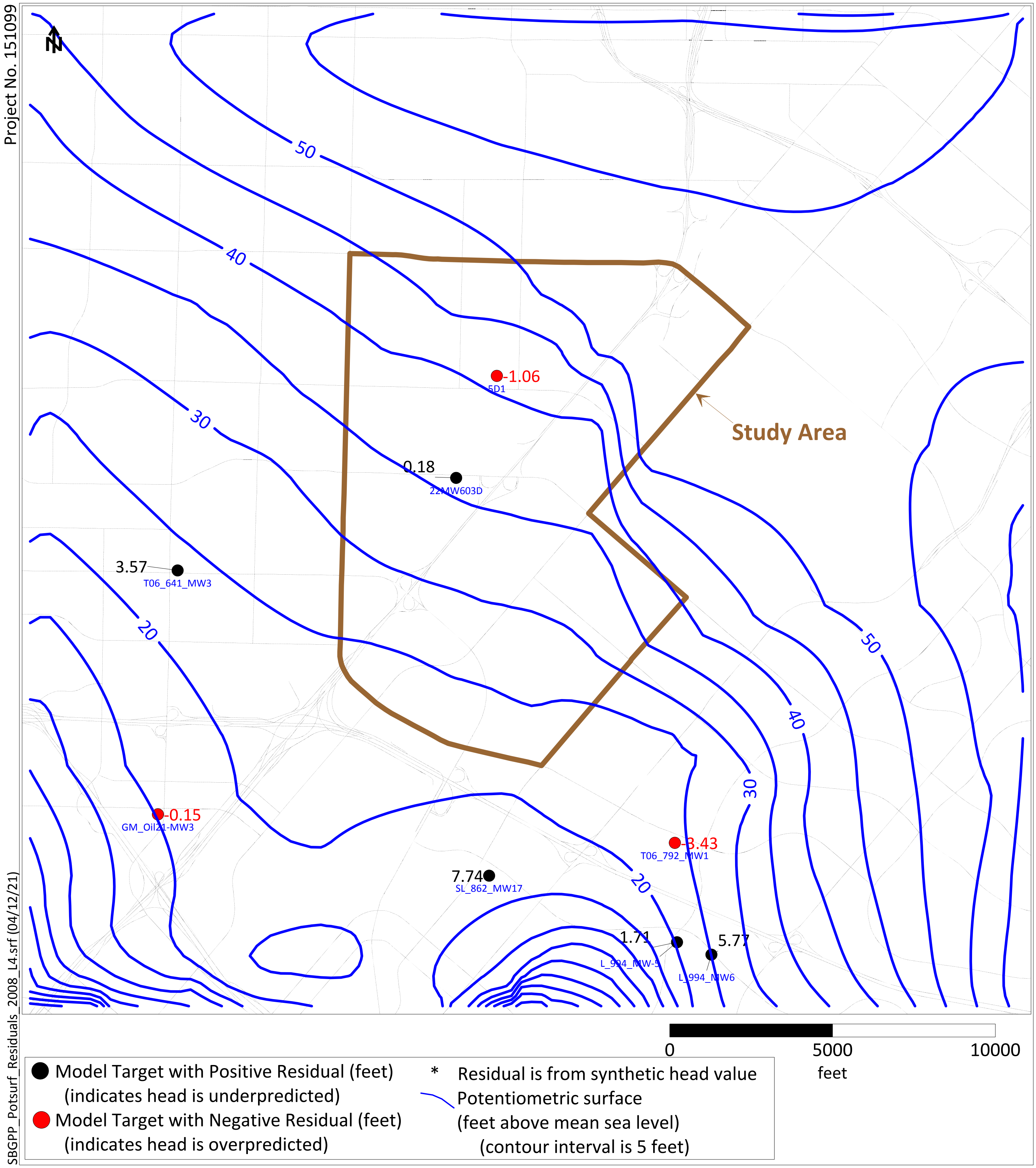


SBGPP_Potsurf_Residuals_2008_L3.srf (04/12/21)

Engineering Analytics, Inc.

Figure 5.3. Simulated 2008 Potentiometric Surface and Calibration Residuals, Layer 3-SBGPP Model

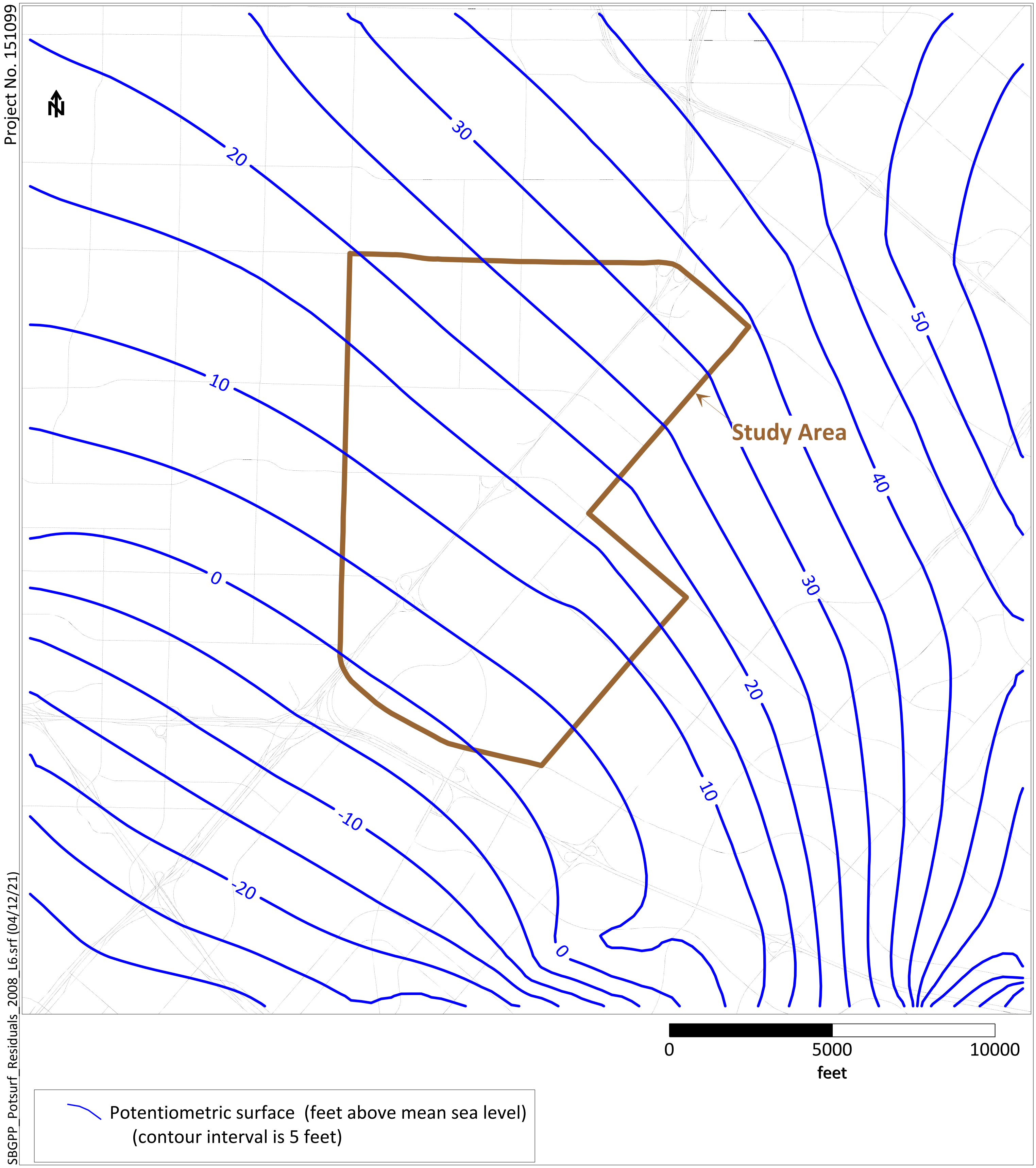
ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Plan



Engineering Analytics, Inc.

Figure 5.4. Simulated 2008 Potentiometric Surface and Calibration Residuals, Layer 4-SBGPP Model

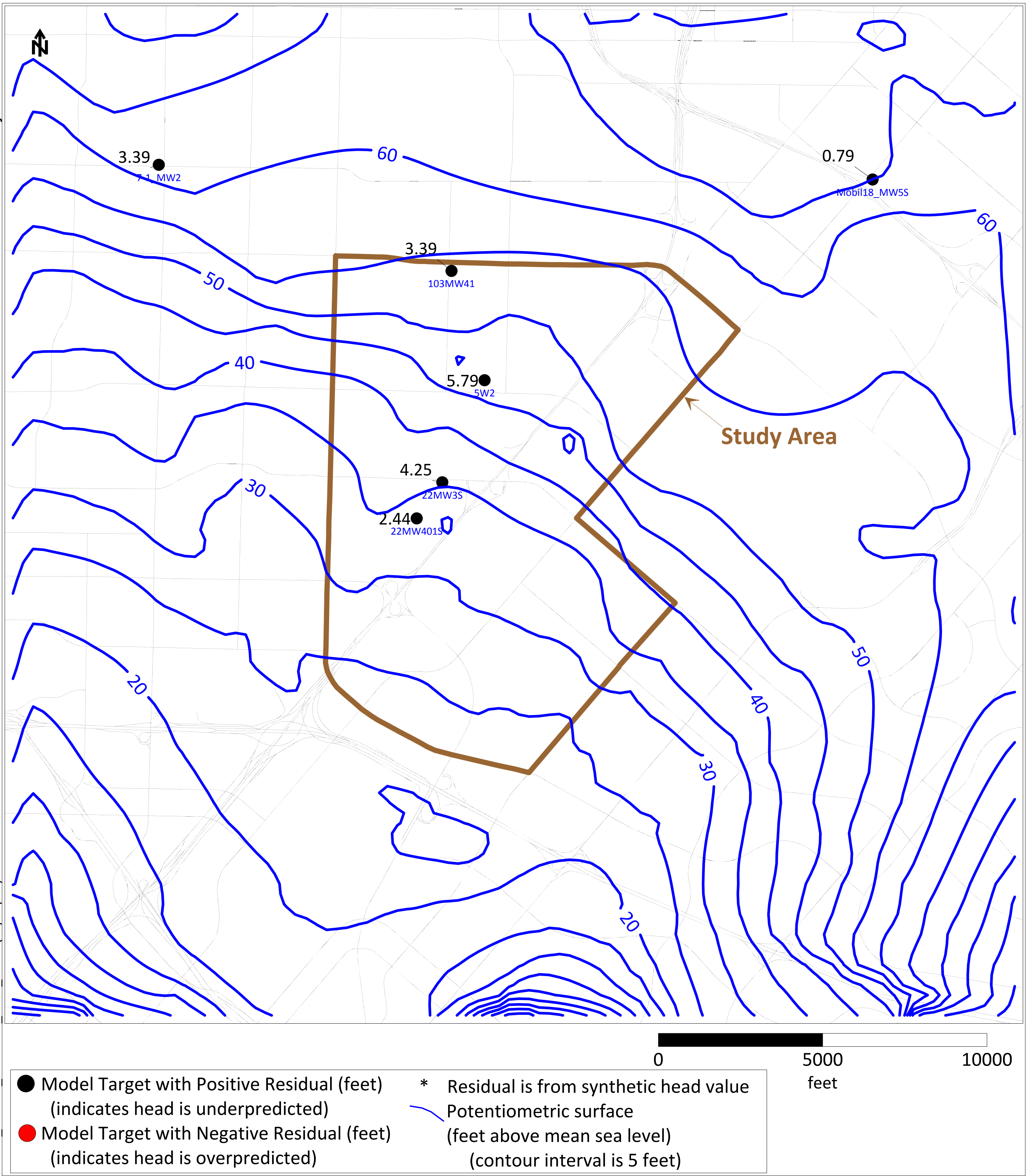
ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Plan



Engineering Analytics, Inc.

Figure 5.5. Simulated 2008 Potentiometric Surface Layer 6-SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Plan



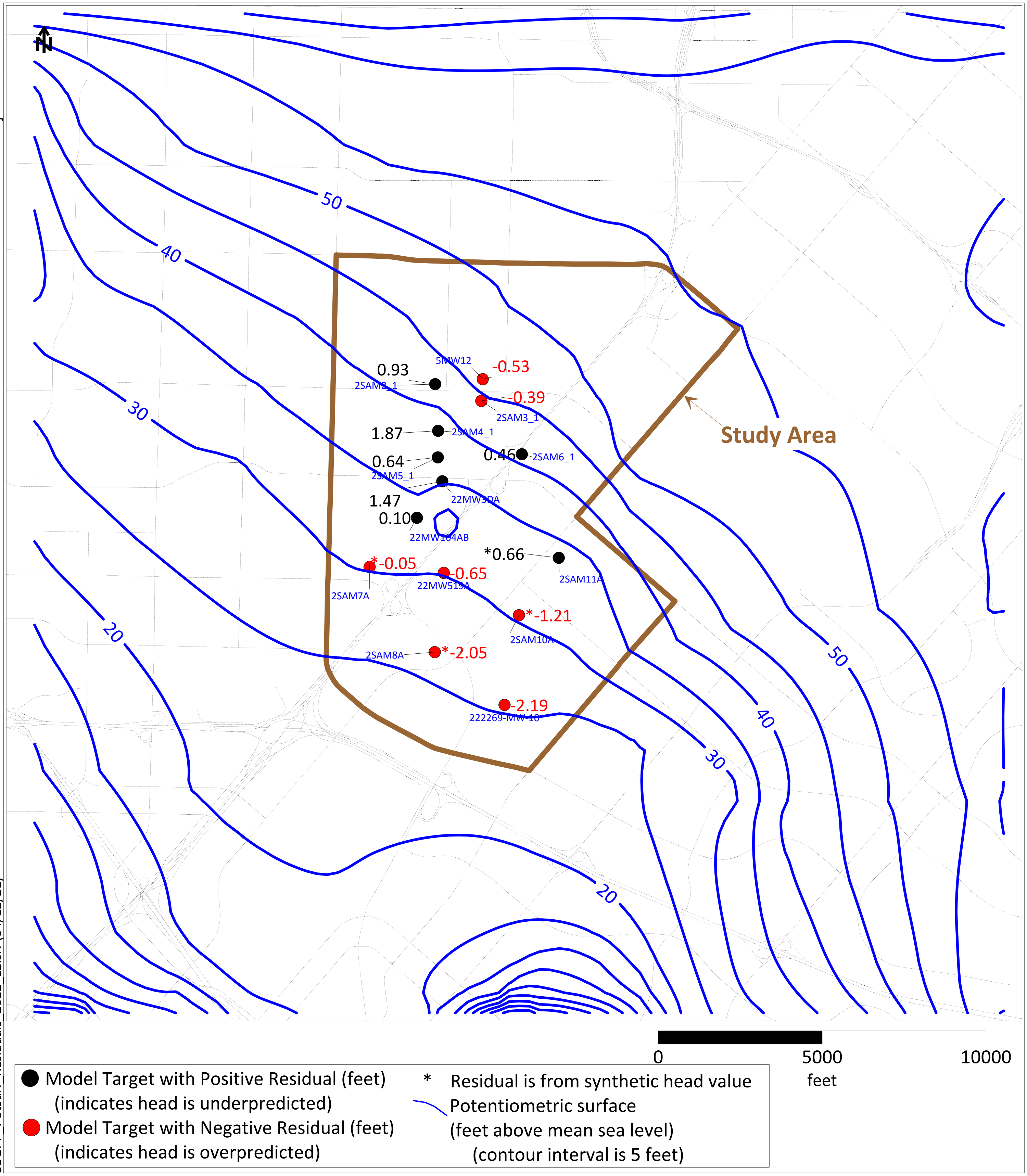
SBGPP_Potsurf_Residuals_2012_L1.srf (04/12/21)

Engineering Analytics, Inc.

Figure 5.6. Simulated 2012 Potentiometric Surface and Calibration Residuals, Layer 1-SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Plan

Project No. 151099



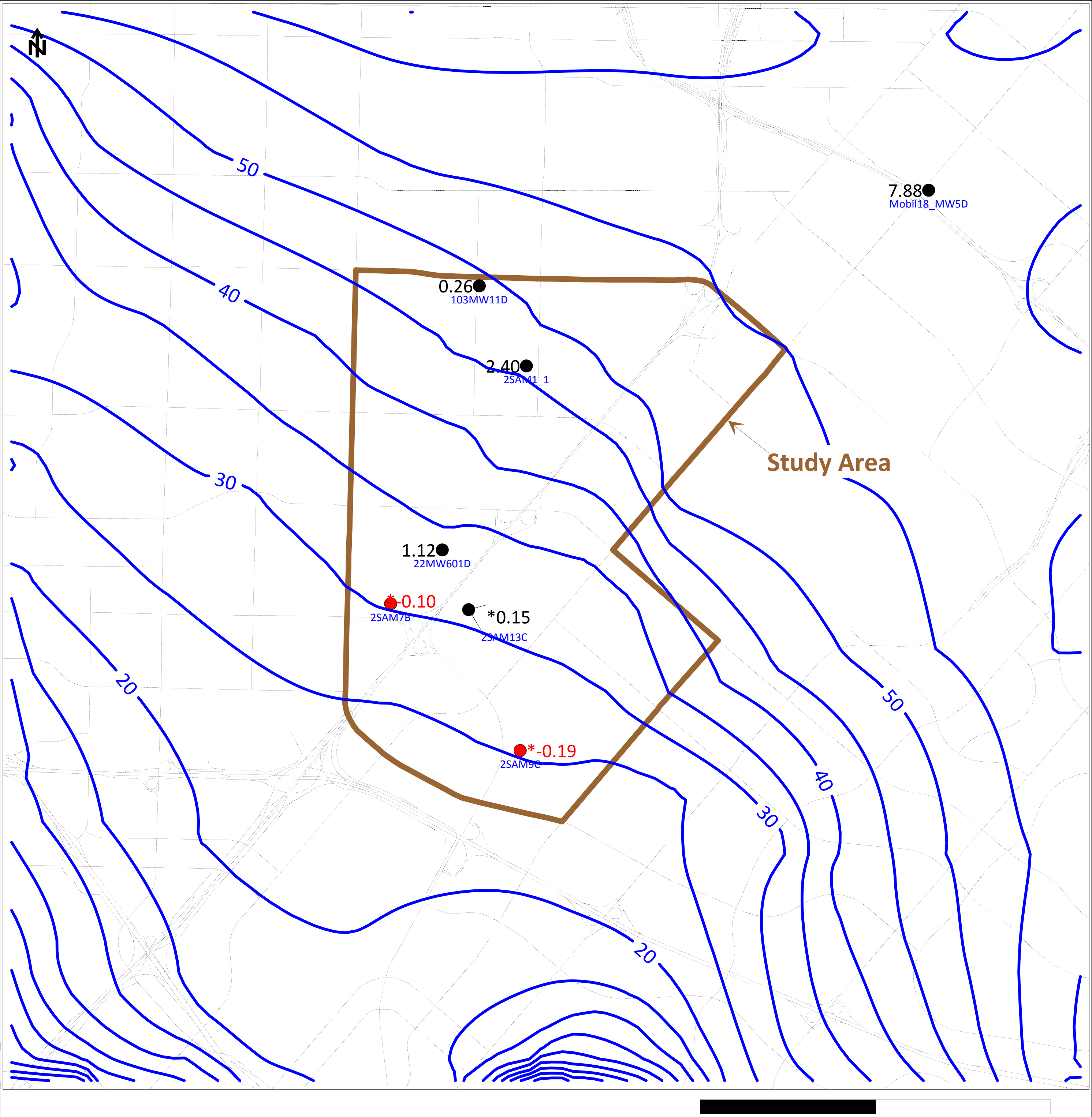
SBGPP_Potsurf_Residuals_2012_L2.srf (04/12/21)

Engineering Analytics, Inc.

Figure 5.7. Simulated 2012 Potentiometric Surface and Calibration Residuals, Layer 2-SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Plan

Project No. 151099



Model Target with Positive Residual (feet) (indicates head is underpredicted)

Model Target with Negative Residual (feet) (indicates head is overpredicted)

* Residual is from synthetic head value

Potentiometric surface (feet above mean sea level) (contour interval is 5 feet)

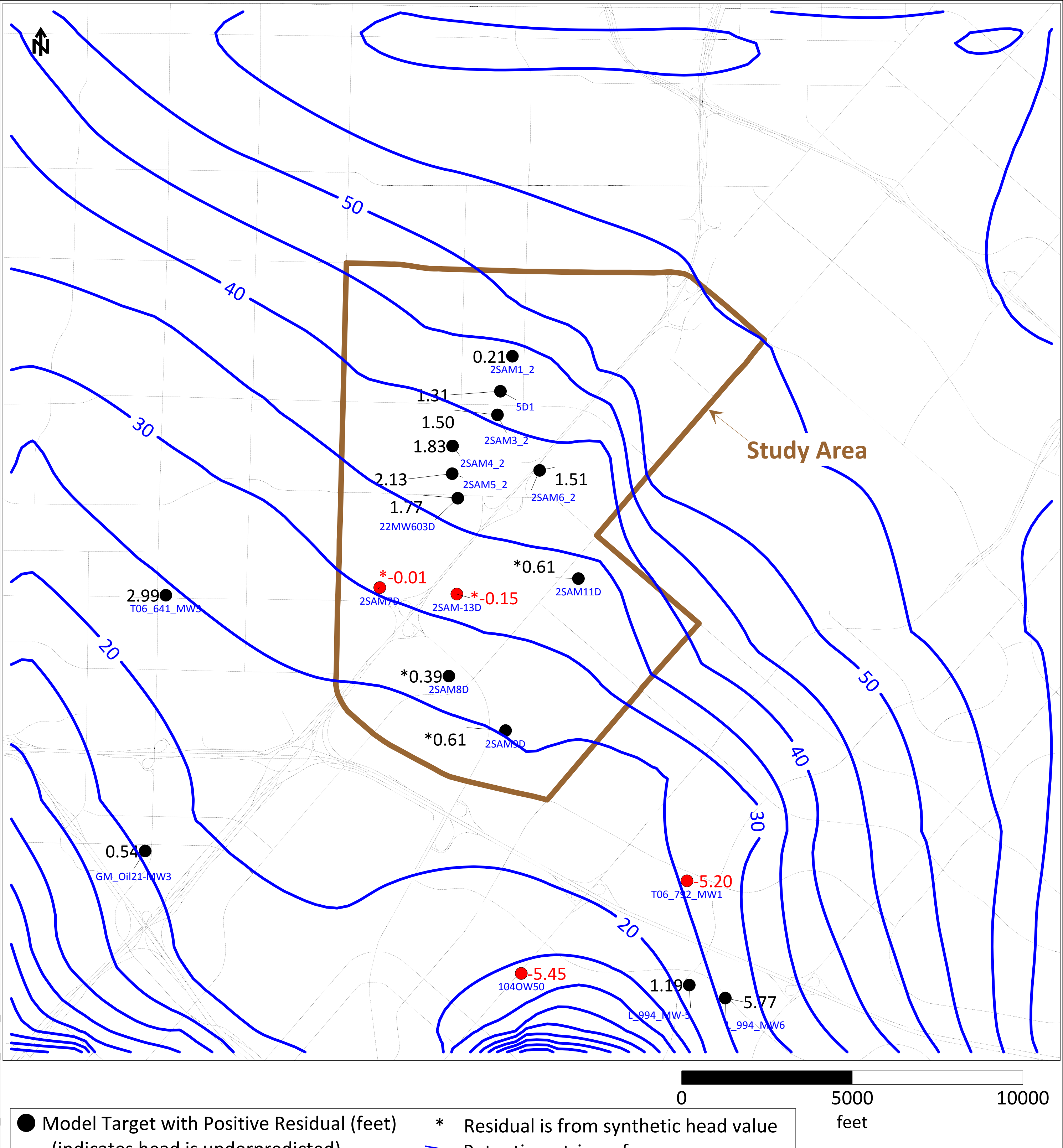
SBGPP_Potsurf_Residuals_2012_L3.srf (04/12/21)

Engineering Analytics, Inc.

Figure 5.8. Simulated 2012 Potentiometric Surface and Calibration Residuals, Layer 3-SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Plan

Project No. 151099



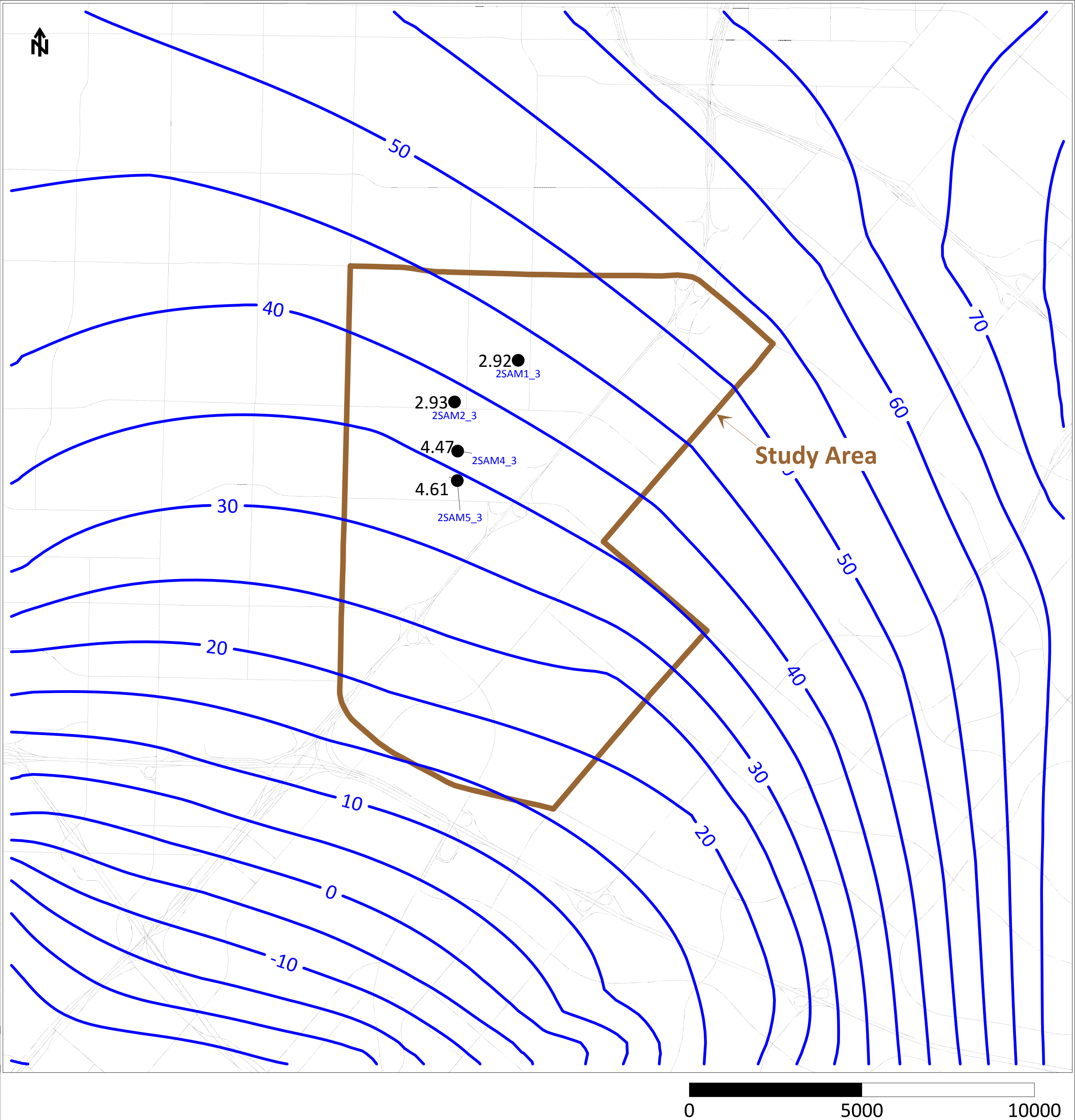
- Model Target with Positive Residual (feet) (indicates head is underpredicted)
- Model Target with Negative Residual (feet) (indicates head is overpredicted)
- * Residual is from synthetic head value
- Potentiometric surface (feet above mean sea level) (contour interval is 5 feet)

SBGPP_Potsurf_Residuals_2012_L4.srf (04/12/21)

Engineering Analytics, Inc.

Figure 5.9. Simulated 2012 Potentiometric Surface and Calibration Residuals, Layer 4-SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Plan



● Model Target with Positive Residual (feet)
(indicates head is underpredicted)

● Model Target with Negative Residual (feet)
(indicates head is overpredicted)

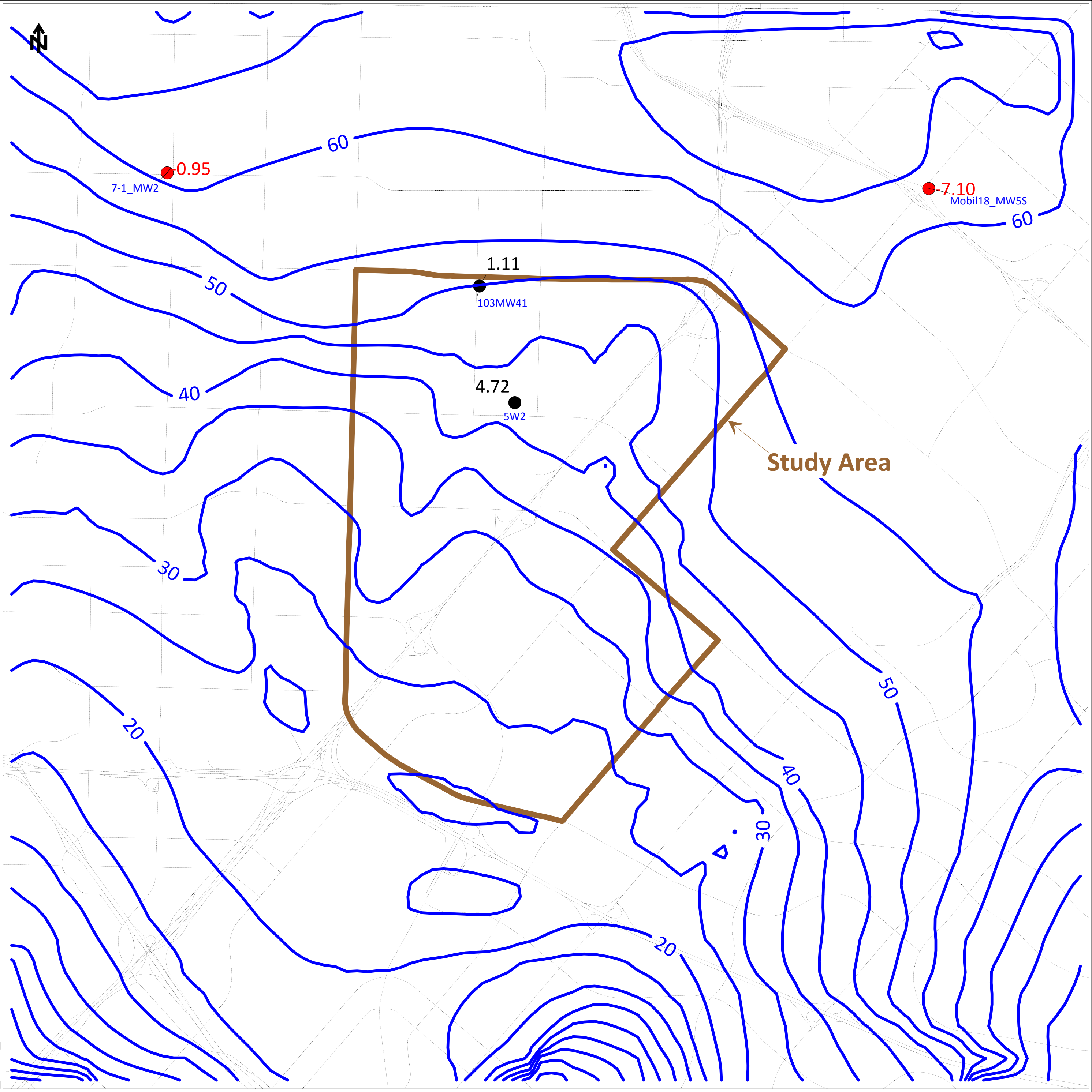
* Residual is from synthetic head value

Potentiometric surface
(feet above mean sea level)
(contour interval is 5 feet)

Engineering Analytics, Inc.

Figure 5.10. Simulated 2012 Potentiometric Surface and Calibration Residuals, Layer 6-SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Plan



● Model Target with Positive Residual (feet) (indicates head is underpredicted)

● Model Target with Negative Residual (feet) (indicates head is overpredicted)

* Residual is from synthetic head value

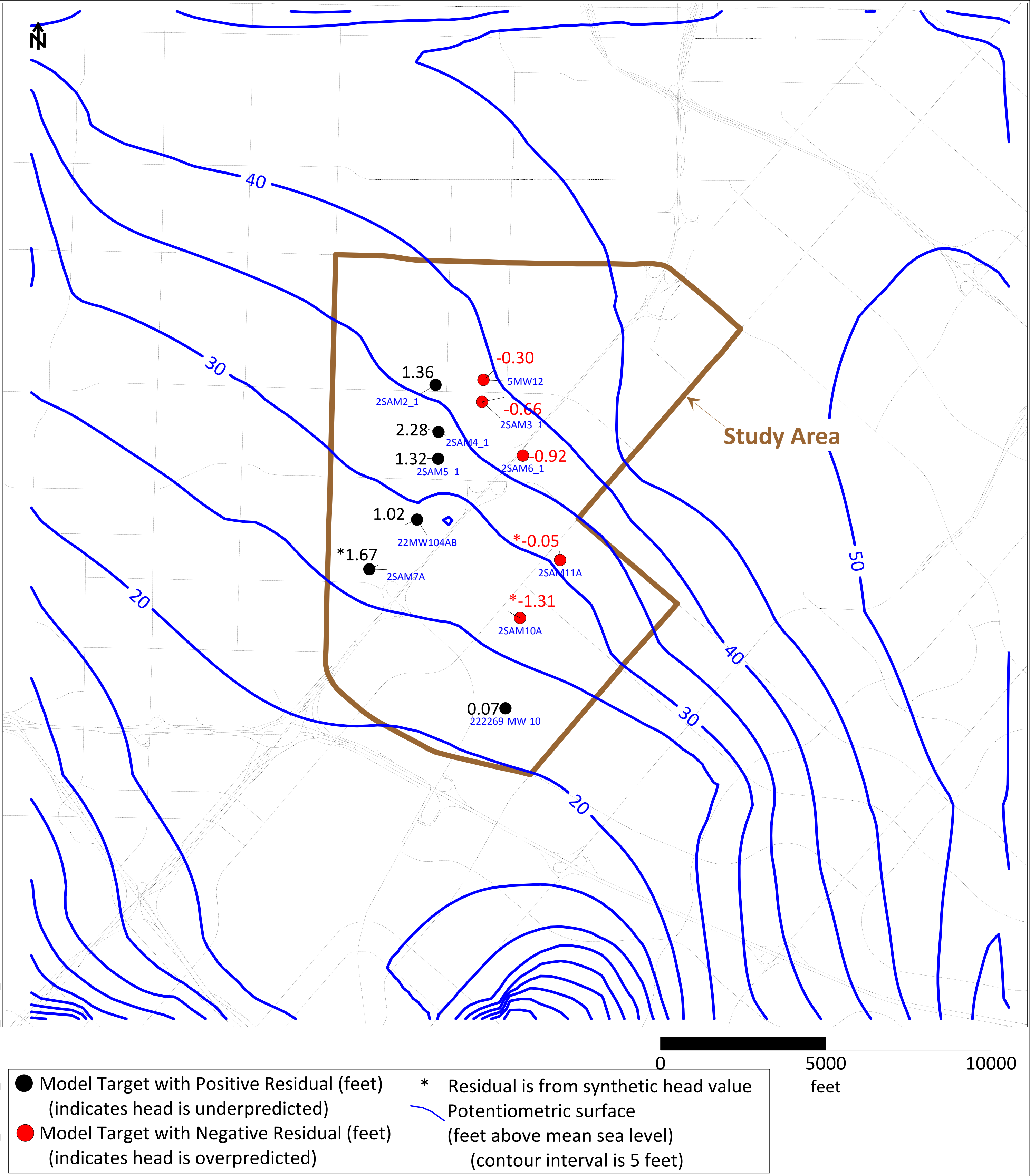
Potentiometric surface (feet above mean sea level) (contour interval is 5 feet)

SBGPP_Potsurf_Residuals_2016_L1.srf (04/12/21)

Engineering Analytics, Inc.

Figure 5.11. Simulated 2016 Potentiometric Surface and Calibration Residuals, Layer 1-SBGPP Model

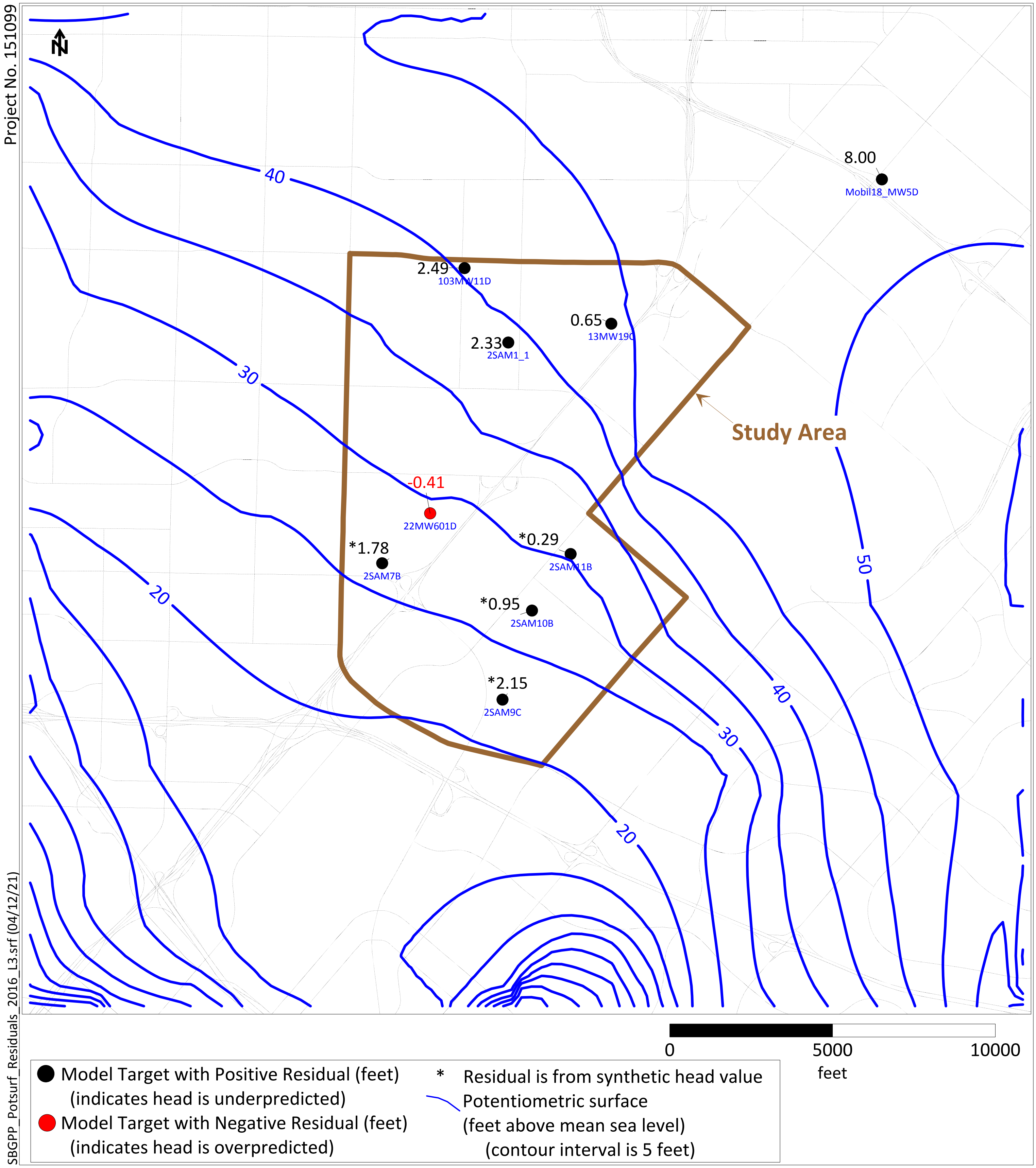
ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Plan



Engineering Analytics, Inc.

Figure 5.12. Simulated 2016 Potentiometric Surface and Calibration Residuals, Layer 2-SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Plan

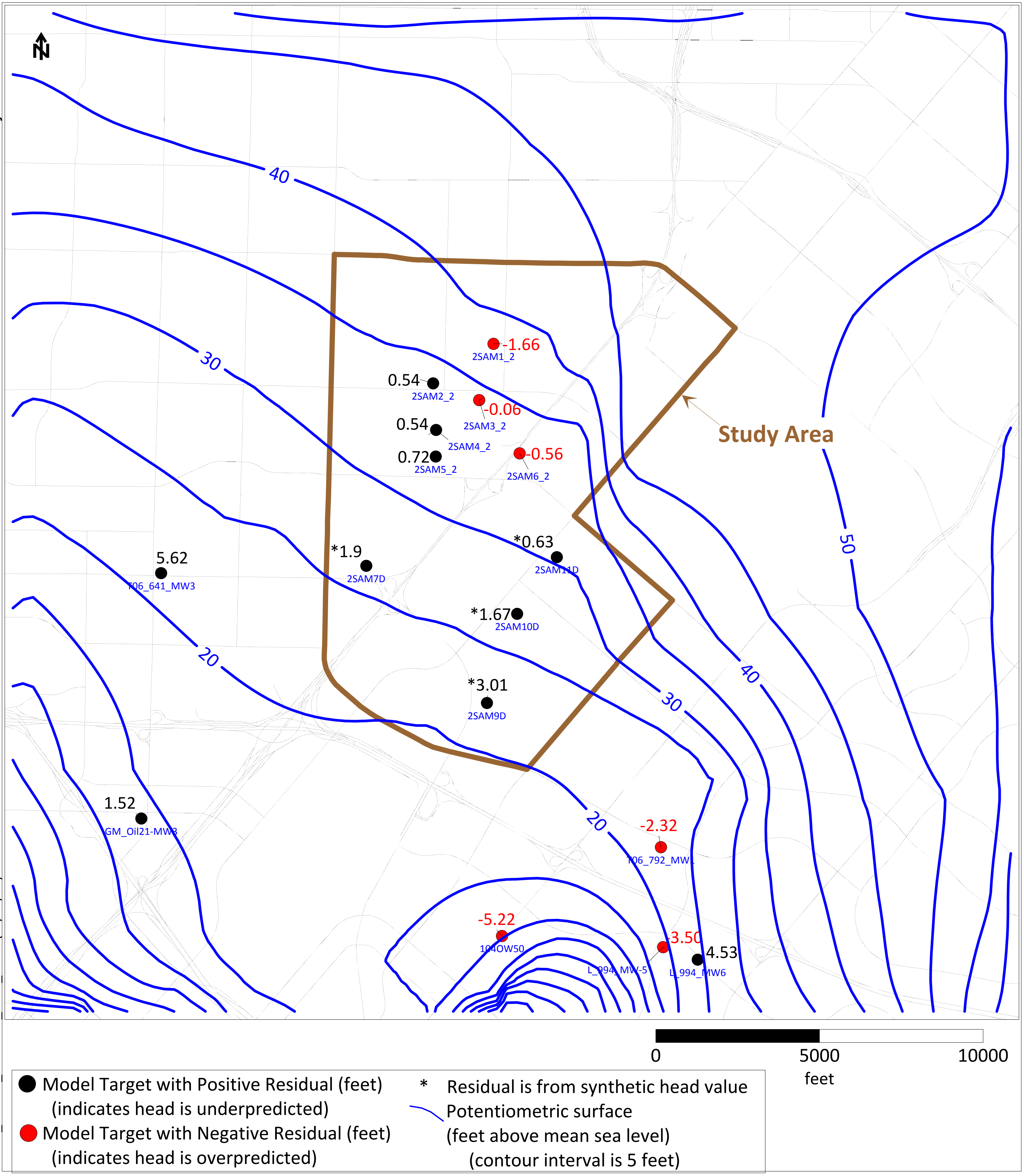


Engineering Analytics, Inc.

Figure 5.13. Simulated 2016 Potentiometric Surface and Calibration Residuals, Layer 3-SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Plan

Project No. 151099



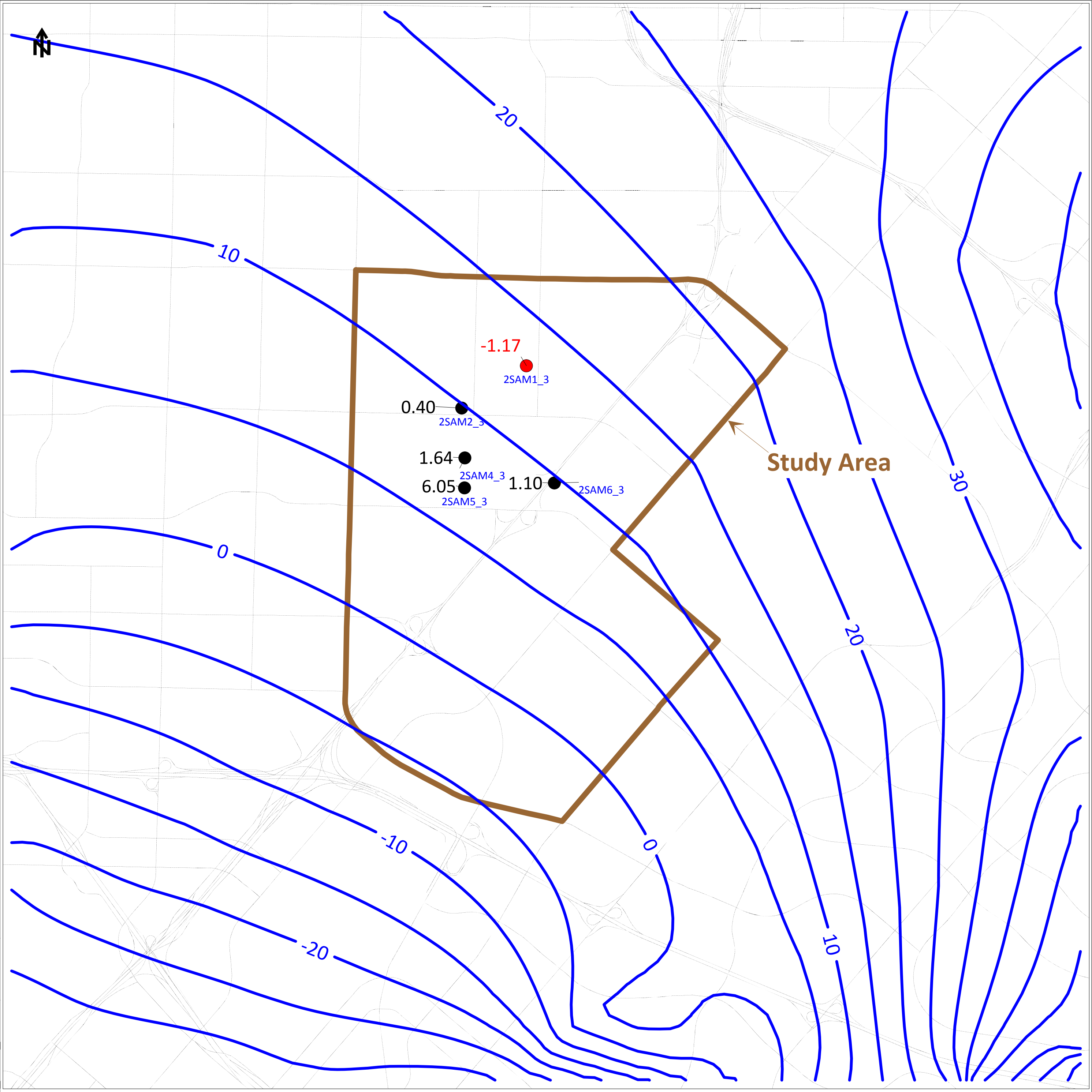
SBGPP_Potsurf_Residuals_2016_L4.srf (04/12/21)

Engineering Analytics, Inc.

Figure 5.14. Simulated 2016 Potentiometric Surface and Calibration Residuals, Layer 4-SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Plan

Project No. 151099



● Model Target with Positive Residual (feet) (indicates head is underpredicted)

● Model Target with Negative Residual (feet) (indicates head is overpredicted)

* Residual is from synthetic head value

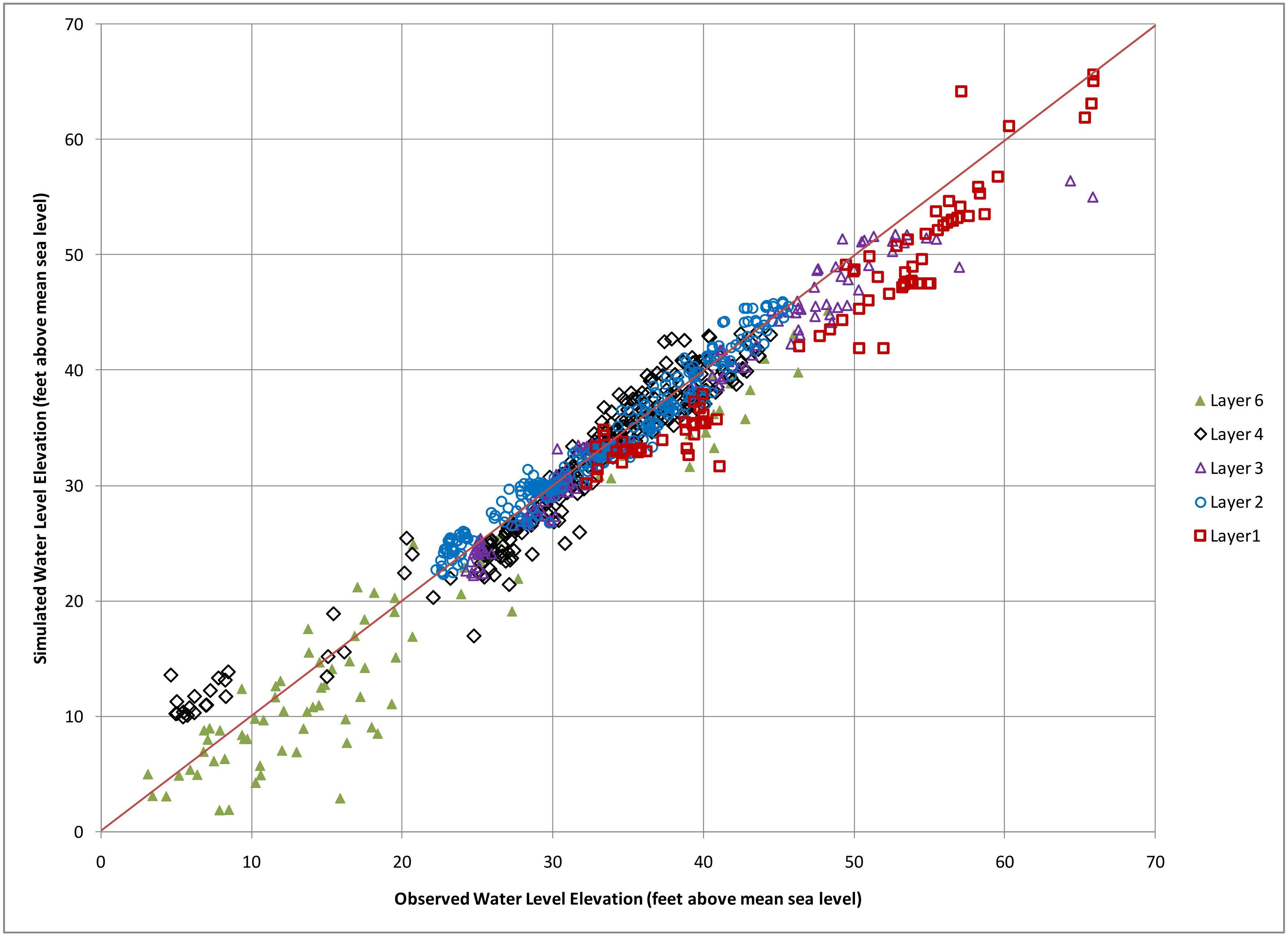
Potentiometric surface (feet above mean sea level) (contour interval is 5 feet)

SBGPP_Potsurf_Residuals_2016_L6.srf (04/12/21)

Engineering Analytics, Inc.

Figure 5.15. Simulated 2016 Potentiometric Surface and Calibration Residuals, Layer 6-SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Plan



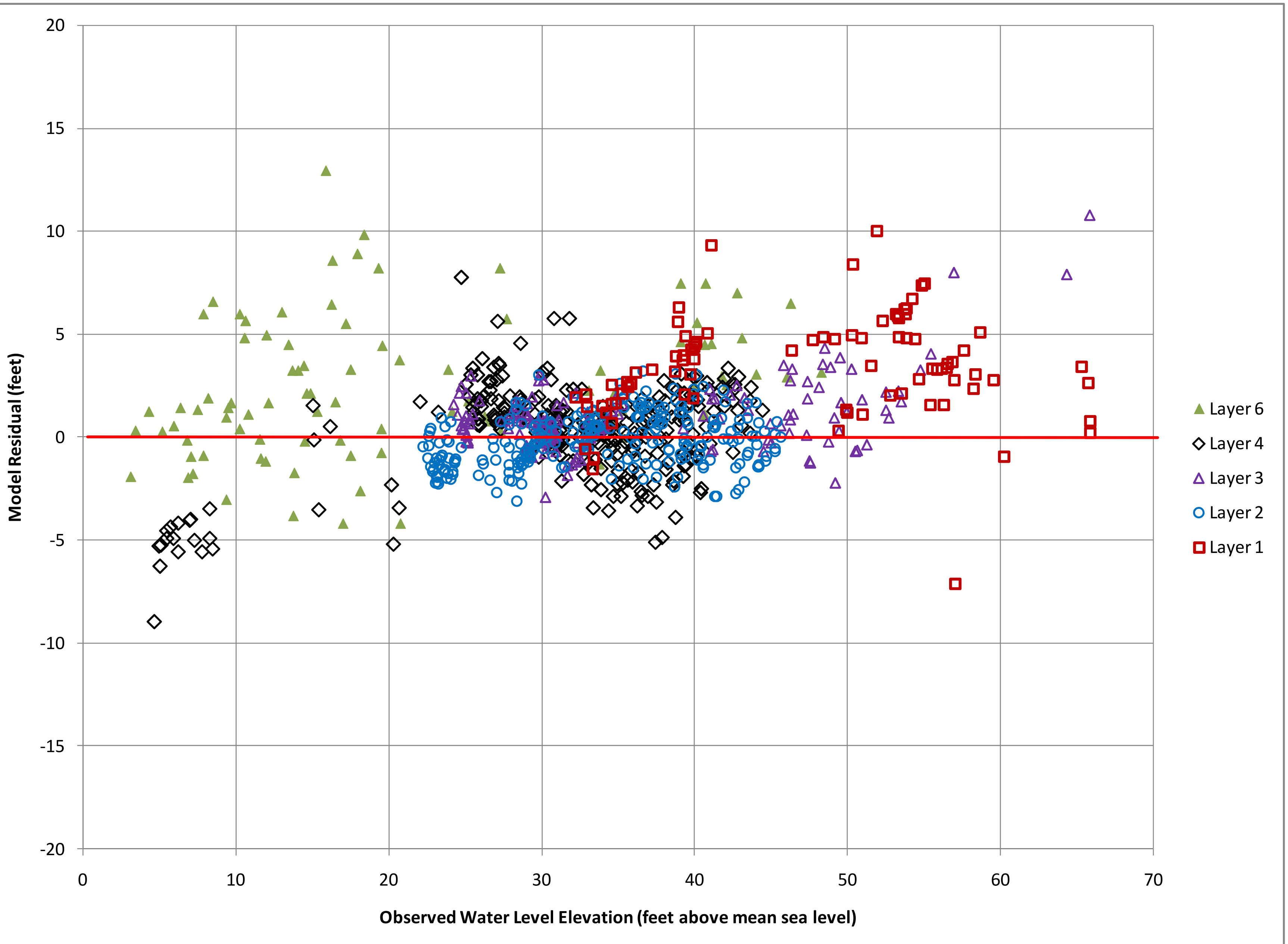
Project No. 151099

SBGPP_Model__Obs_vs_Residuals_All.srf (04/12/21)

Engineering Analytics, Inc.

Figure 5.16. Observed vs. Simulated Water Level Elevations All Layers, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project



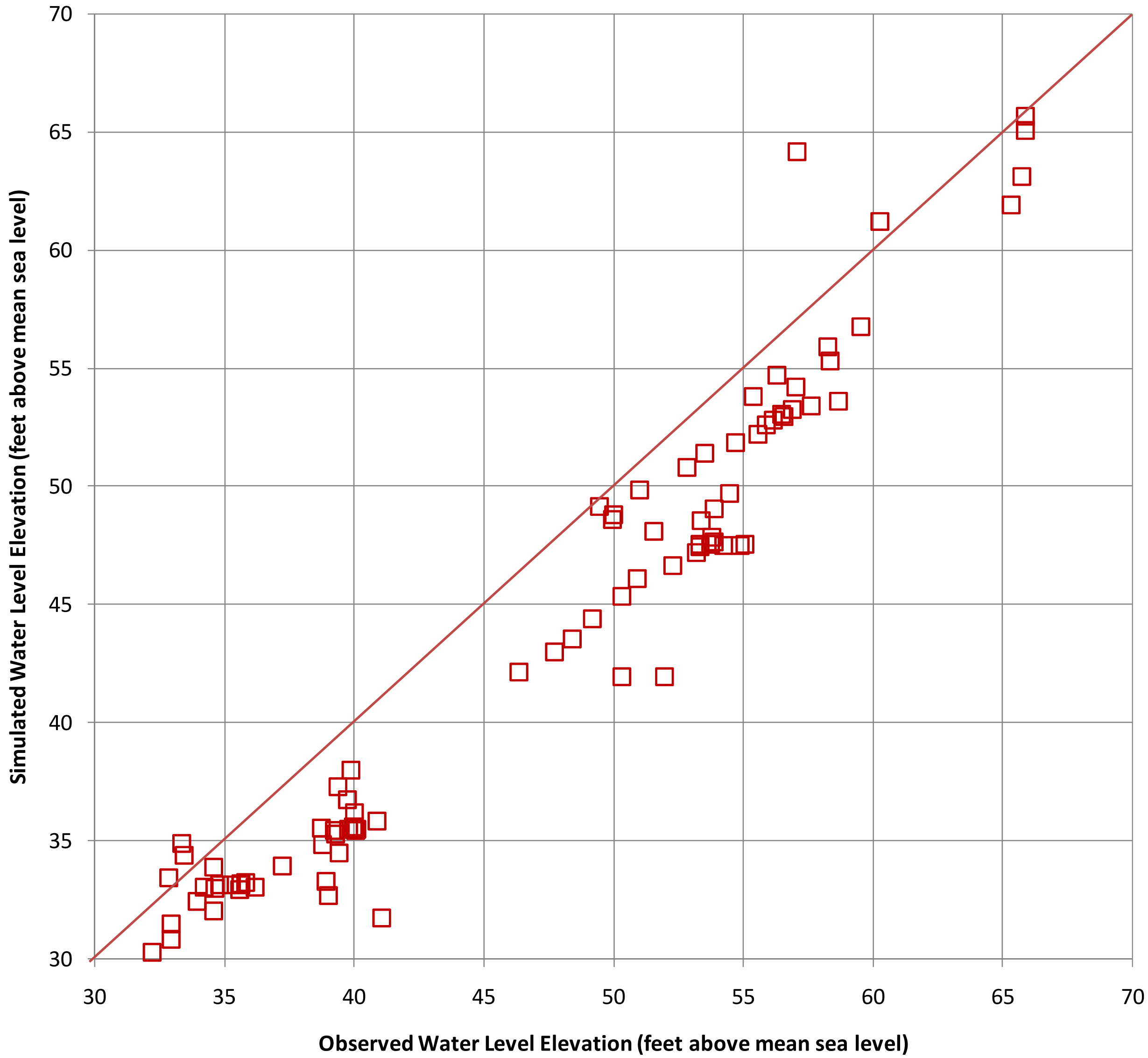
SBGPP_Model__Obs_vs_Residuals_All.srf (04/12/21)

Engineering Analytics, Inc.

Figure 5.17. Observed Water Level Elevations vs Residuals All Layers, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099

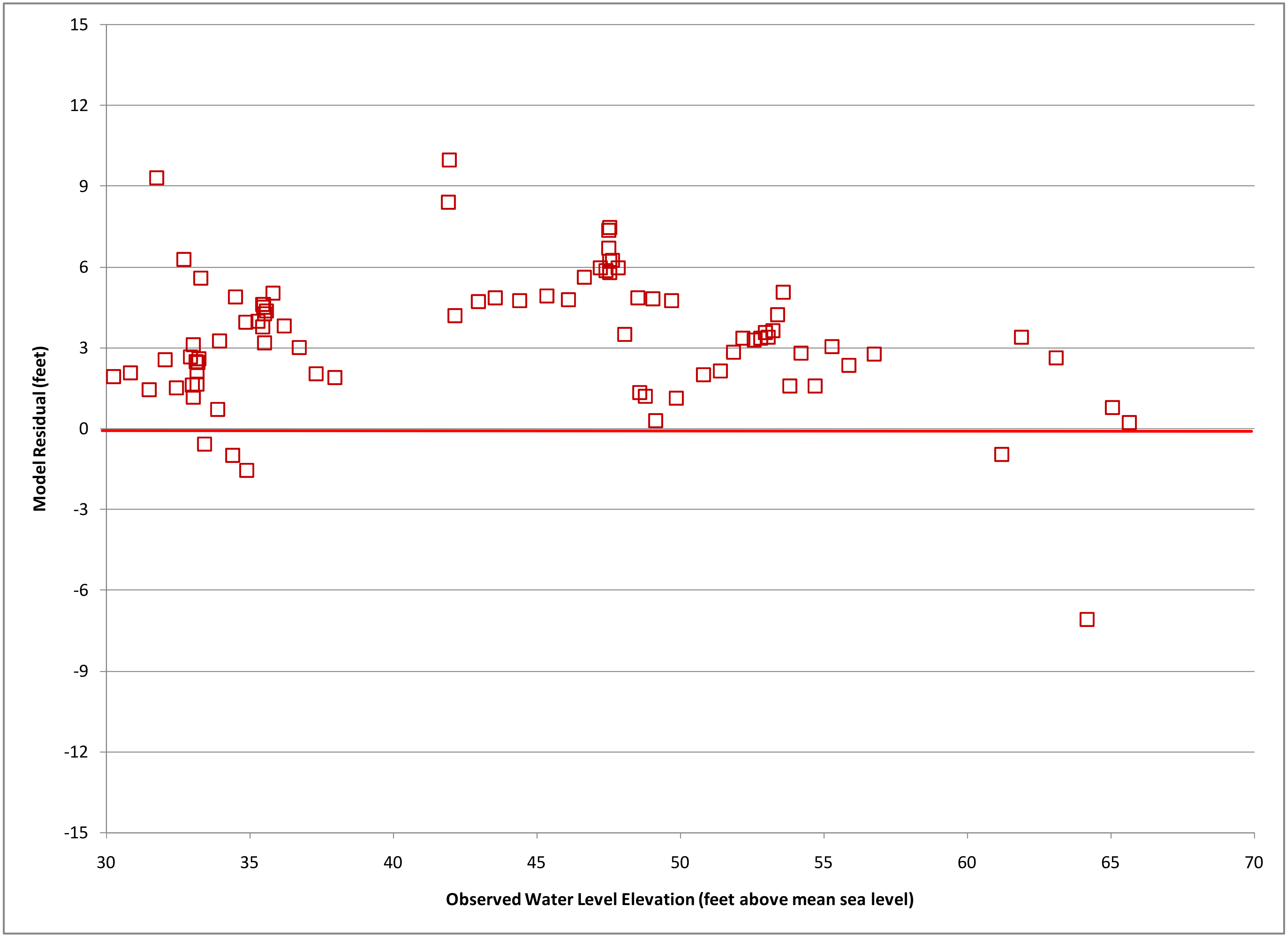


SBGPP_Model__Obs_vs_Sim_L1.srf (04/12/21)

Engineering Analytics, Inc.

Figure 5.18. Observed vs. Simulated Water Level Elevations Layer 1, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

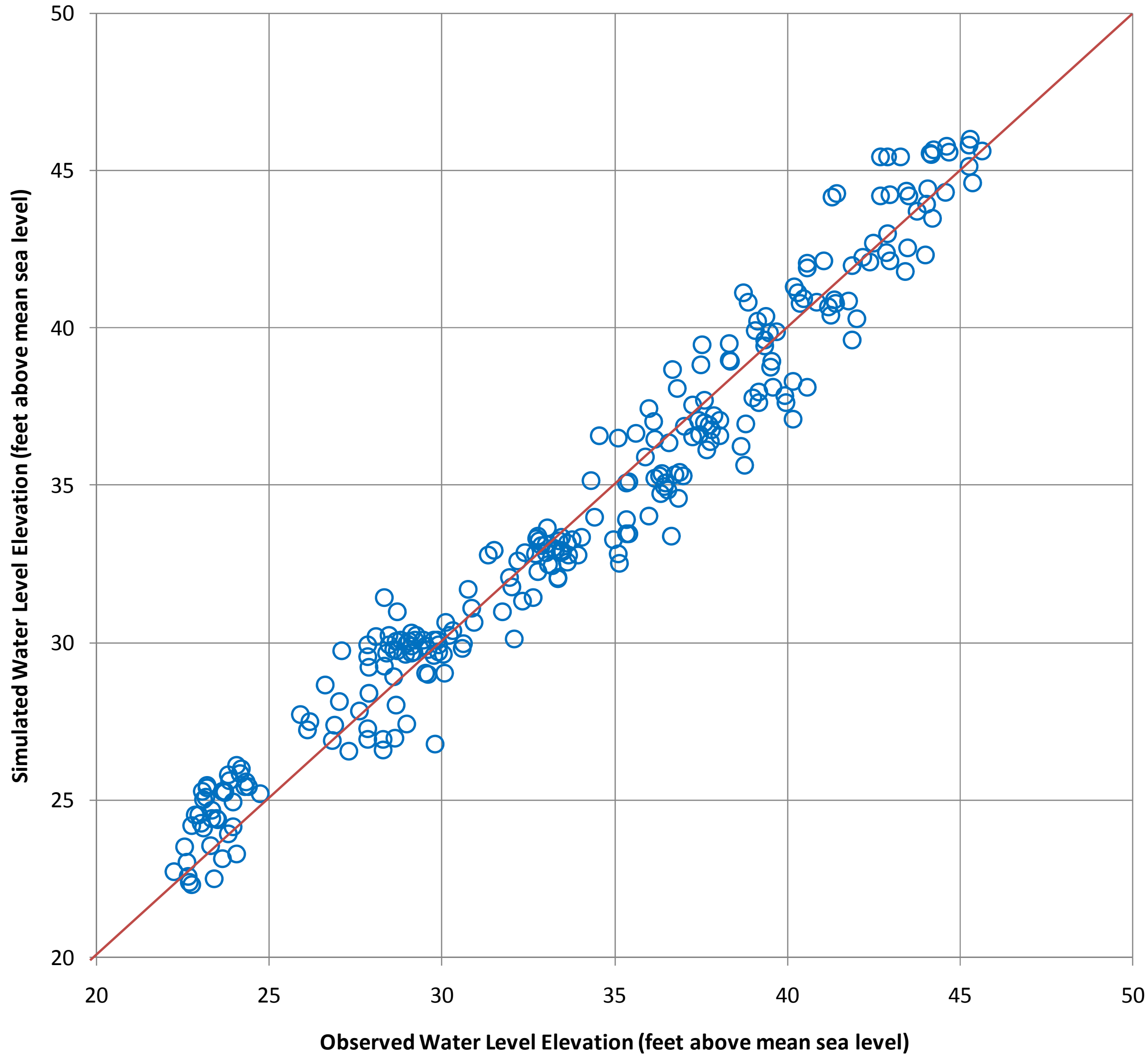


SBGPP_Model__Obs_vs_Residuals_All.srf (04/12/21)

Engineering Analytics, Inc.

Figure 5.19. Observed Water Level Elevations vs Residuals Layer 1, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project



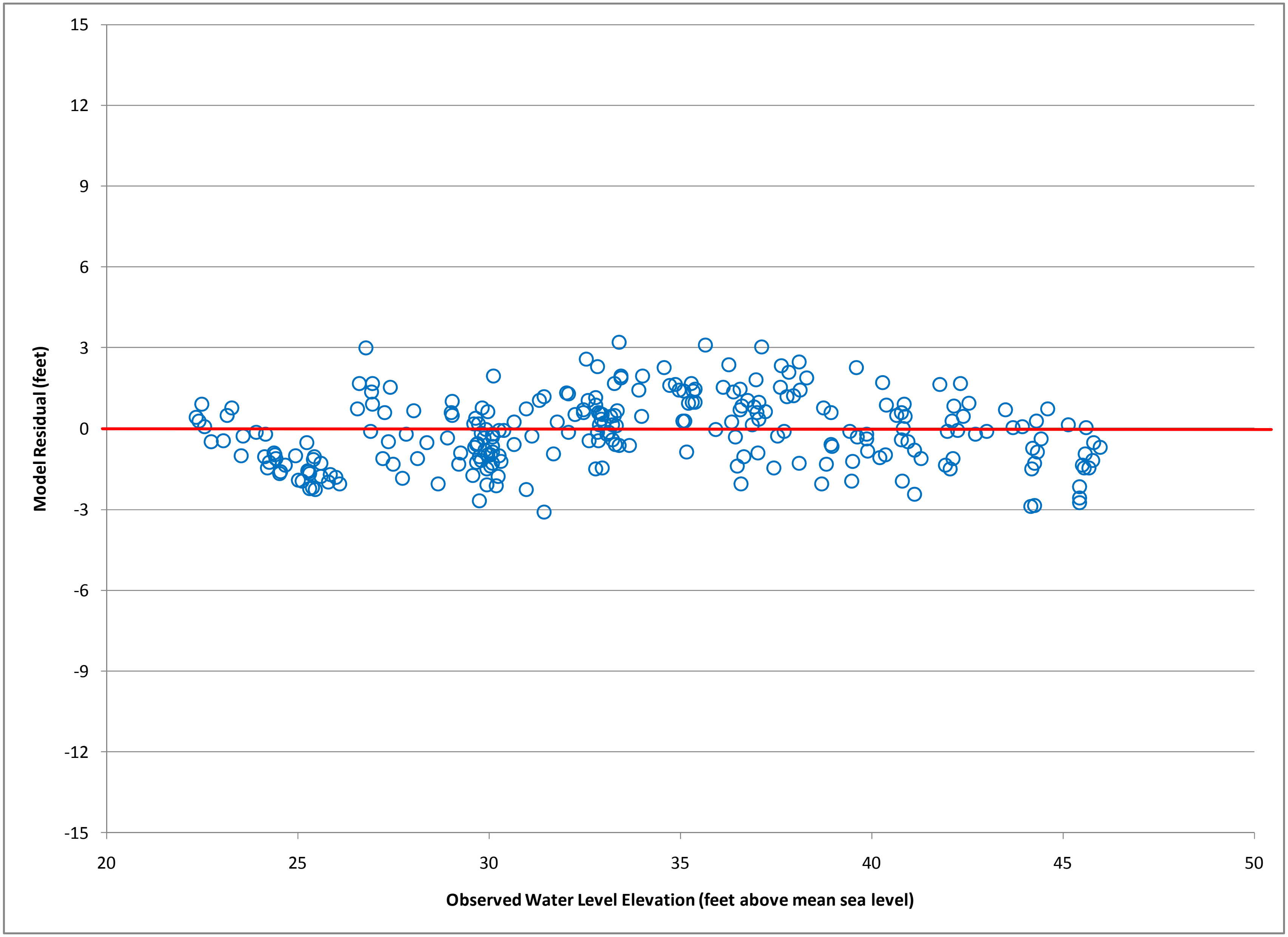
SBGPP_Model__Obs_vs_Sim_L2.srf (04/12/21)

Engineering Analytics, Inc.

Figure 5.20. Observed vs. Simulated Water Level Elevations Layer 2, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



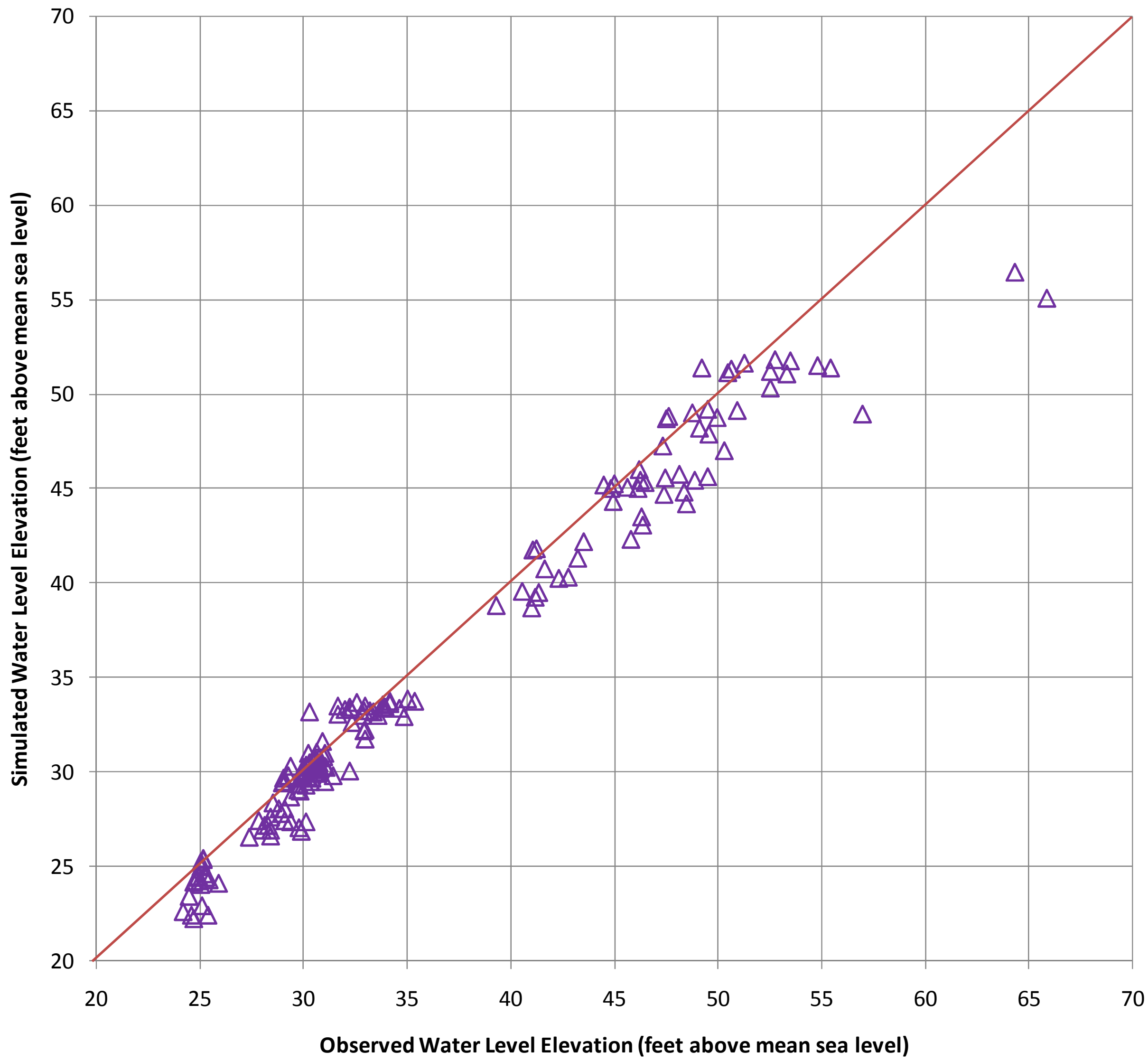
SBGPP_Model__Obs_vs_Residuals_L2.srf (04/12/21)

Engineering Analytics, Inc.

Figure 5.21. Observed Water Level Elevations vs Residuals Layer 2, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



SBGPP_Model__Obs_vs_Sim_L3.srf (04/12/21)

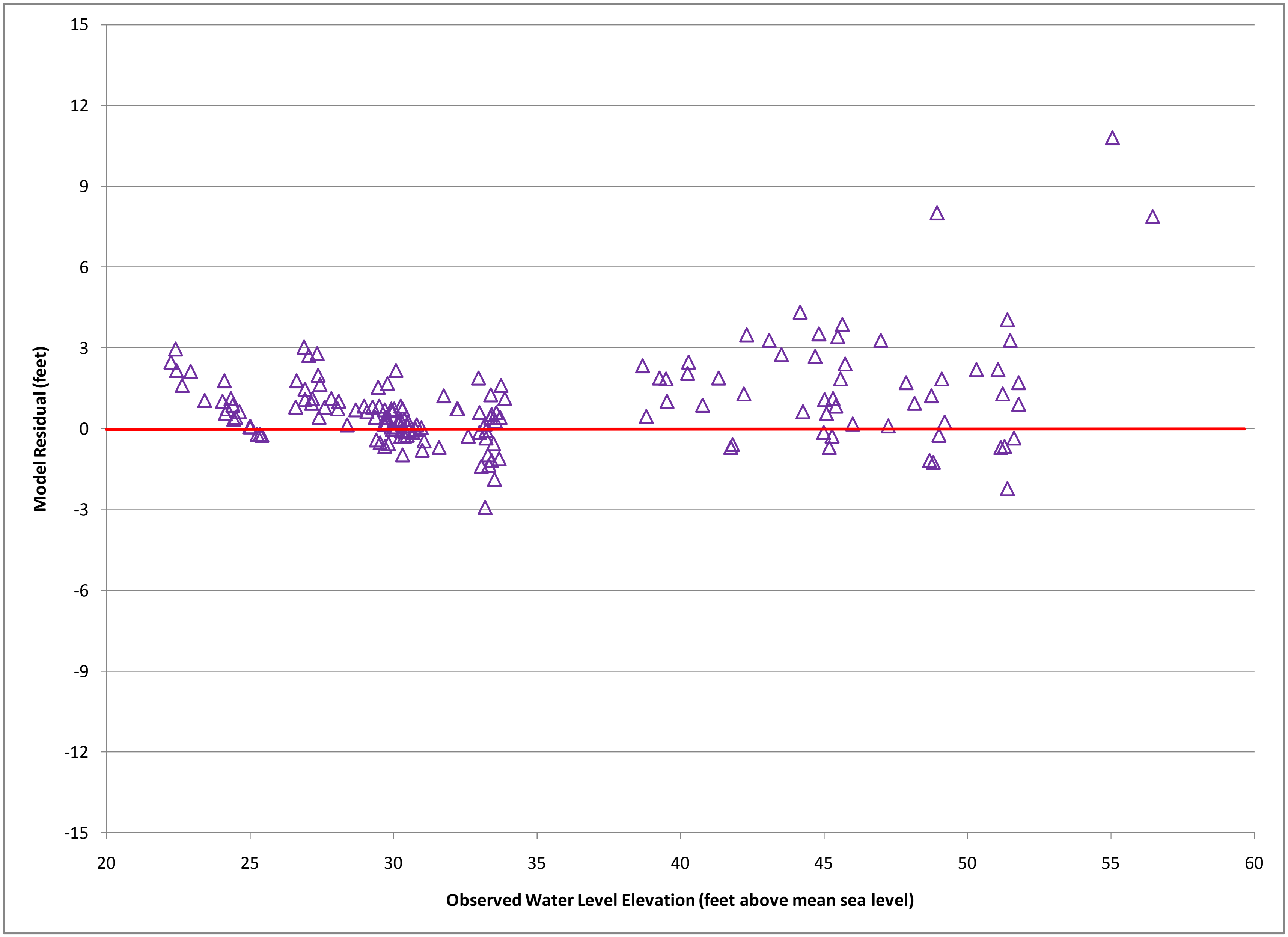
Engineering Analytics, Inc.

Figure 5.22. Observed vs. Simulated Water Level Elevations Layer 3, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099

SBGPP_Model__Obs_vs_Residuals_L3.srf (04/12/21)



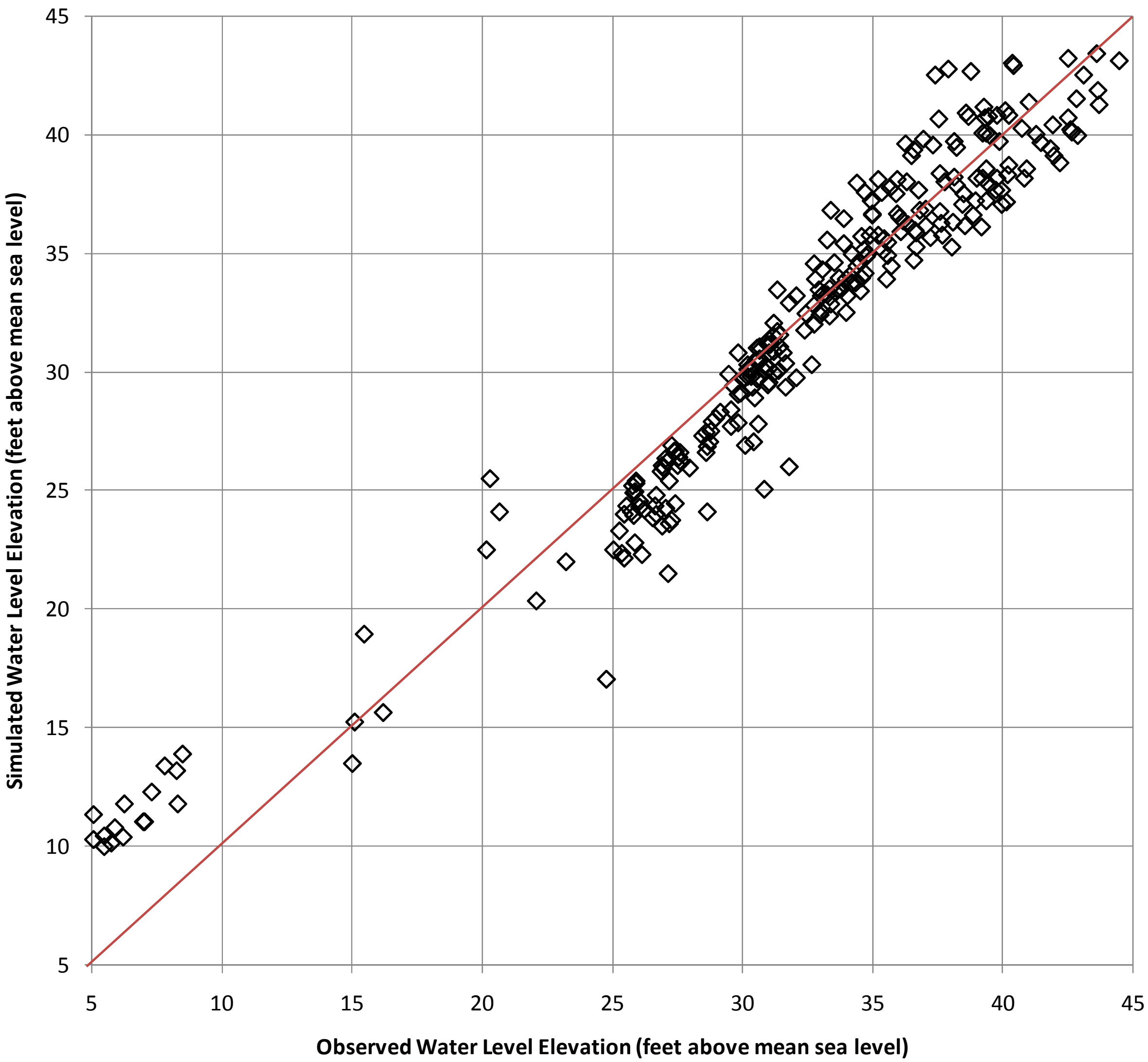
Engineering Analytics, Inc.

Figure 5.23. Observed Water Level Elevations vs Residuals Layer 3, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099

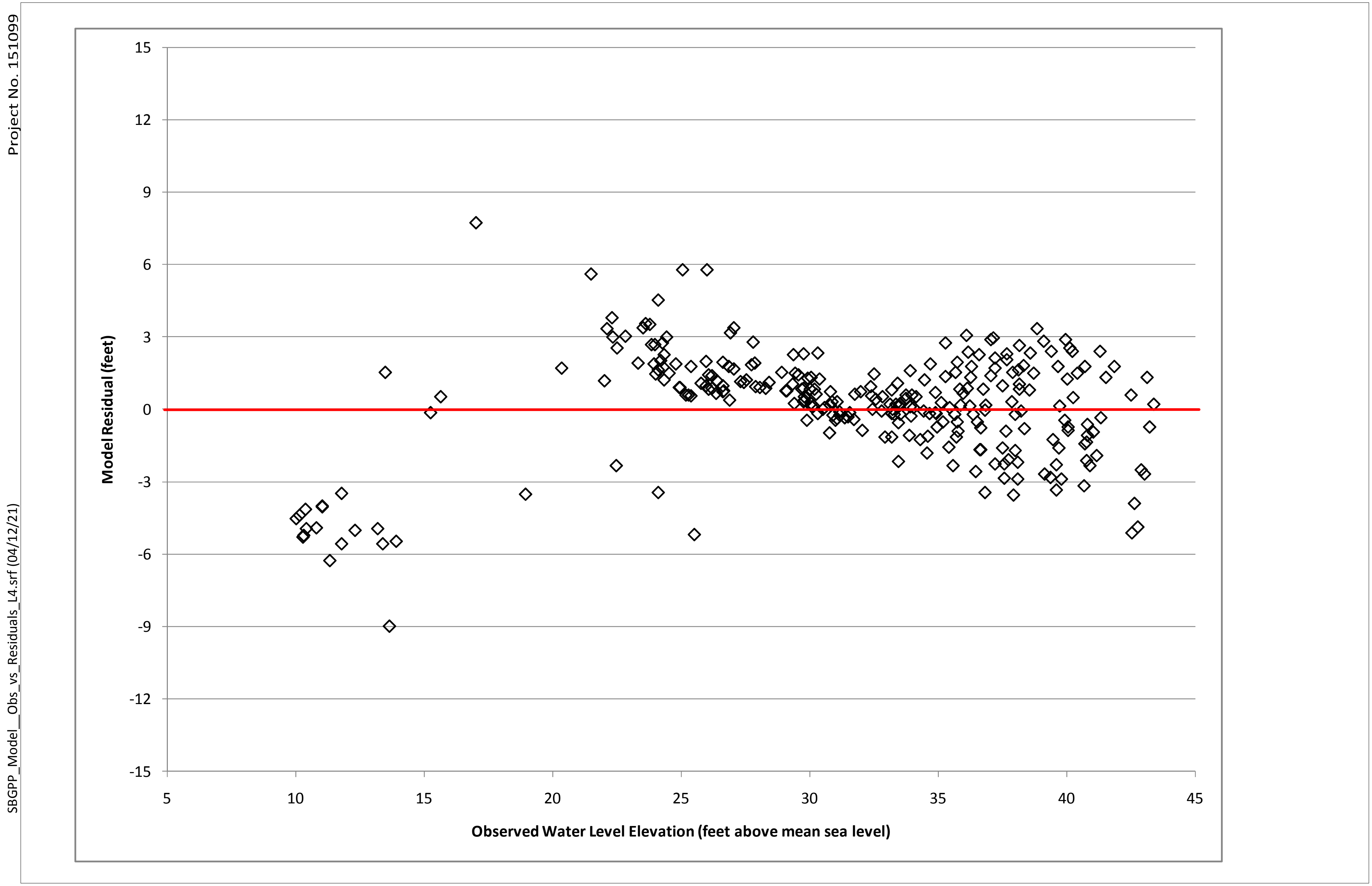
SBGPP_Model__Obs_vs_Sim_L4.srf (04/12/21)



Engineering Analytics, Inc.

Figure 5.24. Observed vs. Simulated Water Level Elevations Layer 4, SBGPP Model

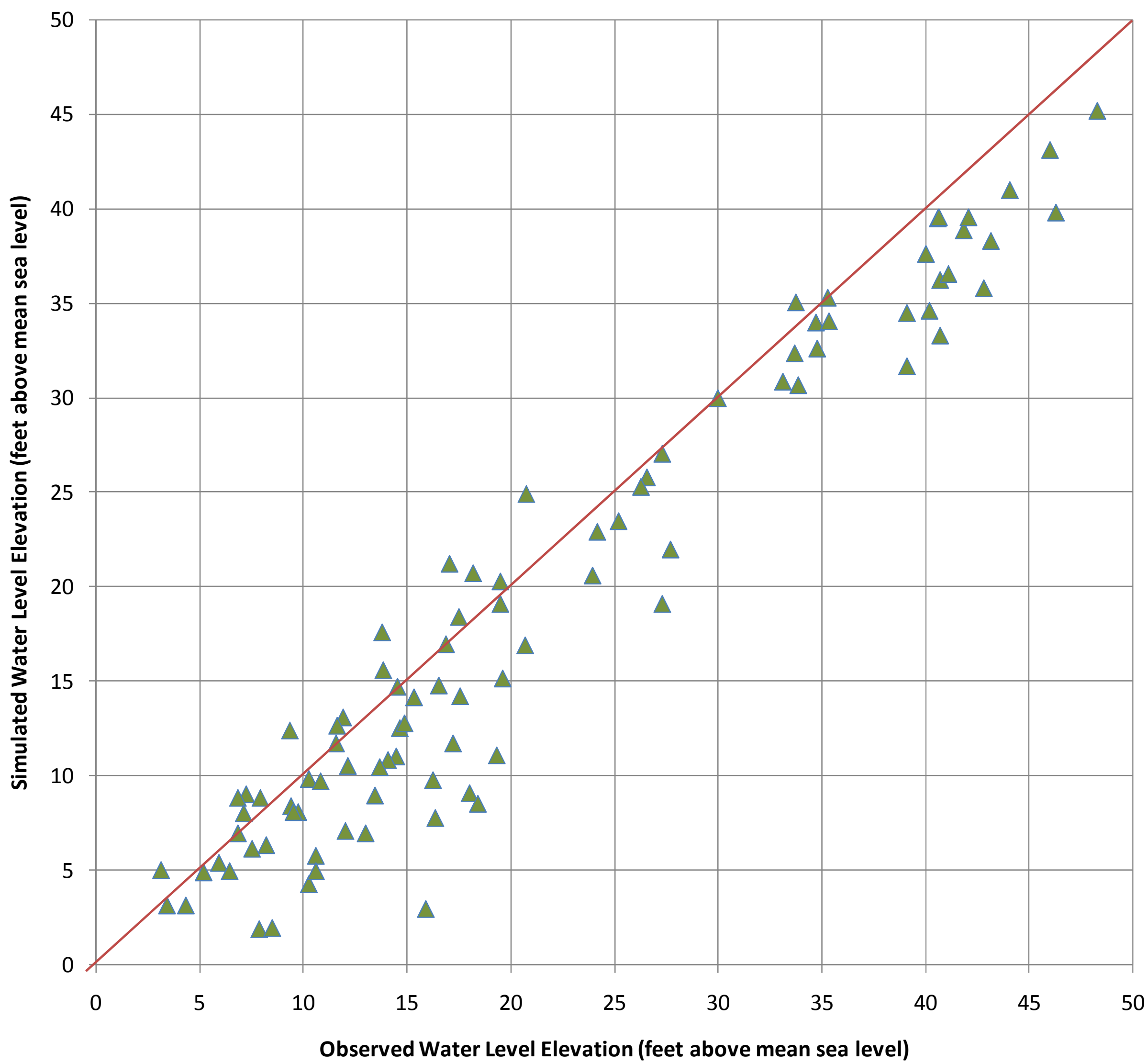
ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project



Engineering Analytics, Inc.

Figure 5.25. Observed Water Level Elevations vs Residuals Layer 4, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

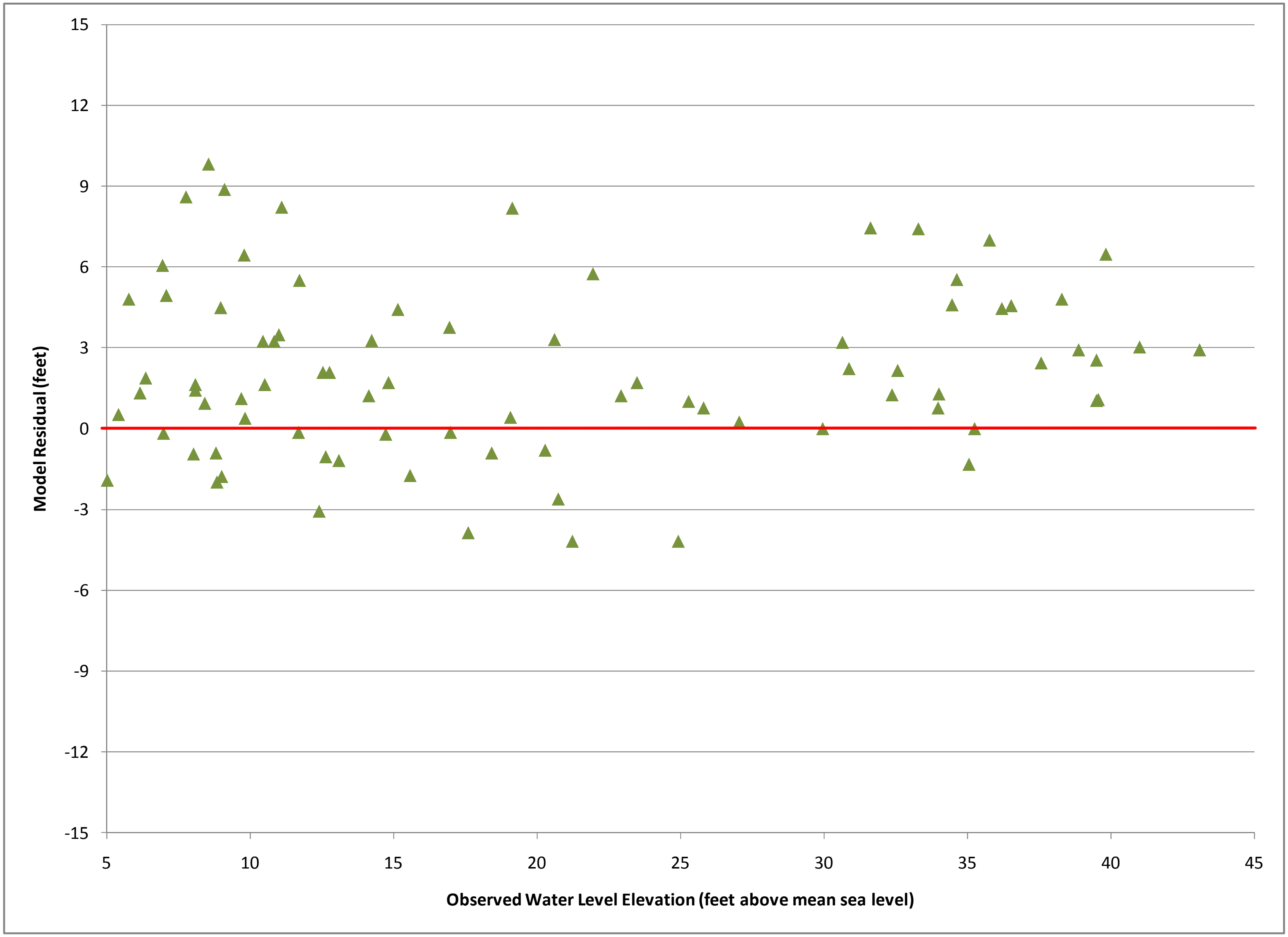


Engineering Analytics, Inc.

Figure 5.26. Observed vs. Simulated Water Level Elevations Layer 6, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099

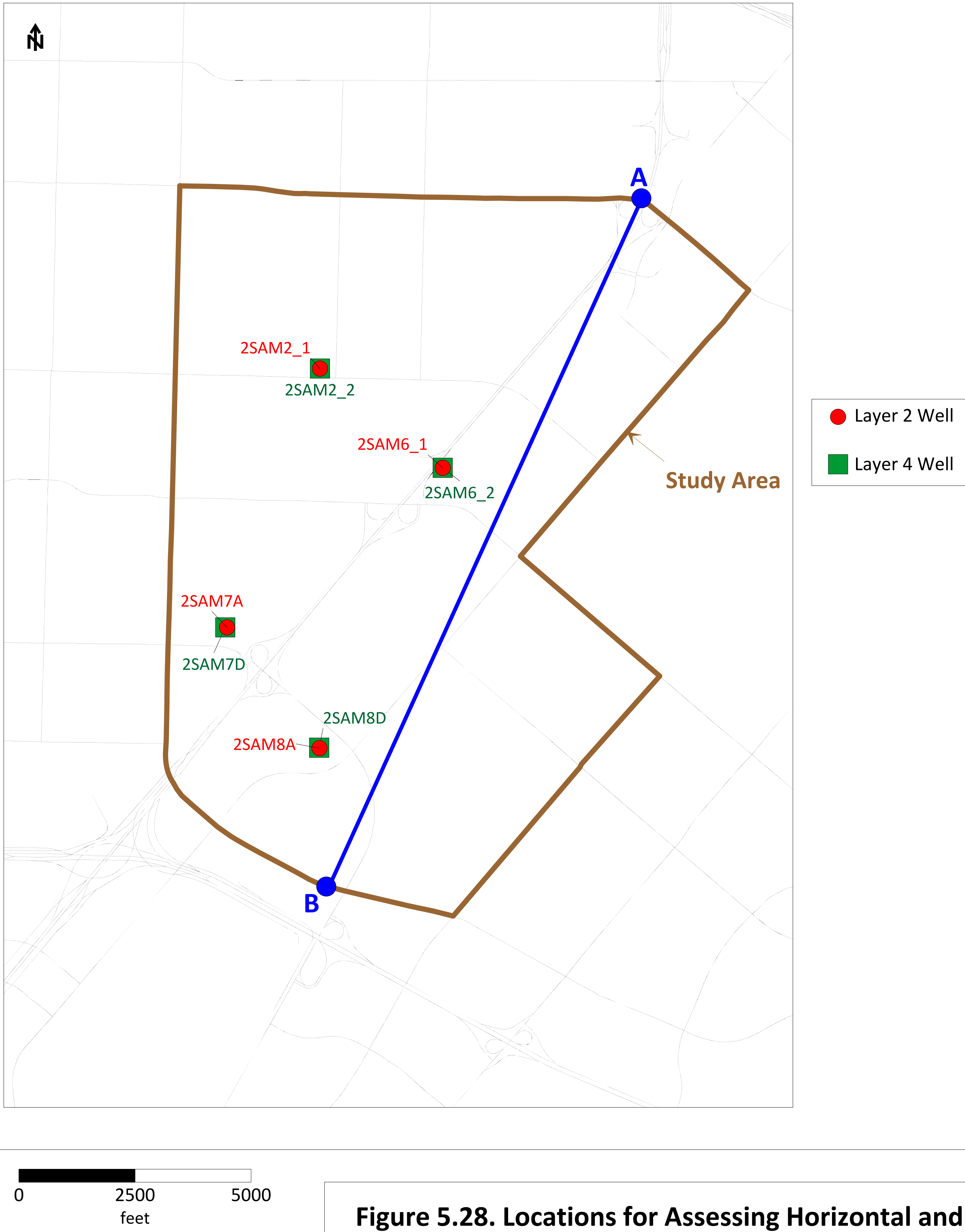


SBGPP_Model__Obs_vs_Residuals_L6.srf (04/12/21)

Engineering Analytics, Inc.

Figure 5.27. Observed Water Level Elevations vs Residuals Layer 6, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project



Project No. 151099

SBGPP_HydGradAssess.srf (04/12/21)

Engineering Analytics, Inc.

Figure 5.28. Locations for Assessing Horizontal and Vertical Hydraulic Gradients, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Plan

Project No. 151099

SBGPP_Hydrographs_2SAM.srf (04/12/21)

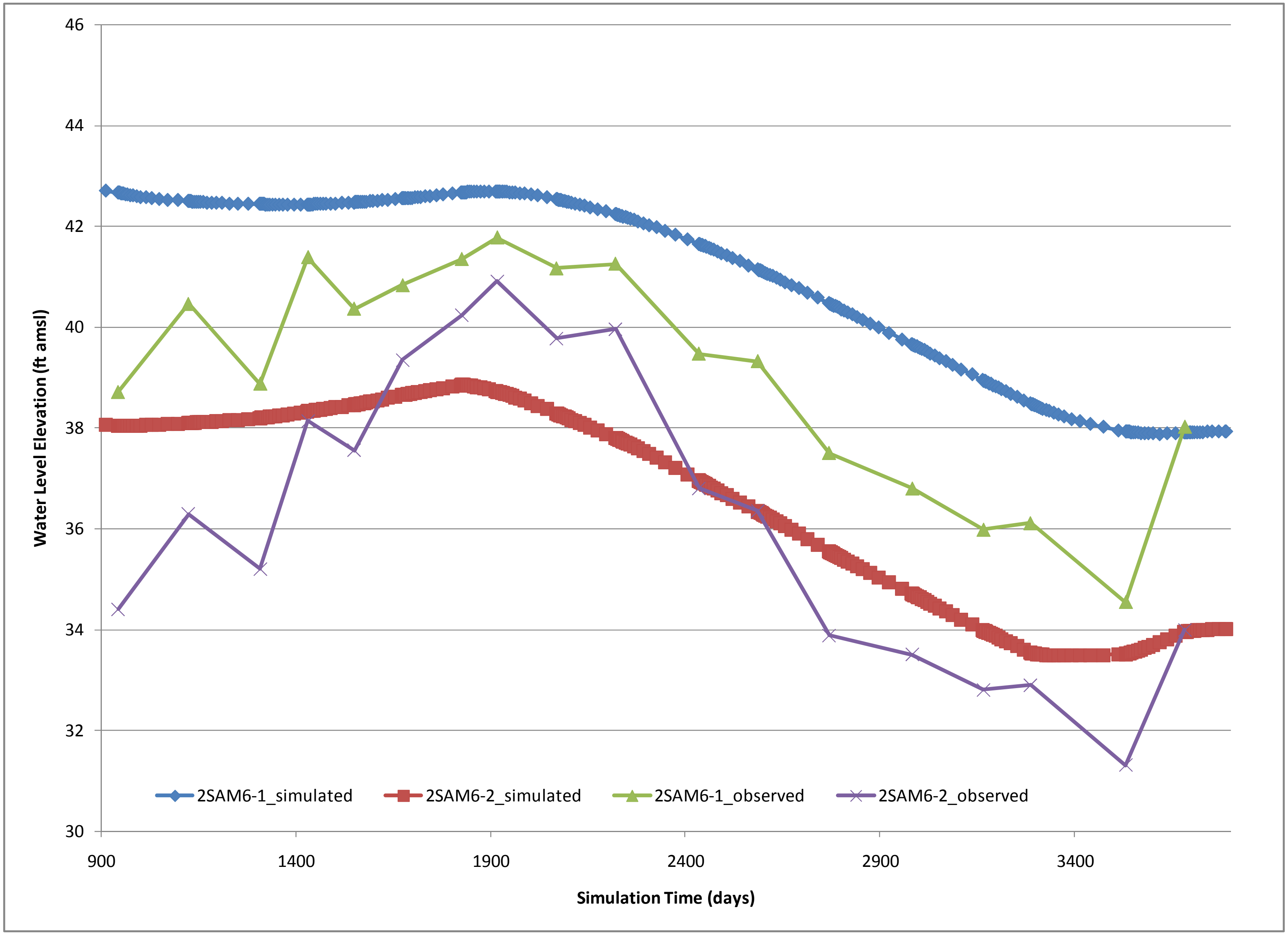
Engineering Analytics, Inc.

Well 2SAM2-1 is screened in Layer 2
Well 2SAM2-2 is screened in Layer 4

Figure 5.29. Hydrographs of Simulated and Observed Water Level Elevations, 2SAM2-1 and 2SAM2-2

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Plan

Project No. 151099



SBGPP_Hydrographs_6SAM.srf (04/12/21)

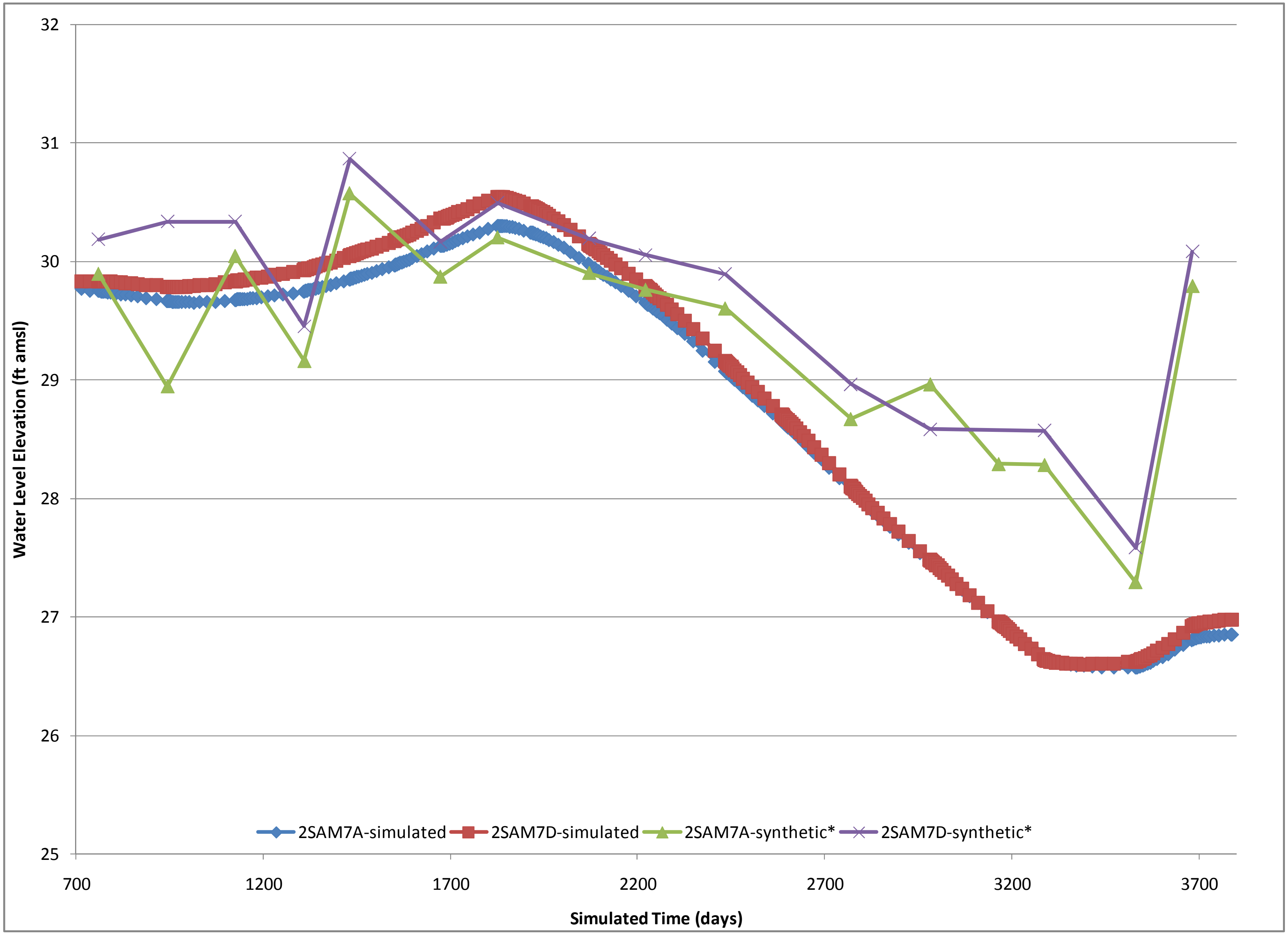
Engineering Analytics, Inc.

Well 6SAM2-1 is screened in Layer 2
Well 6SAM2-2 is screened in Layer 4

Figure 5.30. Hydrographs of Simulated and Observed Water Level Elevations, 2SAM6-1 and 2SAM6-2

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Plan

Project No. 151099



SBGPP_Hydrographs_7SAM.srf (04/12/21)

Engineering Analytics, Inc.

Well 2SAM7A is screened in Layer 2
Well 2SAM7D is screened in Layer 4
*Note that there are no observed data for the 2SAM7 series wells over the modeled time. Synthetic data developed from potentiometric surface maps are presented.

Figure 5.31. Hydrographs of Simulated and Synthetic Water Level Elevations, 2SAM7A and 2SAM7D

ORANGE COUNTY WATER DISTRICT
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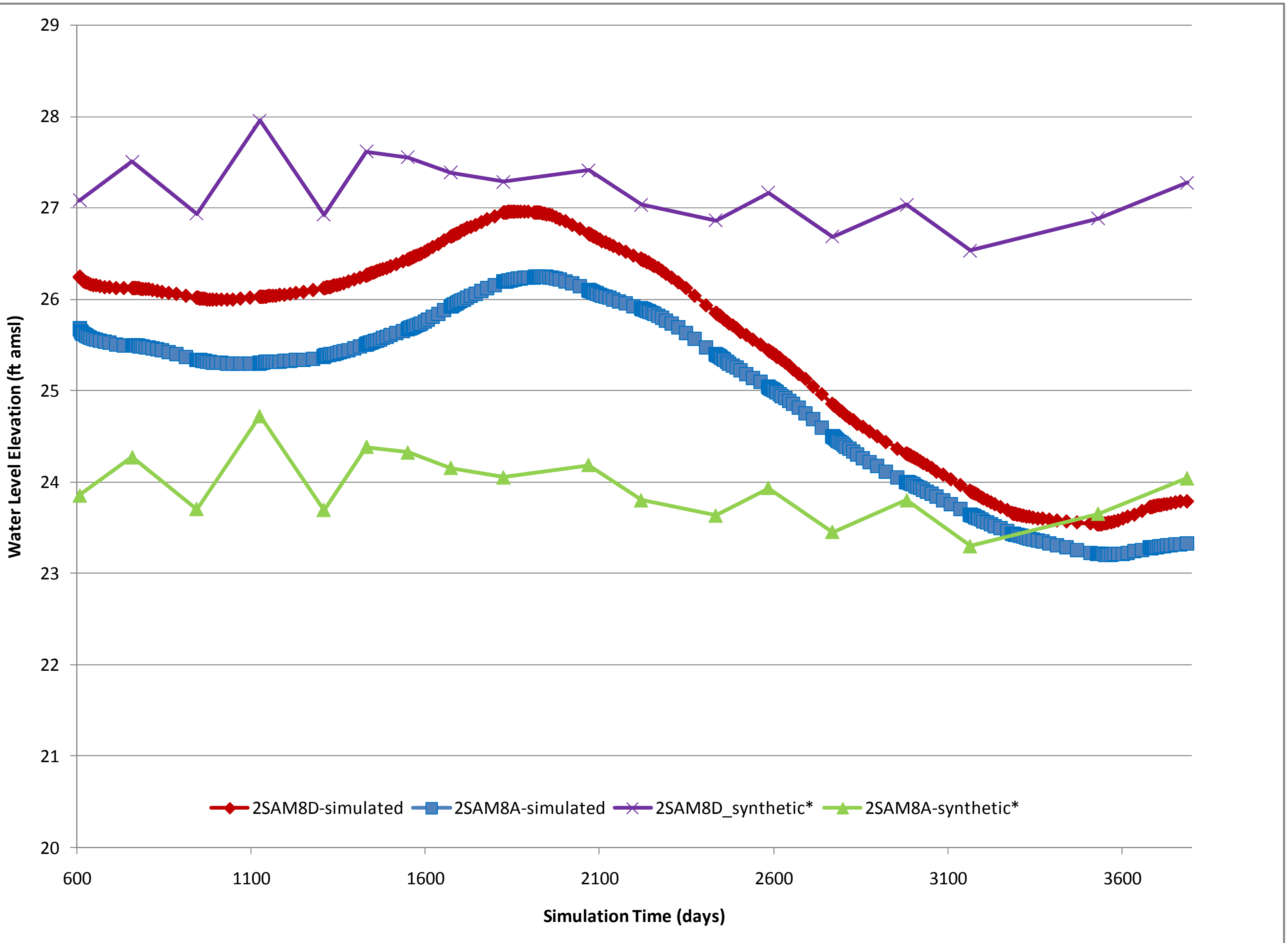

SBGPP_Hydrographs_8SAM.srf (04/12/21)

Engineering Analytics, Inc.

Well 2SAM8A is screened in Layer 2
Well 2SAM8D is screened in Layer 4
*Note that there are no observed data for the 2SAM8 series wells over the modeled time. Synthetic data developed from potentiometric surface maps are presented.

Figure 5.32. Hydrographs of Simulated and Synthetic Water Level Elevations, 2SAM8A and 2SAM8D

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Plan

APPENDIX A-1
SUMMARY OF REMEDIAL EXTRACTION SYSTEMS WITHIN THE SBGPP STUDY AREA

Appendix A-1. Summary of Remedial Extraction Systems, South Basin Groundwater Protection Project Study Area

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
Gallade Chemical	3	E-10	P&T, DPE	6073586.707	2208840.493	48.35	28.35	Full	1	2/16/2007	9/14/2007	0.05	1	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-10	P&T, DPE	6073586.707	2208840.493	48.35	28.35	Full	1	9/14/2007	4/18/2008	0.14	2	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-10	P&T, DPE	6073586.707	2208840.493	48.35	28.35	Full	1	4/18/2008	10/24/2008	0.17	3	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-10	P&T, DPE	6073586.707	2208840.493	48.35	28.35	Full	1	10/24/2008	3/20/2009	0.15	4	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-10	P&T, DPE	6073586.707	2208840.493	48.35	28.35	Full	1	3/20/2009	9/17/2009	0.09	5	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-10	P&T, DPE	6073586.707	2208840.493	48.35	28.35	Full	1	9/17/2009	3/19/2010	0.16	6	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-10	P&T, DPE	6073586.707	2208840.493	48.35	28.35	Full	1	3/19/2010	9/16/2010	0.20	7	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-10	P&T, DPE	6073586.707	2208840.493	48.35	28.35	Full	1	9/16/2010	1/20/2011	0.13	8	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-10	P&T, DPE	6073586.707	2208840.493	48.35	28.35	Full	1	1/20/2011	5/20/2011	0.17	9	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-10	P&T, DPE	6073586.707	2208840.493	48.35	28.35	Full	1	5/20/2011	9/15/2011	0.21	10	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-10	P&T, DPE	6073586.707	2208840.493	48.35	28.35	Full	1	9/15/2011	2/16/2012	0.20	11	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-10	P&T, DPE	6073586.707	2208840.493	48.35	28.35	Full	1	2/16/2012	5/10/2012	0.22	12	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-10	P&T, DPE	6073586.707	2208840.493	48.35	28.35	Full	1	5/10/2012	10/18/2012	0.25	13	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-10	P&T, DPE	6073586.707	2208840.493	48.35	28.35	Full	1	10/18/2012	3/14/2013	0.20	14	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-10	P&T, DPE	6073586.707	2208840.493	48.35	28.35	Full	1	3/14/2013	10/17/2013	0.25	15	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-10	P&T, DPE	6073586.707	2208840.493	48.35	28.35	Full	1	10/17/2013	3/17/2014	0.24	16	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-10	P&T, DPE	6073586.707	2208840.493	48.35	28.35	Full	1	3/17/2014	9/18/2014	0.27	17	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-10	P&T, DPE	6073586.707	2208840.493	48.35	28.35	Full	1	9/18/2014	4/16/2015	0.18	18	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-10	P&T, DPE	6073586.707	2208840.493	48.35	28.35	Full	1	4/16/2015	10/15/2015	0.09	19	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-10	P&T, DPE	6073586.707	2208840.493	48.35	28.35	Full	1	10/15/2015	2/18/2016	0.11	20	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-10	P&T, DPE	6073586.707	2208840.493	48.35	28.35	Full	1	2/18/2016	6/30/2016	0.11	21	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-11	P&T, DPE	6073651.879	2208994.527	49.35	29.35	Full	1	2/16/2007	9/14/2007	0.05	1	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-11	P&T, DPE	6073651.879	2208994.527	49.35	29.35	Full	1	9/14/2007	4/18/2008	0.14	2	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-11	P&T, DPE	6073651.879	2208994.527	49.35	29.35	Full	1	4/18/2008	10/24/2008	0.17	3	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-11	P&T, DPE	6073651.879	2208994.527	49.35	29.35	Full	1	10/24/2008	3/20/2009	0.15	4	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-11	P&T, DPE	6073651.879	2208994.527	49.35	29.35	Full	1	3/20/2009	9/17/2009	0.09	5	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-11	P&T, DPE	6073651.879	2208994.527	49.35	29.35	Full	1	9/17/2009	3/19/2010	0.16	6	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-11	P&T, DPE	6073651.879	2208994.527	49.35	29.35	Full	1	3/19/2010	9/16/2010	0.20	7	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-11	P&T, DPE	6073651.879	2208994.527	49.35	29.35	Full	1	9/16/2010	1/20/2011	0.13	8	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-11	P&T, DPE	6073651.879	2208994.527	49.35	29.35	Full	1	1/20/2011	5/20/2011	0.17	9	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-11	P&T, DPE	6073651.879	2208994.527	49.35	29.35	Full	1	5/20/2011	9/15/2011	0.21	10	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-11	P&T, DPE	6073651.879	2208994.527	49.35	29.35	Full	1	9/15/2011	2/16/2012	0.20	11	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-11	P&T, DPE	6073651.879	2208994.527	49.35	29.35	Full	1	2/16/2012	5/10/2012	0.22	12	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-11	P&T, DPE	6073651.879	2208994.527	49.35	29.35	Full	1	5/10/2012	10/18/2012	0.25	13	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-11	P&T, DPE	6073651.879	2208994.527	49.35	29.35	Full	1	10/18/2012	3/14/2013	0.20	14	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-11	P&T, DPE	6073651.879	2208994.527	49.35	29.35	Full	1	3/14/2013	10/17/2013	0.25	15	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	

Appendix A-1. Summary of Remedial Extraction Systems, South Basin Groundwater Protection Project Study Area

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
Gallade Chemical	3	E-11	P&T, DPE	6073651.879	2208994.527	49.35	29.35	Full	1	10/17/2013	3/17/2014	0.24	16	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-11	P&T, DPE	6073651.879	2208994.527	49.35	29.35	Full	1	3/17/2014	9/18/2014	0.27	17	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-11	P&T, DPE	6073651.879	2208994.527	49.35	29.35	Full	1	9/18/2014	4/16/2015	0.18	18	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-11	P&T, DPE	6073651.879	2208994.527	49.35	29.35	Full	1	4/16/2015	10/15/2015	0.09	19	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-11	P&T, DPE	6073651.879	2208994.527	49.35	29.35	Full	1	10/15/2015	2/18/2016	0.11	20	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-11	P&T, DPE	6073651.879	2208994.527	49.35	29.35	Full	1	2/18/2016	6/30/2016	0.11	21	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-12	P&T, DPE	6073664.134	2208931.231	48.19	28.19	Full	1	2/16/2007	9/14/2007	0.05	1	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-12	P&T, DPE	6073664.134	2208931.231	48.19	28.19	Full	1	9/14/2007	4/18/2008	0.14	2	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-12	P&T, DPE	6073664.134	2208931.231	48.19	28.19	Full	1	4/18/2008	10/24/2008	0.17	3	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-12	P&T, DPE	6073664.134	2208931.231	48.19	28.19	Full	1	10/24/2008	3/20/2009	0.15	4	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-12	P&T, DPE	6073664.134	2208931.231	48.19	28.19	Full	1	3/20/2009	9/17/2009	0.09	5	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-12	P&T, DPE	6073664.134	2208931.231	48.19	28.19	Full	1	9/17/2009	3/19/2010	0.16	6	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-12	P&T, DPE	6073664.134	2208931.231	48.19	28.19	Full	1	3/19/2010	9/16/2010	0.20	7	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-12	P&T, DPE	6073664.134	2208931.231	48.19	28.19	Full	1	9/16/2010	1/20/2011	0.13	8	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-12	P&T, DPE	6073664.134	2208931.231	48.19	28.19	Full	1	1/20/2011	5/20/2011	0.17	9	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-12	P&T, DPE	6073664.134	2208931.231	48.19	28.19	Full	1	5/20/2011	9/15/2011	0.21	10	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-12	P&T, DPE	6073664.134	2208931.231	48.19	28.19	Full	1	9/15/2011	2/16/2012	0.20	11	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-12	P&T, DPE	6073664.134	2208931.231	48.19	28.19	Full	1	2/16/2012	5/10/2012	0.22	12	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-12	P&T, DPE	6073664.134	2208931.231	48.19	28.19	Full	1	5/10/2012	10/18/2012	0.25	13	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-12	P&T, DPE	6073664.134	2208931.231	48.19	28.19	Full	1	10/18/2012	3/14/2013	0.20	14	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-12	P&T, DPE	6073664.134	2208931.231	48.19	28.19	Full	1	3/14/2013	10/17/2013	0.25	15	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-12	P&T, DPE	6073664.134	2208931.231	48.19	28.19	Full	1	10/17/2013	3/17/2014	0.24	16	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-12	P&T, DPE	6073664.134	2208931.231	48.19	28.19	Full	1	3/17/2014	9/18/2014	0.27	17	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-12	P&T, DPE	6073664.134	2208931.231	48.19	28.19	Full	1	9/18/2014	4/16/2015	0.18	18	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-12	P&T, DPE	6073664.134	2208931.231	48.19	28.19	Full	1	4/16/2015	10/15/2015	0.09	19	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-12	P&T, DPE	6073664.134	2208931.231	48.19	28.19	Full	1	10/15/2015	2/18/2016	0.11	20	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-12	P&T, DPE	6073664.134	2208931.231	48.19	28.19	Full	1	2/18/2016	6/30/2016	0.11	21	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-13	P&T, DPE	6073607.543	2208917.8	49.08	29.08	Full	1	2/16/2007	9/14/2007	0.05	1	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-13	P&T, DPE	6073607.543	2208917.8	49.08	29.08	Full	1	9/14/2007	4/18/2008	0.14	2	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-13	P&T, DPE	6073607.543	2208917.8	49.08	29.08	Full	1	4/18/2008	10/24/2008	0.17	3	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-13	P&T, DPE	6073607.543	2208917.8	49.08	29.08	Full	1	10/24/2008	3/20/2009	0.15	4	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-13	P&T, DPE	6073607.543	2208917.8	49.08	29.08	Full	1	3/20/2009	9/17/2009	0.09	5	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-13	P&T, DPE	6073607.543	2208917.8	49.08	29.08	Full	1	9/17/2009	3/19/2010	0.16	6	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-13	P&T, DPE	6073607.543	2208917.8	49.08	29.08	Full	1	3/19/2010	9/16/2010	0.20	7	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-13	P&T, DPE	6073607.543	2208917.8	49.08	29.08	Full	1	9/16/2010	1/20/2011	0.13	8	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-13	P&T, DPE	6073607.543	2208917.8	49.08	29.08	Full	1	1/20/2011	5/20/2011	0.17	9	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	

Appendix A-1. Summary of Remedial Extraction Systems, South Basin Groundwater Protection Project Study Area

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
Gallade Chemical	3	E-13	P&T, DPE	6073607.543	2208917.8	49.08	29.08	Full	1	5/20/2011	9/15/2011	0.21	10	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-13	P&T, DPE	6073607.543	2208917.8	49.08	29.08	Full	1	9/15/2011	2/16/2012	0.20	11	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-13	P&T, DPE	6073607.543	2208917.8	49.08	29.08	Full	1	2/16/2012	5/10/2012	0.22	12	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-13	P&T, DPE	6073607.543	2208917.8	49.08	29.08	Full	1	5/10/2012	10/18/2012	0.25	13	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-13	P&T, DPE	6073607.543	2208917.8	49.08	29.08	Full	1	10/18/2012	3/14/2013	0.20	14	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-13	P&T, DPE	6073607.543	2208917.8	49.08	29.08	Full	1	3/14/2013	10/17/2013	0.25	15	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-13	P&T, DPE	6073607.543	2208917.8	49.08	29.08	Full	1	10/17/2013	3/17/2014	0.24	16	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-13	P&T, DPE	6073607.543	2208917.8	49.08	29.08	Full	1	3/17/2014	9/18/2014	0.27	17	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-13	P&T, DPE	6073607.543	2208917.8	49.08	29.08	Full	1	9/18/2014	4/16/2015	0.18	18	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-13	P&T, DPE	6073607.543	2208917.8	49.08	29.08	Full	1	4/16/2015	10/15/2015	0.09	19	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-13	P&T, DPE	6073607.543	2208917.8	49.08	29.08	Full	1	10/15/2015	2/18/2016	0.11	20	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-13	P&T, DPE	6073607.543	2208917.8	49.08	29.08	Full	1	2/18/2016	6/30/2016	0.11	21	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-14	P&T, DPE	6073535.067	2208959.022	49.89	29.89	Full	1	2/16/2007	9/14/2007	0.05	1	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-14	P&T, DPE	6073535.067	2208959.022	49.89	29.89	Full	1	9/14/2007	4/18/2008	0.14	2	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-14	P&T, DPE	6073535.067	2208959.022	49.89	29.89	Full	1	4/18/2008	10/24/2008	0.17	3	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-14	P&T, DPE	6073535.067	2208959.022	49.89	29.89	Full	1	10/24/2008	3/20/2009	0.15	4	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-14	P&T, DPE	6073535.067	2208959.022	49.89	29.89	Full	1	3/20/2009	9/17/2009	0.09	5	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-14	P&T, DPE	6073535.067	2208959.022	49.89	29.89	Full	1	9/17/2009	3/19/2010	0.16	6	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-14	P&T, DPE	6073535.067	2208959.022	49.89	29.89	Full	1	3/19/2010	9/16/2010	0.20	7	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-14	P&T, DPE	6073535.067	2208959.022	49.89	29.89	Full	1	9/16/2010	1/20/2011	0.13	8	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-14	P&T, DPE	6073535.067	2208959.022	49.89	29.89	Full	1	1/20/2011	5/20/2011	0.17	9	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-14	P&T, DPE	6073535.067	2208959.022	49.89	29.89	Full	1	5/20/2011	9/15/2011	0.21	10	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-14	P&T, DPE	6073535.067	2208959.022	49.89	29.89	Full	1	9/15/2011	2/16/2012	0.20	11	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-14	P&T, DPE	6073535.067	2208959.022	49.89	29.89	Full	1	2/16/2012	5/10/2012	0.22	12	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-14	P&T, DPE	6073535.067	2208959.022	49.89	29.89	Full	1	5/10/2012	10/18/2012	0.25	13	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-14	P&T, DPE	6073535.067	2208959.022	49.89	29.89	Full	1	10/18/2012	3/14/2013	0.20	14	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-14	P&T, DPE	6073535.067	2208959.022	49.89	29.89	Full	1	3/14/2013	10/17/2013	0.25	15	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-14	P&T, DPE	6073535.067	2208959.022	49.89	29.89	Full	1	10/17/2013	3/17/2014	0.24	16	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-14	P&T, DPE	6073535.067	2208959.022	49.89	29.89	Full	1	3/17/2014	9/18/2014	0.27	17	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-14	P&T, DPE	6073535.067	2208959.022	49.89	29.89	Full	1	9/18/2014	4/16/2015	0.18	18	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-14	P&T, DPE	6073535.067	2208959.022	49.89	29.89	Full	1	4/16/2015	10/15/2015	0.09	19	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-14	P&T, DPE	6073535.067	2208959.022	49.89	29.89	Full	1	10/15/2015	2/18/2016	0.11	20	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-14	P&T, DPE	6073535.067	2208959.022	49.89	29.89	Full	1	2/18/2016	6/30/2016	0.11	21	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-15	P&T, DPE	6073611.912	2208994.159	49.81	29.81	Full	1	2/16/2007	9/14/2007	0.05	1	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-15	P&T, DPE	6073611.912	2208994.159	49.81	29.81	Full	1	9/14/2007	4/18/2008	0.14	2	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-15	P&T, DPE	6073611.912	2208994.159	49.81	29.81	Full	1	4/18/2008	10/24/2008	0.17	3	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	

Appendix A-1. Summary of Remedial Extraction Systems, South Basin Groundwater Protection Project Study Area

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
Gallade Chemical	3	E-15	P&T, DPE	6073611.912	2208994.159	49.81	29.81	Full	1	10/24/2008	3/20/2009	0.15	4	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-15	P&T, DPE	6073611.912	2208994.159	49.81	29.81	Full	1	3/20/2009	9/17/2009	0.09	5	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-15	P&T, DPE	6073611.912	2208994.159	49.81	29.81	Full	1	9/17/2009	3/19/2010	0.16	6	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-15	P&T, DPE	6073611.912	2208994.159	49.81	29.81	Full	1	3/19/2010	9/16/2010	0.20	7	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-15	P&T, DPE	6073611.912	2208994.159	49.81	29.81	Full	1	9/16/2010	1/20/2011	0.13	8	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-15	P&T, DPE	6073611.912	2208994.159	49.81	29.81	Full	1	1/20/2011	5/20/2011	0.17	9	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-15	P&T, DPE	6073611.912	2208994.159	49.81	29.81	Full	1	5/20/2011	9/15/2011	0.21	10	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-15	P&T, DPE	6073611.912	2208994.159	49.81	29.81	Full	1	9/15/2011	2/16/2012	0.20	11	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-15	P&T, DPE	6073611.912	2208994.159	49.81	29.81	Full	1	2/16/2012	5/10/2012	0.22	12	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-15	P&T, DPE	6073611.912	2208994.159	49.81	29.81	Full	1	5/10/2012	10/18/2012	0.25	13	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-15	P&T, DPE	6073611.912	2208994.159	49.81	29.81	Full	1	10/18/2012	3/14/2013	0.20	14	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-15	P&T, DPE	6073611.912	2208994.159	49.81	29.81	Full	1	3/14/2013	10/17/2013	0.25	15	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-15	P&T, DPE	6073611.912	2208994.159	49.81	29.81	Full	1	10/17/2013	3/17/2014	0.24	16	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-15	P&T, DPE	6073611.912	2208994.159	49.81	29.81	Full	1	3/17/2014	9/18/2014	0.27	17	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-15	P&T, DPE	6073611.912	2208994.159	49.81	29.81	Full	1	9/18/2014	4/16/2015	0.18	18	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-15	P&T, DPE	6073611.912	2208994.159	49.81	29.81	Full	1	4/16/2015	10/15/2015	0.09	19	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-15	P&T, DPE	6073611.912	2208994.159	49.81	29.81	Full	1	10/15/2015	2/18/2016	0.11	20	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-15	P&T, DPE	6073611.912	2208994.159	49.81	29.81	Full	1	2/18/2016	6/30/2016	0.11	21	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-16	P&T, DPE	6073509.633	2208841.935	48.09	28.09	Full	1	2/16/2007	9/14/2007	0.05	1	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-16	P&T, DPE	6073509.633	2208841.935	48.09	28.09	Full	1	9/14/2007	4/18/2008	0.14	2	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-16	P&T, DPE	6073509.633	2208841.935	48.09	28.09	Full	1	4/18/2008	10/24/2008	0.17	3	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-16	P&T, DPE	6073509.633	2208841.935	48.09	28.09	Full	1	10/24/2008	3/20/2009	0.15	4	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-16	P&T, DPE	6073509.633	2208841.935	48.09	28.09	Full	1	3/20/2009	9/17/2009	0.09	5	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-16	P&T, DPE	6073509.633	2208841.935	48.09	28.09	Full	1	9/17/2009	3/19/2010	0.16	6	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-16	P&T, DPE	6073509.633	2208841.935	48.09	28.09	Full	1	3/19/2010	9/16/2010	0.20	7	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-16	P&T, DPE	6073509.633	2208841.935	48.09	28.09	Full	1	9/16/2010	1/20/2011	0.13	8	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-16	P&T, DPE	6073509.633	2208841.935	48.09	28.09	Full	1	1/20/2011	5/20/2011	0.17	9	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-16	P&T, DPE	6073509.633	2208841.935	48.09	28.09	Full	1	5/20/2011	9/15/2011	0.21	10	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-16	P&T, DPE	6073509.633	2208841.935	48.09	28.09	Full	1	9/15/2011	2/16/2012	0.20	11	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-16	P&T, DPE	6073509.633	2208841.935	48.09	28.09	Full	1	2/16/2012	5/10/2012	0.22	12	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-16	P&T, DPE	6073509.633	2208841.935	48.09	28.09	Full	1	5/10/2012	10/18/2012	0.25	13	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-16	P&T, DPE	6073509.633	2208841.935	48.09	28.09	Full	1	10/18/2012	3/14/2013	0.20	14	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-16	P&T, DPE	6073509.633	2208841.935	48.09	28.09	Full	1	3/14/2013	10/17/2013	0.25	15	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-16	P&T, DPE	6073509.633	2208841.935	48.09	28.09	Full	1	10/17/2013	3/17/2014	0.24	16	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-16	P&T, DPE	6073509.633	2208841.935	48.09	28.09	Full	1	3/17/2014	9/18/2014	0.27	17	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-16	P&T, DPE	6073509.633	2208841.935	48.09	28.09	Full	1	9/18/2014	4/16/2015	0.18	18	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	

Appendix A-1. Summary of Remedial Extraction Systems, South Basin Groundwater Protection Project Study Area

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
Gallade Chemical	3	E-16	P&T, DPE	6073509.633	2208841.935	48.09	28.09	Full	1	4/16/2015	10/15/2015	0.09	19	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-16	P&T, DPE	6073509.633	2208841.935	48.09	28.09	Full	1	10/15/2015	2/18/2016	0.11	20	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-16	P&T, DPE	6073509.633	2208841.935	48.09	28.09	Full	1	2/18/2016	6/30/2016	0.11	21	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-2A	P&T, DPE	6073764.551	2208960.548	49.11	29.11	Full	1	2/16/2007	9/14/2007	0.05	1	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-2A	P&T, DPE	6073764.551	2208960.548	49.11	29.11	Full	1	9/14/2007	4/18/2008	0.14	2	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-2A	P&T, DPE	6073764.551	2208960.548	49.11	29.11	Full	1	4/18/2008	10/24/2008	0.17	3	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-2A	P&T, DPE	6073764.551	2208960.548	49.11	29.11	Full	1	10/24/2008	3/20/2009	0.15	4	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-2A	P&T, DPE	6073764.551	2208960.548	49.11	29.11	Full	1	3/20/2009	9/17/2009	0.09	5	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-2A	P&T, DPE	6073764.551	2208960.548	49.11	29.11	Full	1	9/17/2009	3/19/2010	0.16	6	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-2A	P&T, DPE	6073764.551	2208960.548	49.11	29.11	Full	1	3/19/2010	9/16/2010	0.20	7	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-2A	P&T, DPE	6073764.551	2208960.548	49.11	29.11	Full	1	9/16/2010	1/20/2011	0.13	8	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-2A	P&T, DPE	6073764.551	2208960.548	49.11	29.11	Full	1	1/20/2011	5/20/2011	0.17	9	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-2A	P&T, DPE	6073764.551	2208960.548	49.11	29.11	Full	1	5/20/2011	9/15/2011	0.21	10	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-2A	P&T, DPE	6073764.551	2208960.548	49.11	29.11	Full	1	9/15/2011	2/16/2012	0.20	11	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-2A	P&T, DPE	6073764.551	2208960.548	49.11	29.11	Full	1	2/16/2012	5/10/2012	0.22	12	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-2A	P&T, DPE	6073764.551	2208960.548	49.11	29.11	Full	1	5/10/2012	10/18/2012	0.25	13	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-2A	P&T, DPE	6073764.551	2208960.548	49.11	29.11	Full	1	10/18/2012	3/14/2013	0.20	14	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-2A	P&T, DPE	6073764.551	2208960.548	49.11	29.11	Full	1	3/14/2013	10/17/2013	0.25	15	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-2A	P&T, DPE	6073764.551	2208960.548	49.11	29.11	Full	1	10/17/2013	3/17/2014	0.24	16	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-2A	P&T, DPE	6073764.551	2208960.548	49.11	29.11	Full	1	3/17/2014	9/18/2014	0.27	17	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-2A	P&T, DPE	6073764.551	2208960.548	49.11	29.11	Full	1	9/18/2014	4/16/2015	0.18	18	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-2A	P&T, DPE	6073764.551	2208960.548	49.11	29.11	Full	1	4/16/2015	10/15/2015	0.09	19	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-2A	P&T, DPE	6073764.551	2208960.548	49.11	29.11	Full	1	10/15/2015	2/18/2016	0.11	20	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-2A	P&T, DPE	6073764.551	2208960.548	49.11	29.11	Full	1	2/18/2016	6/30/2016	0.11	21	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-3	P&T	6073510.721	2208963.909	49.90	29.90	Full	1	2/16/2007	9/14/2007	0.05	1	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-3	P&T	6073510.721	2208963.909	49.90	29.90	Full	1	9/14/2007	4/18/2008	0.14	2	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-3	P&T	6073510.721	2208963.909	49.90	29.90	Full	1	4/18/2008	10/24/2008	0.17	3	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-3	P&T	6073510.721	2208963.909	49.90	29.90	Full	1	10/24/2008	3/20/2009	0.15	4	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-3	P&T	6073510.721	2208963.909	49.90	29.90	Full	1	3/20/2009	9/17/2009	0.09	5	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-3	P&T	6073510.721	2208963.909	49.90	29.90	Full	1	9/17/2009	3/19/2010	0.16	6	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-3	P&T	6073510.721	2208963.909	49.90	29.90	Full	1	3/19/2010	9/16/2010	0.20	7	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-3	P&T	6073510.721	2208963.909	49.90	29.90	Full	1	9/16/2010	1/20/2011	0.13	8	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-3	P&T	6073510.721	2208963.909	49.90	29.90	Full	1	1/20/2011	5/20/2011	0.17	9	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-3	P&T	6073510.721	2208963.909	49.90	29.90	Full	1	5/20/2011	9/15/2011	0.21	10	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-3	P&T	6073510.721	2208963.909	49.90	29.90	Full	1	9/15/2011	2/16/2012	0.20	11	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-3	P&T	6073510.721	2208963.909	49.90	29.90	Full	1	2/16/2012	5/10/2012	0.22	12	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
Gallade Chemical	3	E-3	P&T	6073510.721	2208963.909	49.90	29.90	Full	1	5/10/2012	10/18/2012	0.25	13	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-3	P&T	6073510.721	2208963.909	49.90	29.90	Full	1	10/18/2012	3/14/2013	0.20	14	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-3	P&T	6073510.721	2208963.909	49.90	29.90	Full	1	3/14/2013	10/17/2013	0.25	15	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-3	P&T	6073510.721	2208963.909	49.90	29.90	Full	1	10/17/2013	3/17/2014	0.24	16	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-3	P&T	6073510.721	2208963.909	49.90	29.90	Full	1	3/17/2014	9/18/2014	0.27	17	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-3	P&T	6073510.721	2208963.909	49.90	29.90	Full	1	9/18/2014	4/16/2015	0.18	18	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-3	P&T	6073510.721	2208963.909	49.90	29.90	Full	1	4/16/2015	10/15/2015	0.09	19	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-3	P&T	6073510.721	2208963.909	49.90	29.90	Full	1	10/15/2015	2/18/2016	0.11	20	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-3	P&T	6073510.721	2208963.909	49.90	29.90	Full	1	2/18/2016	6/30/2016	0.11	21	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-6R	P&T	6073582.352	2208678.172	47.98	27.98	Full	1	2/16/2007	9/14/2007	0.05	1	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-6R	P&T	6073582.352	2208678.172	47.98	27.98	Full	1	9/14/2007	4/18/2008	0.14	2	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-6R	P&T	6073582.352	2208678.172	47.98	27.98	Full	1	4/18/2008	10/24/2008	0.17	3	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-6R	P&T	6073582.352	2208678.172	47.98	27.98	Full	1	10/24/2008	3/20/2009	0.15	4	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-6R	P&T	6073582.352	2208678.172	47.98	27.98	Full	1	3/20/2009	9/17/2009	0.09	5	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-6R	P&T	6073582.352	2208678.172	47.98	27.98	Full	1	9/17/2009	3/19/2010	0.16	6	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-6R	P&T	6073582.352	2208678.172	47.98	27.98	Full	1	3/19/2010	9/16/2010	0.20	7	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-6R	P&T	6073582.352	2208678.172	47.98	27.98	Full	1	9/16/2010	1/20/2011	0.13	8	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-6R	P&T	6073582.352	2208678.172	47.98	27.98	Full	1	1/20/2011	5/20/2011	0.17	9	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-6R	P&T	6073582.352	2208678.172	47.98	27.98	Full	1	5/20/2011	9/15/2011	0.21	10	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-6R	P&T	6073582.352	2208678.172	47.98	27.98	Full	1	9/15/2011	2/16/2012	0.20	11	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-6R	P&T	6073582.352	2208678.172	47.98	27.98	Full	1	2/16/2012	5/10/2012	0.22	12	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-6R	P&T	6073582.352	2208678.172	47.98	27.98	Full	1	5/10/2012	10/18/2012	0.25	13	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-6R	P&T	6073582.352	2208678.172	47.98	27.98	Full	1	10/18/2012	3/14/2013	0.20	14	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-6R	P&T	6073582.352	2208678.172	47.98	27.98	Full	1	3/14/2013	10/17/2013	0.25	15	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-6R	P&T	6073582.352	2208678.172	47.98	27.98	Full	1	10/17/2013	3/17/2014	0.24	16	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-6R	P&T	6073582.352	2208678.172	47.98	27.98	Full	1	3/17/2014	9/18/2014	0.27	17	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-6R	P&T	6073582.352	2208678.172	47.98	27.98	Full	1	9/18/2014	4/16/2015	0.18	18	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-6R	P&T	6073582.352	2208678.172	47.98	27.98	Full	1	4/16/2015	10/15/2015	0.09	19	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-6R	P&T	6073582.352	2208678.172	47.98	27.98	Full	1	10/15/2015	2/18/2016	0.11	20	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	E-6R	P&T	6073582.352	2208678.172	47.98	27.98	Full	1	2/18/2016	6/30/2016	0.11	21	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-18	P&T, DPE	6073703.498	2208981.285	44.33	24.33	Partial	1	2/16/2007	9/14/2007	0.05	1	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-18	P&T, DPE	6073703.498	2208981.285	44.33	24.33	Partial	1	9/14/2007	4/18/2008	0.14	2	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-18	P&T, DPE	6073703.498	2208981.285	44.33	24.33	Partial	1	4/18/2008	10/24/2008	0.17	3	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-18	P&T, DPE	6073703.498	2208981.285	44.33	24.33	Partial	1	10/24/2008	3/20/2009	0.15	4	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-18	P&T, DPE	6073703.498	2208981.285	44.33	24.33	Partial	1	3/20/2009	9/17/2009	0.09	5	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-18	P&T, DPE	6073703.498	2208981.285	44.33	24.33	Partial	1	9/17/2009	3/19/2010	0.16	6	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	

Appendix A-1. Summary of Remedial Extraction Systems, South Basin Groundwater Protection Project Study Area

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
Gallade Chemical	3	MW-18	P&T, DPE	6073703.498	2208981.285	44.33	24.33	Partial	1	3/19/2010	9/16/2010	0.20	7	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-18	P&T, DPE	6073703.498	2208981.285	44.33	24.33	Partial	1	9/16/2010	1/20/2011	0.13	8	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-18	P&T, DPE	6073703.498	2208981.285	44.33	24.33	Partial	1	1/20/2011	5/20/2011	0.17	9	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-18	P&T, DPE	6073703.498	2208981.285	44.33	24.33	Partial	1	5/20/2011	9/15/2011	0.21	10	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-18	P&T, DPE	6073703.498	2208981.285	44.33	24.33	Partial	1	9/15/2011	2/16/2012	0.20	11	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-18	P&T, DPE	6073703.498	2208981.285	44.33	24.33	Partial	1	2/16/2012	5/10/2012	0.22	12	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-18	P&T, DPE	6073703.498	2208981.285	44.33	24.33	Partial	1	5/10/2012	10/18/2012	0.25	13	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-18	P&T, DPE	6073703.498	2208981.285	44.33	24.33	Partial	1	10/18/2012	3/14/2013	0.20	14	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-18	P&T, DPE	6073703.498	2208981.285	44.33	24.33	Partial	1	3/14/2013	10/17/2013	0.25	15	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-18	P&T, DPE	6073703.498	2208981.285	44.33	24.33	Partial	1	10/17/2013	3/17/2014	0.24	16	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-18	P&T, DPE	6073703.498	2208981.285	44.33	24.33	Partial	1	3/17/2014	9/18/2014	0.27	17	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-18	P&T, DPE	6073703.498	2208981.285	44.33	24.33	Partial	1	9/18/2014	4/16/2015	0.18	18	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-18	P&T, DPE	6073703.498	2208981.285	44.33	24.33	Partial	1	4/16/2015	10/15/2015	0.09	19	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-18	P&T, DPE	6073703.498	2208981.285	44.33	24.33	Partial	1	10/15/2015	2/18/2016	0.11	20	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-18	P&T, DPE	6073703.498	2208981.285	44.33	24.33	Partial	1	2/18/2016	6/30/2016	0.11	21	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-19	P&T, DPE	6073755.263	2209028.928	44.66	24.66	Partial	1	2/16/2007	9/14/2007	0.05	1	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-19	P&T, DPE	6073755.263	2209028.928	44.66	24.66	Partial	1	9/14/2007	4/18/2008	0.14	2	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-19	P&T, DPE	6073755.263	2209028.928	44.66	24.66	Partial	1	4/18/2008	10/24/2008	0.17	3	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-19	P&T, DPE	6073755.263	2209028.928	44.66	24.66	Partial	1	10/24/2008	3/20/2009	0.15	4	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-19	P&T, DPE	6073755.263	2209028.928	44.66	24.66	Partial	1	3/20/2009	9/17/2009	0.09	5	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-19	P&T, DPE	6073755.263	2209028.928	44.66	24.66	Partial	1	9/17/2009	3/19/2010	0.16	6	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-19	P&T, DPE	6073755.263	2209028.928	44.66	24.66	Partial	1	3/19/2010	9/16/2010	0.20	7	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-19	P&T, DPE	6073755.263	2209028.928	44.66	24.66	Partial	1	9/16/2010	1/20/2011	0.13	8	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-19	P&T, DPE	6073755.263	2209028.928	44.66	24.66	Partial	1	1/20/2011	5/20/2011	0.17	9	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-19	P&T, DPE	6073755.263	2209028.928	44.66	24.66	Partial	1	5/20/2011	9/15/2011	0.21	10	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-19	P&T, DPE	6073755.263	2209028.928	44.66	24.66	Partial	1	9/15/2011	2/16/2012	0.20	11	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-19	P&T, DPE	6073755.263	2209028.928	44.66	24.66	Partial	1	2/16/2012	5/10/2012	0.22	12	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-19	P&T, DPE	6073755.263	2209028.928	44.66	24.66	Partial	1	5/10/2012	10/18/2012	0.25	13	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-19	P&T, DPE	6073755.263	2209028.928	44.66	24.66	Partial	1	10/18/2012	3/14/2013	0.20	14	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-19	P&T, DPE	6073755.263	2209028.928	44.66	24.66	Partial	1	3/14/2013	10/17/2013	0.25	15	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-19	P&T, DPE	6073755.263	2209028.928	44.66	24.66	Partial	1	10/17/2013	3/17/2014	0.24	16	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-19	P&T, DPE	6073755.263	2209028.928	44.66	24.66	Partial	1	3/17/2014	9/18/2014	0.27	17	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-19	P&T, DPE	6073755.263	2209028.928	44.66	24.66	Partial	1	9/18/2014	4/16/2015	0.18	18	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-19	P&T, DPE	6073755.263	2209028.928	44.66	24.66	Partial	1	4/16/2015	10/15/2015	0.09	19	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-19	P&T, DPE	6073755.263	2209028.928	44.66	24.66	Partial	1	10/15/2015	2/18/2016	0.11	20	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-19	P&T, DPE	6073755.263	2209028.928	44.66	24.66	Partial	1	2/18/2016	6/30/2016	0.11	21	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	

Appendix A-1. Summary of Remedial Extraction Systems, South Basin Groundwater Protection Project Study Area

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
Gallade Chemical	3	MW-2	P&T, DPE	6073643.777	2208877.136	48.72	24.72	Partial	1	2/16/2007	9/14/2007	0.05	1	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-2	P&T, DPE	6073643.777	2208877.136	48.72	24.72	Partial	1	9/14/2007	4/18/2008	0.14	2	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-2	P&T, DPE	6073643.777	2208877.136	48.72	24.72	Partial	1	4/18/2008	10/24/2008	0.17	3	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-2	P&T, DPE	6073643.777	2208877.136	48.72	24.72	Partial	1	10/24/2008	3/20/2009	0.15	4	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-2	P&T, DPE	6073643.777	2208877.136	48.72	24.72	Partial	1	3/20/2009	9/17/2009	0.09	5	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-2	P&T, DPE	6073643.777	2208877.136	48.72	24.72	Partial	1	9/17/2009	3/19/2010	0.16	6	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-2	P&T, DPE	6073643.777	2208877.136	48.72	24.72	Partial	1	3/19/2010	9/16/2010	0.20	7	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-2	P&T, DPE	6073643.777	2208877.136	48.72	24.72	Partial	1	9/16/2010	1/20/2011	0.13	8	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-2	P&T, DPE	6073643.777	2208877.136	48.72	24.72	Partial	1	1/20/2011	5/20/2011	0.17	9	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-2	P&T, DPE	6073643.777	2208877.136	48.72	24.72	Partial	1	5/20/2011	9/15/2011	0.21	10	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-2	P&T, DPE	6073643.777	2208877.136	48.72	24.72	Partial	1	9/15/2011	2/16/2012	0.20	11	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-2	P&T, DPE	6073643.777	2208877.136	48.72	24.72	Partial	1	2/16/2012	5/10/2012	0.22	12	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-2	P&T, DPE	6073643.777	2208877.136	48.72	24.72	Partial	1	5/10/2012	10/18/2012	0.25	13	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-2	P&T, DPE	6073643.777	2208877.136	48.72	24.72	Partial	1	10/18/2012	3/14/2013	0.20	14	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-2	P&T, DPE	6073643.777	2208877.136	48.72	24.72	Partial	1	3/14/2013	10/17/2013	0.25	15	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-2	P&T, DPE	6073643.777	2208877.136	48.72	24.72	Partial	1	10/17/2013	3/17/2014	0.24	16	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-2	P&T, DPE	6073643.777	2208877.136	48.72	24.72	Partial	1	3/17/2014	9/18/2014	0.27	17	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-2	P&T, DPE	6073643.777	2208877.136	48.72	24.72	Partial	1	9/18/2014	4/16/2015	0.18	18	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-2	P&T, DPE	6073643.777	2208877.136	48.72	24.72	Partial	1	4/16/2015	10/15/2015	0.09	19	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-2	P&T, DPE	6073643.777	2208877.136	48.72	24.72	Partial	1	10/15/2015	2/18/2016	0.11	20	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-2	P&T, DPE	6073643.777	2208877.136	48.72	24.72	Partial	1	2/18/2016	6/30/2016	0.11	21	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-24	P&T	6073732.071	2208911.188	18.94	8.94	Full	2	2/16/2007	9/14/2007	0.05	1	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	26.11	-10.32	
Gallade Chemical	3	MW-24	P&T	6073732.071	2208911.188	18.94	8.94	Full	2	9/14/2007	4/18/2008	0.14	2	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	26.11	-10.32	
Gallade Chemical	3	MW-24	P&T	6073732.071	2208911.188	18.94	8.94	Full	2	4/18/2008	10/24/2008	0.17	3	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	26.11	-10.32	
Gallade Chemical	3	MW-24	P&T	6073732.071	2208911.188	18.94	8.94	Full	2	10/24/2008	3/20/2009	0.15	4	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	26.11	-10.32	
Gallade Chemical	3	MW-24	P&T	6073732.071	2208911.188	18.94	8.94	Full	2	3/20/2009	9/17/2009	0.09	5	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	26.11	-10.32	
Gallade Chemical	3	MW-24	P&T	6073732.071	2208911.188	18.94	8.94	Full	2	9/17/2009	3/19/2010	0.16	6	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	26.11	-10.32	
Gallade Chemical	3	MW-24	P&T	6073732.071	2208911.188	18.94	8.94	Full	2	3/19/2010	9/16/2010	0.20	7	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	26.11	-10.32	
Gallade Chemical	3	MW-24	P&T	6073732.071	2208911.188	18.94	8.94	Full	2	9/16/2010	1/20/2011	0.13	8	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	26.11	-10.32	
Gallade Chemical	3	MW-24	P&T	6073732.071	2208911.188	18.94	8.94	Full	2	1/20/2011	5/20/2011	0.17	9	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	26.11	-10.32	
Gallade Chemical	3	MW-24	P&T	6073732.071	2208911.188	18.94	8.94	Full	2	5/20/2011	9/15/2011	0.21	10	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	26.11	-10.32	
Gallade Chemical	3	MW-24	P&T	6073732.071	2208911.188	18.94	8.94	Full	2	9/15/2011	2/16/2012	0.20	11	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	26.11	-10.32	
Gallade Chemical	3	MW-24	P&T	6073732.071	2208911.188	18.94	8.94	Full	2	2/16/2012	5/10/2012	0.22	12	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	26.11	-10.32	
Gallade Chemical	3	MW-24	P&T	6073732.071	2208911.188	18.94	8.94	Full	2	5/10/2012	10/18/2012	0.25	13	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	26.11	-10.32	
Gallade Chemical	3	MW-24	P&T	6073732.071	2208911.188	18.94	8.94	Full	2	10/18/2012	3/14/2013	0.20	14	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	26.11	-10.32	
Gallade Chemical	3	MW-24	P&T	6073732.071	2208911.188	18.94	8.94	Full	2	3/14/2013	10/17/2013	0.25	15	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	26.11	-10.32	

Appendix A-1. Summary of Remedial Extraction Systems, South Basin Groundwater Protection Project Study Area

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
Gallade Chemical	3	MW-24	P&T	6073732.071	2208911.188	18.94	8.94	Full	2	10/17/2013	3/17/2014	0.24	16	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	26.11	-10.32	
Gallade Chemical	3	MW-24	P&T	6073732.071	2208911.188	18.94	8.94	Full	2	3/17/2014	9/18/2014	0.27	17	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	26.11	-10.32	
Gallade Chemical	3	MW-24	P&T	6073732.071	2208911.188	18.94	8.94	Full	2	9/18/2014	4/16/2015	0.18	18	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	26.11	-10.32	
Gallade Chemical	3	MW-24	P&T	6073732.071	2208911.188	18.94	8.94	Full	2	4/16/2015	10/15/2015	0.09	19	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	26.11	-10.32	
Gallade Chemical	3	MW-24	P&T	6073732.071	2208911.188	18.94	8.94	Full	2	10/15/2015	2/18/2016	0.11	20	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	26.11	-10.32	
Gallade Chemical	3	MW-24	P&T	6073732.071	2208911.188	18.94	8.94	Full	2	2/18/2016	6/30/2016	0.11	21	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	26.11	-10.32	
Gallade Chemical	3	MW-3	P&T, DPE	6073732.597	2208874.241	58.94	34.94	Full	1	2/16/2007	9/14/2007	0.05	1	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-3	P&T, DPE	6073732.597	2208874.241	58.94	34.94	Full	1	9/14/2007	4/18/2008	0.14	2	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-3	P&T, DPE	6073732.597	2208874.241	58.94	34.94	Full	1	4/18/2008	10/24/2008	0.17	3	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-3	P&T, DPE	6073732.597	2208874.241	58.94	34.94	Full	1	10/24/2008	3/20/2009	0.15	4	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-3	P&T, DPE	6073732.597	2208874.241	58.94	34.94	Full	1	3/20/2009	9/17/2009	0.09	5	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-3	P&T, DPE	6073732.597	2208874.241	58.94	34.94	Full	1	9/17/2009	3/19/2010	0.16	6	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-3	P&T, DPE	6073732.597	2208874.241	58.94	34.94	Full	1	3/19/2010	9/16/2010	0.20	7	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-3	P&T, DPE	6073732.597	2208874.241	58.94	34.94	Full	1	9/16/2010	1/20/2011	0.13	8	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-3	P&T, DPE	6073732.597	2208874.241	58.94	34.94	Full	1	1/20/2011	5/20/2011	0.17	9	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-3	P&T, DPE	6073732.597	2208874.241	58.94	34.94	Full	1	5/20/2011	9/15/2011	0.21	10	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-3	P&T, DPE	6073732.597	2208874.241	58.94	34.94	Full	1	9/15/2011	2/16/2012	0.20	11	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-3	P&T, DPE	6073732.597	2208874.241	58.94	34.94	Full	1	2/16/2012	5/10/2012	0.22	12	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-3	P&T, DPE	6073732.597	2208874.241	58.94	34.94	Full	1	5/10/2012	10/18/2012	0.25	13	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-3	P&T, DPE	6073732.597	2208874.241	58.94	34.94	Full	1	10/18/2012	3/14/2013	0.20	14	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-3	P&T, DPE	6073732.597	2208874.241	58.94	34.94	Full	1	3/14/2013	10/17/2013	0.25	15	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-3	P&T, DPE	6073732.597	2208874.241	58.94	34.94	Full	1	10/17/2013	3/17/2014	0.24	16	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-3	P&T, DPE	6073732.597	2208874.241	58.94	34.94	Full	1	3/17/2014	9/18/2014	0.27	17	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-3	P&T, DPE	6073732.597	2208874.241	58.94	34.94	Full	1	9/18/2014	4/16/2015	0.18	18	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-3	P&T, DPE	6073732.597	2208874.241	58.94	34.94	Full	1	4/16/2015	10/15/2015	0.09	19	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-3	P&T, DPE	6073732.597	2208874.241	58.94	34.94	Full	1	10/15/2015	2/18/2016	0.11	20	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Gallade Chemical	3	MW-3	P&T, DPE	6073732.597	2208874.241	58.94	34.94	Full	1	2/18/2016	6/30/2016	0.11	21	Semiannual GW Monitoring and Remediation Report, 3Q-4Q 2016. Integral Consulting, Inc. 4/26/2017	63.94	26.37	
Holchem	5	HEW-1	P&T (HVDPE)	6074349.219	2208166.925	56.89	56.89	Full	1	11/1/2008	7/1/2009	0.01	4	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period
Holchem	5	HEW-1	P&T (HVDPE)	6074349.219	2208166.925	56.89	56.89	Full	1	11/1/2008	7/1/2009	0.01	5	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period
Holchem	5	HEW-10	P&T (HVDPE)	6074353.552	2208350.025	57.71	57.71	Full	1	11/1/2008	7/1/2009	0.01	4	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period
Holchem	5	HEW-10	P&T (HVDPE)	6074353.552	2208350.025	57.71	57.71	Full	1	11/1/2008	7/1/2009	0.01	5	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period
Holchem	5	HEW-11	P&T (HVDPE)	6074283.527	2208352.234	57.26	57.26	Full	1	11/1/2008	7/1/2009	0.01	4	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period
Holchem	5	HEW-11	P&T (HVDPE)	6074283.527	2208352.234	57.26	57.26	Full	1	11/1/2008	7/1/2009	0.01	5	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period
Holchem	5	HEW-2	P&T (HVDPE)	6074349.997	2208188.258	56.96	56.96	Full	1	11/1/2008	7/1/2009	0.01	4	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period
Holchem	5	HEW-2	P&T (HVDPE)	6074349.997	2208188.258	56.96	56.96	Full	1	11/1/2008	7/1/2009	0.01	5	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period

Appendix A-1. Summary of Remedial Extraction Systems, South Basin Groundwater Protection Project Study Area

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
Holchem	5	HEW-3	P&T (HVDPE)	6074350.327	2208209.739	57.00	57.00	Full	1	11/1/2008	7/1/2009	0.01	4	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period
Holchem	5	HEW-3	P&T (HVDPE)	6074350.327	2208209.739	57.00	57.00	Full	1	11/1/2008	7/1/2009	0.01	5	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period
Holchem	5	HEW-4	P&T (HVDPE)	6074351.006	2208232.116	57.06	57.06	Full	1	11/1/2008	7/1/2009	0.01	4	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period
Holchem	5	HEW-4	P&T (HVDPE)	6074351.006	2208232.116	57.06	57.06	Full	1	11/1/2008	7/1/2009	0.01	5	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period
Holchem	5	HEW-5	P&T (HVDPE)	6074351.69	2208253.369	57.10	57.10	Full	1	11/1/2008	7/1/2009	0.01	4	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period
Holchem	5	HEW-5	P&T (HVDPE)	6074351.69	2208253.369	57.10	57.10	Full	1	11/1/2008	7/1/2009	0.01	5	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period
Holchem	5	HEW-6	P&T (HVDPE)	6074352.345	2208275.089	57.12	57.12	Full	1	11/1/2008	7/1/2009	0.01	4	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period
Holchem	5	HEW-6	P&T (HVDPE)	6074352.345	2208275.089	57.12	57.12	Full	1	11/1/2008	7/1/2009	0.01	5	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period
Holchem	5	HEW-7	P&T (HVDPE)	6074352.922	2208296.512	57.15	57.15	Full	1	11/1/2008	7/1/2009	0.01	4	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period
Holchem	5	HEW-7	P&T (HVDPE)	6074352.922	2208296.512	57.15	57.15	Full	1	11/1/2008	7/1/2009	0.01	5	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period
Holchem	5	HEW-8	P&T (HVDPE)	6074353.661	2208318.174	57.32	57.32	Full	1	11/1/2008	7/1/2009	0.01	4	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period
Holchem	5	HEW-8	P&T (HVDPE)	6074353.661	2208318.174	57.32	57.32	Full	1	11/1/2008	7/1/2009	0.01	5	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period
Holchem	5	HEW-9	P&T (HVDPE)	6074354.247	2208339.608	57.59	57.59	Full	1	11/1/2008	7/1/2009	0.01	4	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period
Holchem	5	HEW-9	P&T (HVDPE)	6074354.247	2208339.608	57.59	57.59	Full	1	11/1/2008	7/1/2009	0.01	5	Remedial Investigation Summary and Risk Assessment Report, Geosyntec. 9/29/2014	62.60	15.97	67,200 gal treated between Nov 2008 and July 2009, average over time period
GE_Plastics	7	CEI-6	P&T	6077063.9	2206327.387	48.54	28.54	Full	1	1/1/2014	3/31/2014	0.03	16	4Q 2014 GW. Amec. 1/15/2015	57.32	9.38	
GE_Plastics	7	CEI-6	P&T	6077063.9	2206327.387	48.54	28.54	Full	1	4/1/2014	9/30/2014	0.01	17	4Q 2014 GW. Amec. 1/15/2015	57.32	9.38	
GE_Plastics	7	CEI-6	P&T	6077063.9	2206327.387	48.54	28.54	Full	1	10/1/2014	3/31/2015	0.01	18	4Q 2014 GW. Amec. 1/15/2015	57.32	9.38	
GE_Plastics	7	CEI-6	P&T	6077063.9	2206327.387	48.54	28.54	Full	1	4/1/2015	9/30/2015	0.01	19	4Q 2015 GW report. Amec. 1/15/2016	57.32	9.38	
GE_Plastics	7	CEI-6	P&T	6077063.9	2206327.387	48.54	28.54	Full	1	10/1/2015	2/15/2016	0.02	20	4Q 2015 GW report. Amec. 1/15/2016	57.32	9.38	
GE_Plastics	7	CEI-6	P&T	6077063.9	2206327.387	48.54	28.54	Full	1	2/15/2016	9/30/2016	0.02	21	4Q 2016 GW report. Amec. 1/17/2017	57.32	9.38	
GE_Plastics	7	CEI-6	P&T	6077063.9	2206327.387	48.54	28.54	Full	1	10/1/2016	3/31/2017	0.04	22	4Q 2016 GW report. Amec. 1/17/2017	57.32	9.38	
GE_Plastics	7	CEI-6	P&T	6077063.9	2206327.387	48.54	28.54	Full	1	4/1/2017	6/30/2017	0.07	23	Summary of 4Q 2017 GW Mon. Activities. Amec. 01/16/2018	57.32	9.38	
GE_Plastics	7	CEJ-7	P&T	6077116.024	2206324.916	48.59	28.59	Full	1	1/1/2014	3/31/2014	0.03	16	4Q 2014 GW. Amec. 1/15/2015	57.32	9.38	
GE_Plastics	7	CEJ-7	P&T	6077116.024	2206324.916	48.59	28.59	Full	1	4/1/2014	9/30/2014	0.02	17	4Q 2014 GW. Amec. 1/15/2015	57.32	9.38	
GE_Plastics	7	CEJ-7	P&T	6077116.024	2206324.916	48.59	28.59	Full	1	10/1/2014	3/31/2015	0.03	18	4Q 2014 GW. Amec. 1/15/2015	57.32	9.38	
GE_Plastics	7	CEJ-7	P&T	6077116.024	2206324.916	48.59	28.59	Full	1	4/1/2015	9/30/2015	0.01	19	4Q 2015 GW report. Amec. 1/15/2016	57.32	9.38	
GE_Plastics	7	CEJ-7	P&T	6077116.024	2206324.916	48.59	28.59	Full	1	10/1/2015	2/15/2016	0.01	20	4Q 2015 GW report. Amec. 1/15/2016	57.32	9.38	
GE_Plastics	7	CEJ-7	P&T	6077116.024	2206324.916	48.59	28.59	Full	1	2/15/2016	3/31/2016	0.01	21	4Q 2016 GW report. Amec. 1/17/2017	57.32	9.38	
GE_Plastics	7	CEJ-7	P&T	6077116.024	2206324.916	48.59	28.59	Full	1	10/1/2016	12/31/2016	0.02	22	4Q 2016 GW report. Amec. 1/17/2017	57.32	9.38	
GE_Plastics	7	CEJ-7	P&T	6077116.024	2206324.916	48.59	28.59	Full	1	4/1/2017	6/30/2017	0.03	23	Summary of 4Q 2017 GW Mon. Activities. Amec. 01/16/2018	57.32	9.38	
GE_Plastics	7	EX-1	P&T	6076794.086	2206189.832	41.01	31.01	Full	1	1/1/2010	3/31/2010	0.80	6	4Q 2010 GW. Amec. 1/14/2011	57.32	10.87	
GE_Plastics	7	EX-1	P&T	6076794.086	2206189.832	41.01	31.01	Full	1	4/1/2010	9/30/2011	1.20	7	4Q 2010 GW. Amec. 1/14/2011	57.32	10.87	
GE_Plastics	7	EX-1	P&T	6076794.086	2206189.832	41.01	31.01	Full	1	10/1/2010	12/31/2010	1.30	8	4Q 2010 GW. Amec. 1/14/2011	57.32	10.87	
GE_Plastics	7	EX-1	P&T	6076794.086	2206189.832	41.01	31.01	Full	1	1/1/2011	5/16/2011	2.05	9	4Q 2011 GW. Amec. 1/13/2012	57.32	10.87	
GE_Plastics	7	EX-1	P&T	6076794.086	2206189.832	41.01	31.01	Full	1	5/16/2011	9/30/2011	1.56	10	4Q 2011 GW. Amec. 1/13/2012	57.32	10.87	
GE_Plastics	7	EX-1	P&T	6076794.086	2206189.832	41.01	31.01	Full	1	10/1/2011	2/15/2012	1.35	11	4Q 2011 GW. Amec. 1/13/2012	57.32	10.87	
GE_Plastics	7	EX-1	P&T	6076794.086	2206189.832	41.01	31.01	Full	1	2/15/2012	5/16/2012	1.57	12	4Q 2012 GW. Amec. 1/15/2013	57.32	10.87	
GE_Plastics	7	EX-1	P&T	6076794.086	2206189.832	41.01	31.01	Full	1	5/16/2012	9/30/2012	1.46	13	4Q 2012 GW. Amec. 1/15/2013	57.32	10.87	
GE_Plastics	7	EX-1	P&T	6076794.086	2206189.832	41.01	31.01	Full	1	10/1/2012	3/31/2013	1.13	14	4Q 2012 GW. Amec. 1/15/2013	57.32	10.87	
GE_Plastics	7	EX-1	P&T	6076794.086	2206189.832	41.01	31.01	Full	1	4/1/2013	9/30/2013	1.30	15	4Q 2013 GW. Amec. 1/15/2014	57.32	10.87	
GE_Plastics	7	EX-1	P&T	6076794.086	2206189.832	41.01	31.01	Full	1	10/1/2013	3/31/2014	1.17	16	4Q 2013 GW. Amec. 1/15/2014	57.32	10.87	
GE_Plastics	7	EX-1	P&T	6076794.086	2206189.832	41.01	31.01	Full	1	4/1/2014	9/30/2014	1.23	17	4Q 2014 GW. Amec. 1/15/2015	57.32	10.87	
GE_Plastics	7	EX-1	P&T	6076794.086	2206189.832	41.01	31.01	Full	1	10/1/2014	3/31/2015	1.20	18	4Q 2014 GW. Amec. 1/15/2015	57.32	10.87	
GE_Plastics	7	EX-1	P&T	6076794.086	2206189.832	41.01	31.01	Full	1	4/1/2015	9/30/2015	0.87	19	4Q 2015 GW report. Amec. 1/15/2016	57.32	10.87	
GE_Plastics	7	EX-1	P&T	6076794.086	2206189.832	41.01	31.01	Full	1	10/1/2015	2/15/2016	0.72	20	4Q 2015 GW report. Amec. 1/15/2016	57.32	10.87	
GE_Plastics	7	EX-1	P&T	6076794.086	2206189.832	41.01	31.01	Full	1	2/15/2016	9/30/2016	0.70	21	4Q 2016 GW report. Amec. 1/17/2017	57.32	10.87	
GE_Plastics	7	EX-1	P&T	6076794.086	2206189.832	41.01	31.01	Full	1	10/1/2016	3/31/2017	0.84	22	4Q 2016 GW report. Amec. 1/17/2017	57.32	10.87	
GE_Plastics	7	EX-1	P&T	6076794.086	2206189.832	41.01	31.01	Full	1	4/1/2017	6/30/2017	0.85	23	Summary of 4Q 2017 GW Mon. Activities. Amec. 01/16/2018	57.32	10.87	

Appendix A-1. Summary of Remedial Extraction Systems, South Basin Groundwater Protection Project Study Area

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
GE_Plastics	7	EX-2	P&T	6076907.822	2206343.93	40.26	30.26	Full	1	1/1/2010	3/31/2010	0.90	6	4Q 2010 GW. Amec. 1/14/2011	57.32	10.87	
GE_Plastics	7	EX-2	P&T	6076907.822	2206343.93	40.26	30.26	Full	1	4/1/2010	9/30/2010	0.75	7	4Q 2010 GW. Amec. 1/14/2011	57.32	10.87	
GE_Plastics	7	EX-2	P&T	6076907.822	2206343.93	40.26	30.26	Full	1	10/1/2010	12/31/2010	1.00	8	4Q 2010 GW. Amec. 1/14/2011	57.32	10.87	
GE_Plastics	7	EX-2	P&T	6076907.822	2206343.93	40.26	30.26	Full	1	1/1/2011	5/16/2011	1.83	9	4Q 2011 GW. Amec. 1/13/2012	57.32	10.87	
GE_Plastics	7	EX-2	P&T	6076907.822	2206343.93	40.26	30.26	Full	1	5/16/2011	9/30/2011	1.84	10	4Q 2011 GW. Amec. 1/13/2012	57.32	10.87	
GE_Plastics	7	EX-2	P&T	6076907.822	2206343.93	40.26	30.26	Full	1	10/1/2011	2/15/2012	1.33	11	4Q 2011 GW. Amec. 1/13/2012	57.32	10.87	
GE_Plastics	7	EX-2	P&T	6076907.822	2206343.93	40.26	30.26	Full	1	2/15/2012	5/16/2012	1.70	12	4Q 2012 GW. Amec. 1/15/2013	57.32	10.87	
GE_Plastics	7	EX-2	P&T	6076907.822	2206343.93	40.26	30.26	Full	1	5/16/2012	9/30/2012	1.33	13	4Q 2012 GW. Amec. 1/15/2013	57.32	10.87	
GE_Plastics	7	EX-2	P&T	6076907.822	2206343.93	40.26	30.26	Full	1	10/1/2012	3/31/2013	1.70	14	4Q 2012 GW. Amec. 1/15/2013	57.32	10.87	
GE_Plastics	7	EX-2	P&T	6076907.822	2206343.93	40.26	30.26	Full	1	4/1/2013	9/30/2013	1.40	15	4Q 2013 GW. Amec. 1/15/2014	57.32	10.87	
GE_Plastics	7	EX-2	P&T	6076907.822	2206343.93	40.26	30.26	Full	1	10/2/2013	3/31/2014	1.35	16	4Q 2013 GW. Amec. 1/15/2014	57.32	10.87	
GE_Plastics	7	EX-2	P&T	6076907.822	2206343.93	40.26	30.26	Full	1	4/1/2014	9/30/2014	0.95	17	4Q 2014 GW. Amec. 1/15/2015	57.32	10.87	
GE_Plastics	7	EX-2	P&T	6076907.822	2206343.93	40.26	30.26	Full	1	10/1/2014	3/31/2015	0.50	18	4Q 2014 GW. Amec. 1/15/2015	57.32	10.87	
GE_Plastics	7	EX-2	P&T	6076907.822	2206343.93	40.26	30.26	Full	1	4/1/2015	9/30/2015	0.35	19	4Q 2015 GW report. Amec. 1/15/2016	57.32	10.87	
GE_Plastics	7	EX-2	P&T	6076907.822	2206343.93	40.26	30.26	Full	1	10/1/2015	2/15/2016	0.30	20	4Q 2015 GW report. Amec. 1/15/2016	57.32	10.87	
GE_Plastics	7	EX-2	P&T	6076907.822	2206343.93	40.26	30.26	Full	1	2/15/2016	9/30/2016	0.36	21	4Q 2016 GW report. Amec. 1/17/2017	57.32	10.87	
GE_Plastics	7	EX-2	P&T	6076907.822	2206343.93	40.26	30.26	Full	1	10/1/2016	3/31/2017	0.48	22	4Q 2016 GW report. Amec. 1/17/2017	57.32	10.87	
GE_Plastics	7	EX-2	P&T	6076907.822	2206343.93	40.26	30.26	Full	1	4/1/2017	6/30/2017	0.64	23	Summary of 4Q 2017 GW Mon. Activities. Amec. 01/16/2018	57.32	10.87	
GE_Plastics	7	EX-3	P&T	6077054.245	2206312.577	40.49	30.49	Full	1	1/1/2010	3/31/2010	0.10	6	4Q 2010 GW. Amec. 1/14/2011	57.32	10.87	
GE_Plastics	7	EX-3	P&T	6077054.245	2206312.577	40.49	30.49	Full	1	4/1/2010	9/30/2010	0.10	7	4Q 2010 GW. Amec. 1/14/2011	57.32	10.87	
GE_Plastics	7	EX-3	P&T	6077054.245	2206312.577	40.49	30.49	Full	1	10/1/2010	12/31/2010	0.10	8	4Q 2010 GW. Amec. 1/14/2011	57.32	10.87	
GE_Plastics	7	EX-3	P&T	6077054.245	2206312.577	40.49	30.49	Full	1	1/1/2011	5/16/2011	0.10	9	4Q 2011 GW. Amec. 1/13/2012	57.32	10.87	
GE_Plastics	7	EX-3	P&T	6077054.245	2206312.577	40.49	30.49	Full	1	5/16/2011	9/30/2011	0.10	10	4Q 2011 GW. Amec. 1/13/2012	57.32	10.87	
GE_Plastics	7	EX-3	P&T	6077054.245	2206312.577	40.49	30.49	Full	1	10/1/2011	2/15/2012	0.10	11	4Q 2011 GW. Amec. 1/13/2012	57.32	10.87	
GE_Plastics	7	EX-3	P&T	6077054.245	2206312.577	40.49	30.49	Full	1	2/15/2012	5/16/2012	0.10	12	4Q 2012 GW. Amec. 1/15/2013	57.32	10.87	
GE_Plastics	7	EX-3	P&T	6077054.245	2206312.577	40.49	30.49	Full	1	5/16/2012	9/30/2012	0.10	13	4Q 2012 GW. Amec. 1/15/2013	57.32	10.87	
GE_Plastics	7	EX-3	P&T	6077054.245	2206312.577	40.49	30.49	Full	1	10/1/2012	3/31/2013	0.10	14	4Q 2012 GW. Amec. 1/15/2013	57.32	10.87	
GE_Plastics	7	EX-3	P&T	6077054.245	2206312.577	40.49	30.49	Full	1	4/1/2013	9/30/2013	0.07	15	4Q 2013 GW. Amec. 1/15/2014	57.32	10.87	
GE_Plastics	7	EX-3	P&T	6077054.245	2206312.577	40.49	30.49	Full	1	10/3/2013	3/31/2014	0.03	16	4Q 2013 GW. Amec. 1/15/2014	57.32	10.87	
GE_Plastics	7	EX-3	P&T	6077054.245	2206312.577	40.49	30.49	Full	1	4/1/2014	9/30/2014	0.01	17	4Q 2014 GW. Amec. 1/15/2015	57.32	10.87	
GE_Plastics	7	EX-3	P&T	6077054.245	2206312.577	40.49	30.49	Full	1	10/1/2014	3/31/2015	0.01	18	4Q 2014 GW. Amec. 1/15/2015	57.32	10.87	
GE_Plastics	7	EX-3	P&T	6077054.245	2206312.577	40.49	30.49	Full	1	4/1/2015	9/30/2015	0.005	19	4Q 2015 GW report. Amec. 1/15/2016	57.32	10.87	
GE_Plastics	7	EX-3	P&T	6077054.245	2206312.577	40.49	30.49	Full	1	10/1/2015	2/15/2016	0.003	20	4Q 2015 GW report. Amec. 1/15/2016	57.32	10.87	
GE_Plastics	7	EX-3	P&T	6077054.245	2206312.577	40.49	30.49	Full	1	2/15/2016	9/30/2016	0.002	21	4Q 2016 GW report. Amec. 1/17/2017	57.32	10.87	
GE_Plastics	7	EX-3	P&T	6077054.245	2206312.577	40.49	30.49	Full	1	10/1/2016	3/31/2017	0.02	22	4Q 2016 GW report. Amec. 1/17/2017	57.32	10.87	
GE_Plastics	7	EX-3	P&T	6077054.245	2206312.577	40.49	30.49	Full	1	4/1/2017	6/30/2017	0.07	23	Summary of 4Q 2017 GW Mon. Activities. Amec. 01/16/2018	57.32	10.87	
GE_Plastics	7	EX-3R	P&T	6077057.95	2206315.973	37.51	27.51	Full	1	1/1/2010	3/31/2010	0.40	6	4Q 2010 GW. Amec. 1/14/2011	57.32	10.87	
GE_Plastics	7	EX-3R	P&T	6077057.95	2206315.973	37.51	27.51	Full	1	4/1/2010	9/30/2010	0.30	7	4Q 2010 GW. Amec. 1/14/2011	57.32	10.87	
GE_Plastics	7	EX-3R	P&T	6077057.95	2206315.973	37.51	27.51	Full	1	10/1/2010	12/31/2010	0.20	8	4Q 2010 GW. Amec. 1/14/2011	57.32	10.87	
GE_Plastics	7	EX-3R	P&T	6077057.95	2206315.973	37.51	27.51	Full	1	1/1/2011	5/16/2011	0.23	9	4Q 2011 GW. Amec. 1/13/2012	57.32	10.87	
GE_Plastics	7	EX-3R	P&T	6077057.95	2206315.973	37.51	27.51	Full	1	5/16/2011	9/30/2011	0.10	10	4Q 2011 GW. Amec. 1/13/2012	57.32	10.87	
GE_Plastics	7	EX-3R	P&T	6077057.95	2206315.973	37.51	27.51	Full	1	10/1/2011	2/15/2012	0.47	11	4Q 2011 GW. Amec. 1/13/2012	57.32	10.87	
GE_Plastics	7	EX-3R	P&T	6077057.95	2206315.973	37.51	27.51	Full	1	2/15/2012	5/16/2012	0.40	12	4Q 2012 GW. Amec. 1/15/2013	57.32	10.87	
GE_Plastics	7	EX-3R	P&T	6077057.95	2206315.973	37.51	27.51	Full	1	5/16/2012	9/30/2012	0.33	13	4Q 2012 GW. Amec. 1/15/2013	57.32	10.87	
GE_Plastics	7	EX-3R	P&T	6077057.95	2206315.973	37.51	27.51	Full	1	10/1/2012	3/31/2013	0.40	14	4Q 2012 GW. Amec. 1/15/2013	57.32	10.87	
GE_Plastics	7	EX-3R	P&T	6077057.95	2206315.973	37.51	27.51	Full	1	4/1/2013	9/30/2013	0.65	15	4Q 2013 GW. Amec. 1/15/2014	57.32	10.87	
GE_Plastics	7	EX-3R	P&T	6077057.95	2206315.973	37.51	27.51	Full	1	10/4/2013	3/31/2014	1.05	16	4Q 2013 GW. Amec. 1/15/2014	57.32	10.87	
GE_Plastics	7	EX-3R	P&T	6077057.95	2206315.973	37.51	27.51	Full	1	4/1/2014	9/30/2014	1.50	17	4Q 2014 GW. Amec. 1/15/2015	57.32	10.87	
GE_Plastics	7	EX-3R	P&T	6077057.95	2206315.973	37.51	27.51	Full	1	10/1/2014	3/31/2015	1.90	18	4Q 2014 GW. Amec. 1/15/2015	57.32	10.87	
GE_Plastics	7	EX-3R	P&T	6077057.95	2206315.973	37.51	27.51	Full	1	4/1/2015	9/30/2015	2.70	19	4Q 2015 GW report. Amec. 1/15/2016	57.32	10.87	
GE_Plastics	7	EX-3R	P&T	6077057.95	2206315.973	37.51	27.51	Full	1	10/1/2015	2/15/2016	2.60	20	4Q 2015 GW report. Amec. 1/15/2016	57.32	10.87	
GE_Plastics	7	EX-3R	P&T	6077057.95	2206315.973	37.51	27.51	Full	1	2/15/2016	9/30/2016	2.48	21	4Q 2016 GW report. Amec. 1/17/2017	57.32	10.87	
GE_Plastics	7	EX-3R	P&T	6077057.95	2206315.973	37.51	27.51	Full	1	10/1/2016	3/31/2017	2.10	22	4Q 2016 GW report. Amec. 1/17/2017	57.32	10.87	
GE_Plastics	7	EX-3R	P&T	6077057.95	2206315.973	37.51	27.51	Full	1	4/1/2017	6/30/2017	1.50	23	Summary of 4Q 2017 GW Mon. Activities. Amec. 01/16/2018	57.32	10.87	

Appendix A-1. Summary of Remedial Extraction Systems, South Basin Groundwater Protection Project Study Area

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
GE_Plastics	7	EX-4	P&T	6076981.469	2206328.865	37.58	27.58	Full	1	1/1/2010	3/31/2010	0.40	6	4Q 2010 GW. Amec. 1/14/2011	57.32	10.87	
GE_Plastics	7	EX-4	P&T	6076981.469	2206328.865	37.58	27.58	Full	1	4/1/2010	9/30/2010	0.30	7	4Q 2010 GW. Amec. 1/14/2011	57.32	10.87	
GE_Plastics	7	EX-4	P&T	6076981.469	2206328.865	37.58	27.58	Full	1	10/1/2010	12/31/2010	0.20	8	4Q 2010 GW. Amec. 1/14/2011	57.32	10.87	
GE_Plastics	7	EX-4	P&T	6076981.469	2206328.865	37.58	27.58	Full	1	1/1/2011	5/16/2011	0.23	9	4Q 2011 GW. Amec. 1/13/2012	57.32	10.87	
GE_Plastics	7	EX-4	P&T	6076981.469	2206328.865	37.58	27.58	Full	1	5/16/2011	9/30/2011	0.10	10	4Q 2011 GW. Amec. 1/13/2012	57.32	10.87	
GE_Plastics	7	EX-4	P&T	6076981.469	2206328.865	37.58	27.58	Full	1	10/1/2011	2/15/2012	0.20	11	4Q 2011 GW. Amec. 1/13/2012	57.32	10.87	
GE_Plastics	7	EX-4	P&T	6076981.469	2206328.865	37.58	27.58	Full	1	2/15/2012	5/16/2012	0.20	12	4Q 2012 GW. Amec. 1/15/2013	57.32	10.87	
GE_Plastics	7	EX-4	P&T	6076981.469	2206328.865	37.58	27.58	Full	1	5/16/2012	9/30/2012	0.13	13	4Q 2012 GW. Amec. 1/15/2013	57.32	10.87	
GE_Plastics	7	EX-4	P&T	6076981.469	2206328.865	37.58	27.58	Full	1	10/1/2012	3/31/2013	0.15	14	4Q 2012 GW. Amec. 1/15/2013	57.32	10.87	
GE_Plastics	7	EX-4	P&T	6076981.469	2206328.865	37.58	27.58	Full	1	4/1/2013	9/30/2013	0.25	15	4Q 2013 GW. Amec. 1/15/2014	57.32	10.87	
GE_Plastics	7	EX-4	P&T	6076981.469	2206328.865	37.58	27.58	Full	1	10/5/2013	3/31/2014	0.15	16	4Q 2013 GW. Amec. 1/15/2014	57.32	10.87	
GE_Plastics	7	EX-4	P&T	6076981.469	2206328.865	37.58	27.58	Full	1	4/1/2014	9/30/2014	0.10	17	4Q 2014 GW. Amec. 1/15/2015	57.32	10.87	
GE_Plastics	7	EX-4	P&T	6076981.469	2206328.865	37.58	27.58	Full	1	10/1/2014	3/31/2015	0.10	18	4Q 2014 GW. Amec. 1/15/2015	57.32	10.87	Flow rate estimated because flow meter on well was experiencing problems
GE_Plastics	7	EX-4	P&T	6076981.469	2206328.865	37.58	27.58	Full	1	4/1/2015	9/30/2015	0.01	19	4Q 2015 GW report. Amec. 1/15/2016	57.32	10.87	
GE_Plastics	7	EX-4	P&T	6076981.469	2206328.865	37.58	27.58	Full	1	10/1/2015	2/15/2016	0.01	20	4Q 2015 GW report. Amec. 1/15/2016	57.32	10.87	
GE_Plastics	7	EX-4	P&T	6076981.469	2206328.865	37.58	27.58	Full	1	2/15/2016	9/30/2016	0.05	21	4Q 2016 GW report. Amec. 1/17/2017	57.32	10.87	
GE_Plastics	7	EX-4	P&T	6076981.469	2206328.865	37.58	27.58	Full	1	10/1/2016	3/31/2017	0.05	22	4Q 2016 GW report. Amec. 1/17/2017	57.32	10.87	
GE_Plastics	7	EX-4	P&T	6076981.469	2206328.865	37.58	27.58	Full	1	4/1/2017	6/30/2017	0.03	23	Summary of 4Q 2017 GW Mon. Activities. Amec. 01/16/2018	57.32	10.87	
GE_Plastics	7	EX-5	P&T	6077057.427	2206279.956	37.70	27.70	Full	1	1/1/2010	3/31/2010	0.80	6	4Q 2010 GW. Amec. 1/14/2011	57.32	10.87	
GE_Plastics	7	EX-5	P&T	6077057.427	2206279.956	37.70	27.70	Full	1	4/1/2010	9/30/2010	0.90	7	4Q 2010 GW. Amec. 1/14/2011	57.32	10.87	
GE_Plastics	7	EX-5	P&T	6077057.427	2206279.956	37.70	27.70	Full	1	10/1/2010	12/31/2010	0.90	8	4Q 2010 GW. Amec. 1/14/2011	57.32	10.87	
GE_Plastics	7	EX-5	P&T	6077057.427	2206279.956	37.70	27.70	Full	1	1/1/2011	5/16/2011	1.10	9	4Q 2011 GW. Amec. 1/13/2012	57.32	10.87	
GE_Plastics	7	EX-5	P&T	6077057.427	2206279.956	37.70	27.70	Full	1	5/16/2011	9/30/2011	0.90	10	4Q 2011 GW. Amec. 1/13/2012	57.32	10.87	
GE_Plastics	7	EX-5	P&T	6077057.427	2206279.956	37.70	27.70	Full	1	10/1/2011	2/15/2012	0.60	11	4Q 2011 GW. Amec. 1/13/2012	57.32	10.87	
GE_Plastics	7	EX-5	P&T	6077057.427	2206279.956	37.70	27.70	Full	1	2/15/2012	5/16/2012	0.60	12	4Q 2012 GW. Amec. 1/15/2013	57.32	10.87	
GE_Plastics	7	EX-5	P&T	6077057.427	2206279.956	37.70	27.70	Full	1	5/16/2012	9/30/2012	0.60	13	4Q 2012 GW. Amec. 1/15/2013	57.32	10.87	
GE_Plastics	7	EX-5	P&T	6077057.427	2206279.956	37.70	27.70	Full	1	10/1/2012	3/31/2013	0.50	14	4Q 2012 GW. Amec. 1/15/2013	57.32	10.87	
GE_Plastics	7	EX-5	P&T	6077057.427	2206279.956	37.70	27.70	Full	1	4/1/2013	9/30/2013	0.50	15	4Q 2013 GW. Amec. 1/15/2014	57.32	10.87	
GE_Plastics	7	EX-5	P&T	6077057.427	2206279.956	37.70	27.70	Full	1	10/6/2013	3/31/2014	0.40	16	4Q 2013 GW. Amec. 1/15/2014	57.32	10.87	
GE_Plastics	7	EX-5	P&T	6077057.427	2206279.956	37.70	27.70	Full	1	4/1/2014	9/30/2014	0.30	17	4Q 2014 GW. Amec. 1/15/2015	57.32	10.87	
GE_Plastics	7	EX-5	P&T	6077057.427	2206279.956	37.70	27.70	Full	1	10/1/2014	3/31/2015	0.20	18	4Q 2014 GW. Amec. 1/15/2015	57.32	10.87	
GE_Plastics	7	EX-5	P&T	6077057.427	2206279.956	37.70	27.70	Full	1	4/1/2015	9/30/2015	0.20	19	4Q 2015 GW report. Amec. 1/15/2016	57.32	10.87	
GE_Plastics	7	EX-5	P&T	6077057.427	2206279.956	37.70	27.70	Full	1	10/1/2015	2/15/2016	0.05	20	4Q 2015 GW report. Amec. 1/15/2016	57.32	10.87	
GE_Plastics	7	EX-5	P&T	6077057.427	2206279.956	37.70	27.70	Full	1	2/15/2016	9/30/2016	0.06	21	4Q 2016 GW report. Amec. 1/17/2017	57.32	10.87	
GE_Plastics	7	EX-5	P&T	6077057.427	2206279.956	37.70	27.70	Full	1	10/1/2016	3/31/2017	0.02	22	4Q 2016 GW report. Amec. 1/17/2017	57.32	10.87	
GE_Plastics	7	EX-5	P&T	6077057.427	2206279.956	37.70	27.70	Full	1	4/1/2017	6/30/2017	0.22	23	Summary of 4Q 2017 GW Mon. Activities. Amec. 01/16/2018	57.32	10.87	
GE_Plastics	7	EX-6	P&T	6076900.813	2206243.627	37.49	27.49	Full	1	1/1/2010	3/31/2010	1.00	6	4Q 2010 GW. Amec. 1/14/2011	57.32	10.87	
GE_Plastics	7	EX-6	P&T	6076900.813	2206243.627	37.49	27.49	Full	1	4/1/2010	9/30/2010	0.80	7	4Q 2010 GW. Amec. 1/14/2011	57.32	10.87	
GE_Plastics	7	EX-6	P&T	6076900.813	2206243.627	37.49	27.49	Full	1	10/1/2010	12/31/2010	2.70	8	4Q 2010 GW. Amec. 1/14/2011	57.32	10.87	
GE_Plastics	7	EX-6	P&T	6076900.813	2206243.627	37.49	27.49	Full	1	1/1/2011	5/16/2011	0.80	9	4Q 2011 GW. Amec. 1/13/2012	57.32	10.87	
GE_Plastics	7	EX-6	P&T	6076900.813	2206243.627	37.49	27.49	Full	1	5/16/2011	9/30/2011	2.14	10	4Q 2011 GW. Amec. 1/13/2012	57.32	10.87	
GE_Plastics	7	EX-6	P&T	6076900.813	2206243.627	37.49	27.49	Full	1	10/1/2011	2/15/2012	1.53	11	4Q 2011 GW. Amec. 1/13/2012	57.32	10.87	
GE_Plastics	7	EX-6	P&T	6076900.813	2206243.627	37.49	27.49	Full	1	2/15/2012	5/16/2012	1.30	12	4Q 2012 GW. Amec. 1/15/2013	57.32	10.87	
GE_Plastics	7	EX-6	P&T	6076900.813	2206243.627	37.49	27.49	Full	1	5/16/2012	9/30/2012	1.73	13	4Q 2012 GW. Amec. 1/15/2013	57.32	10.87	
GE_Plastics	7	EX-6	P&T	6076900.813	2206243.627	37.49	27.49	Full	1	10/1/2012	3/31/2013	1.85	14	4Q 2012 GW. Amec. 1/15/2013	57.32	10.87	
GE_Plastics	7	EX-6	P&T	6076900.813	2206243.627	37.49	27.49	Full	1	4/1/2013	9/30/2013	1.60	15	4Q 2013 GW. Amec. 1/15/2014	57.32	10.87	
GE_Plastics	7	EX-6	P&T	6076900.813	2206243.627	37.49	27.49	Full	1	10/7/2013	3/31/2014	1.75	16	4Q 2013 GW. Amec. 1/15/2014	57.32	10.87	
GE_Plastics	7	EX-6	P&T	6076900.813	2206243.627	37.49	27.49	Full	1	4/1/2014	9/30/2014	1.50	17	4Q 2014 GW. Amec. 1/15/2015	57.32	10.87	

Appendix A-1. Summary of Remedial Extraction Systems, South Basin Groundwater Protection Project Study Area

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
GE_Plastics	7	EX-6	P&T	6076900.813	2206243.627	37.49	27.49	Full	1	10/1/2014	3/31/2015	1.50	18	4Q 2014 GW. Amec. 1/15/2015	57.32	10.87	
GE_Plastics	7	EX-6	P&T	6076900.813	2206243.627	37.49	27.49	Full	1	4/1/2015	9/30/2015	0.40	19	4Q 2015 GW report. Amec. 1/15/2016	57.32	10.87	
GE_Plastics	7	EX-6	P&T	6076900.813	2206243.627	37.49	27.49	Full	1	10/1/2015	2/15/2016	0.42	20	4Q 2015 GW report. Amec. 1/15/2016	57.32	10.87	
GE_Plastics	7	EX-6	P&T	6076900.813	2206243.627	37.49	27.49	Full	1	2/15/2016	9/30/2016	0.47	21	4Q 2016 GW report. Amec. 1/17/2017	57.32	10.87	
GE_Plastics	7	EX-6	P&T	6076900.813	2206243.627	37.49	27.49	Full	1	10/1/2016	3/31/2017	0.66	22	4Q 2016 GW report. Amec. 1/17/2017	57.32	10.87	
GE_Plastics	7	EX-6	P&T	6076900.813	2206243.627	37.49	27.49	Full	1	4/1/2017	6/30/2017	0.70	23	Summary of 4Q 2017 GW Mon. Activities. Amec. 01/16/2018	57.32	10.87	
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	2/28/2007	9/17/2007	4.30	1	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	Outliers removed from data set, replaced by average of preceding and following flow rates.
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	9/28/2007	4/22/2008	3.51	2	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	5/23/2008	10/29/2008	3.70	3	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	11/26/2008	3/26/2009	3.60	4	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	4/29/2009	9/30/2009	2.83	5	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	Replaced flowmeter 6/12/2009
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	10/29/2009	3/31/2010	1.58	6	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	Equipment repairs done in late March
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	4/30/2010	9/30/2010	3.08	7	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	Outliers removed from data set, replaced by average of preceding and following flow rates.
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	10/28/2010	1/31/2011	3.36	8	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	3/1/2011	5/4/2011	3.04	9	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	6/2/2011	9/30/2011	4.59	10	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	10/28/2011	2/28/2012	4.20	11	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	3/27/2012	5/25/2012	5.63	12	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	7/5/2012	10/26/2012	5.09	13	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	12/6/2012	3/26/2013	4.80	14	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	5/1/2013	10/21/2013	4.76	15	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	11/6/2013	3/14/2014	3.79	16	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	3/18/2014	9/17/2014	4.15	17	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	9/25/2014	4/22/2015	4.19	18	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	5/1/2015	10/30/2015	2.59	19	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	11/25/2015	2/26/2016	2.53	20	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	4/1/2016	10/20/2016	2.72	21	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	11/8/2016	2/24/2017	2.34	22	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-1	P&T	6075243.917	2202606.188	33.61	8.61	Partial	2	4/6/2017	7/6/2017	3.64	23	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	2/28/2007	9/17/2007	4.30	1	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	Outliers removed from data set, replaced by average of preceding and following flow rates.
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	9/28/2007	4/22/2008	3.51	2	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	5/23/2008	10/29/2008	3.70	3	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	11/26/2008	3/26/2009	3.60	4	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	4/29/2009	9/30/2009	2.83	5	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	Replaced flowmeter 6/12/2009
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	10/29/2009	3/31/2010	1.58	6	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	Equipment repairs done in late March
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	4/30/2010	9/30/2010	3.08	7	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	Outliers removed from data set, replaced by average of preceding and following flow rates.

Appendix A-1. Summary of Remedial Extraction Systems, South Basin Groundwater Protection Project Study Area

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	10/28/2010	1/31/2011	3.36	8	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	3/1/2011	5/4/2011	3.04	9	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	6/2/2011	9/30/2011	4.59	10	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	10/28/2011	2/28/2012	4.20	11	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	3/27/2012	5/25/2012	5.63	12	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	7/5/2012	10/26/2012	5.09	13	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	12/6/2012	3/26/2013	4.80	14	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	5/1/2013	10/21/2013	4.76	15	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	11/6/2013	3/14/2014	3.79	16	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	3/18/2014	9/17/2014	4.15	17	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	9/25/2014	4/22/2015	4.19	18	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	5/1/2015	10/30/2015	2.59	19	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	11/25/2015	2/26/2016	2.53	20	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	4/1/2016	10/20/2016	2.72	21	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	11/8/2016	2/24/2017	2.34	22	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Astech	10	EX-2	P&T	6075242.233	2202608.847	12.12	-2.88	Full	2	4/6/2017	7/6/2017	3.64	23	Semi-Annual GW Mon. and Site Rem. Status Report Jul-Dec 2009. WorleyParsons. 02/18/2010	16.10	-12.23	
Circuit_One	11	W-1	P&T	6075079.363	2208904.307	61.07	46.07	Full	1	4/27/2007	8/30/2007	1.30	1	Treatment System Reports, Carlin Environmental Consulting, Inc. April 2007 - August 2007. Geotracker.	65.79	18.74	All flow rates = total gallons removed over total operation time for stress period
Circuit_One	11	W-1	P&T	6075079.363	2208904.307	61.07	46.07	Full	1	9/28/2007	3/28/2008	0.07	2	Treatment System Reports, Carlin Environmental Consulting, Inc. Sept 2007 - March 2008. Geotracker.	65.79	18.74	Meter not functioning properly throughout period
Circuit_One	11	W-1	P&T	6075079.363	2208904.307	61.07	46.07	Full	1	4/30/2008	9/29/2008	0.71	3	Treatment System Reports, Carlin Environmental Consulting, Inc. April 2008 - Sept 2008. Geotracker.	65.79	18.74	No operation month of May 2008
Circuit_One	11	W-1	P&T	6075079.363	2208904.307	61.07	46.07	Full	1	10/31/2008	2/27/2009	1.40	4	Treatment System Reports, Carlin Environmental Consulting, Inc. Oct 2008 - Feb 2009. Geotracker.	65.79	18.74	
Circuit_One	11	W-1	P&T	6075079.363	2208904.307	61.07	46.07	Full	1	3/30/2009	8/28/2009	1.44	5	Treatment System Reports, Carlin Environmental Consulting, Inc. March 2009 - August 2009. Geotracker.	65.79	18.74	
Circuit_One	11	W-1	P&T	6075079.363	2208904.307	61.07	46.07	Full	1	9/30/2009	3/16/2010	1.23	6	Treatment System Reports, Carlin Environmental Consulting, Inc. Sept 2009 - Jan 2010. Geotracker.	65.79	18.74	No operation month of November 2009
Circuit_One	11	W-1	P&T	6075079.363	2208904.307	61.07	46.07	Full	1	3/16/2010	9/16/2010	1.33	7		65.79	18.74	System was operating, pumping data unknown. Estimated from historical data.
Circuit_One	11	W-1	P&T	6075079.363	2208904.307	61.07	46.07	Full	1	9/16/2010	1/16/2011	1.33	8		65.79	18.74	System was operating, pumping data unknown. Estimated from historical data.
Circuit_One	11	W-1	P&T	6075079.363	2208904.307	61.07	46.07	Full	1	1/16/2011	5/16/2011	1.33	9		65.79	18.74	System was operating, pumping data unknown. Estimated from historical data.
Circuit_One	11	W-1	P&T	6075079.363	2208904.307	61.07	46.07	Full	1	5/16/2011	9/16/2011	1.33	10		65.79	18.74	System was operating, pumping data unknown. Estimated from historical data.
Circuit_One	11	W-1	P&T	6075079.363	2208904.307	61.07	46.07	Full	1	9/16/2011	2/15/2012	1.33	11		65.79	18.74	System was operating, pumping data unknown. Estimated from historical data.
Circuit_One	11	W-1	P&T	6075079.363	2208904.307	61.07	46.07	Full	1	2/15/2012	5/1/2012	1.33	12		65.79	18.74	System was operating, pumping data unknown. Estimated from historical data.
Circuit_One	11	W-1	P&T	6075079.363	2208904.307	61.07	46.07	Full	1	5/16/2012	8/1/2012	0.67	13		65.79	18.74	System was operating, pumping data unknown. Estimated from historical data. No operation May 2012
Circuit_One	11	W-2	P&T	6075079.696	2208914.652	61.09	46.09	Full	1	4/27/2007	8/30/2007	1.30	1	Treatment System Reports, Carlin Environmental Consulting, Inc. April 2007 - August 2007. Geotracker.	65.79	18.74	All flow rates = total gallons removed over total operation time for stress period
Circuit_One	11	W-2	P&T	6075079.696	2208914.652	61.09	46.09	Full	1	9/28/2007	3/28/2008	0.07	2	Treatment System Reports, Carlin Environmental Consulting, Inc. Sept 2007 - March 2008. Geotracker.	65.79	18.74	Meter not functioning properly throughout period
Circuit_One	11	W-2	P&T	6075079.696	2208914.652	61.09	46.09	Full	1	4/30/2008	9/29/2008	0.71	3	Treatment System Reports, Carlin Environmental Consulting, Inc. April 2008 - Sept 2008. Geotracker.	65.79	18.74	No operation month of May 2008
Circuit_One	11	W-2	P&T	6075079.696	2208914.652	61.09	46.09	Full	1	10/31/2008	2/27/2009	1.40	4	Treatment System Reports, Carlin Environmental Consulting, Inc. Oct 2008 - Feb 2009. Geotracker.	65.79	18.74	
Circuit_One	11	W-2	P&T	6075079.696	2208914.652	61.09	46.09	Full	1	3/30/2009	8/28/2009	1.44	5	Treatment System Reports, Carlin Environmental Consulting, Inc. March 2009 - August 2009. Geotracker.	65.79	18.74	
Circuit_One	11	W-2	P&T	6075079.696	2208914.652	61.09	46.09	Full	1	9/30/2009	3/16/2010	1.23	6	Treatment System Reports, Carlin Environmental Consulting, Inc. Sept 2009 - Jan 2010. Geotracker.	65.79	18.74	No operation month of November 2009

Appendix A-1. Summary of Remedial Extraction Systems, South Basin Groundwater Protection Project Study Area

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
Circuit_One	11	W-2	P&T	6075079.696	2208914.652	61.09	46.09	Full	1	3/16/2010	9/16/2010	1.33	7		65.79	18.74	System was operating, pumping data unknown. Estimated from historical data.
Circuit_One	11	W-2	P&T	6075079.696	2208914.652	61.09	46.09	Full	1	9/16/2010	1/16/2011	1.33	8		65.79	18.74	System was operating, pumping data unknown. Estimated from historical data.
Circuit_One	11	W-2	P&T	6075079.696	2208914.652	61.09	46.09	Full	1	1/16/2011	5/16/2011	1.33	9		65.79	18.74	System was operating, pumping data unknown. Estimated from historical data.
Circuit_One	11	W-2	P&T	6075079.696	2208914.652	61.09	46.09	Full	1	5/16/2011	9/16/2011	1.33	10		65.79	18.74	System was operating, pumping data unknown. Estimated from historical data.
Circuit_One	11	W-2	P&T	6075079.696	2208914.652	61.09	46.09	Full	1	9/16/2011	2/15/2012	1.33	11		65.79	18.74	System was operating, pumping data unknown. Estimated from historical data.
Circuit_One	11	W-2	P&T	6075079.696	2208914.652	61.09	46.09	Full	1	2/15/2012	5/1/2012	1.33	12		65.79	18.74	System was operating, pumping data unknown. Estimated from historical data.
Circuit_One	11	W-2	P&T	6075079.696	2208914.652	61.09	46.09	Full	1	5/16/2012	8/1/2012	0.67	13		65.79	18.74	System was operating, pumping data unknown. Estimated from historical data. No operation May 2012
Circuit_One	11	W-3	P&T	6075079.696	2208925.665	61.12	46.12	Full	1	4/27/2007	8/30/2007	1.30	1	Treatment System Reports, Carlin Environmental Consulting, Inc. April 2007 - August 2007. Geotracker.	65.79	18.74	All flow rates = total gallons removed over total operation time for stress period
Circuit_One	11	W-3	P&T	6075079.696	2208925.665	61.12	46.12	Full	1	9/28/2007	3/28/2008	0.07	2	Treatment System Reports, Carlin Environmental Consulting, Inc. Sept 2007 - March 2008. Geotracker.	65.79	18.74	Meter not functioning properly throughout period
Circuit_One	11	W-3	P&T	6075079.696	2208925.665	61.12	46.12	Full	1	4/30/2008	9/29/2008	0.71	3	Treatment System Reports, Carlin Environmental Consulting, Inc. April 2008 - Sept 2008. Geotracker.	65.79	18.74	No operation month of May 2008
Circuit_One	11	W-3	P&T	6075079.696	2208925.665	61.12	46.12	Full	1	10/31/2008	2/27/2009	1.40	4	Treatment System Reports, Carlin Environmental Consulting, Inc. Oct 2008 - Feb 2009. Geotracker.	65.79	18.74	
Circuit_One	11	W-3	P&T	6075079.696	2208925.665	61.12	46.12	Full	1	3/30/2009	8/28/2009	1.44	5	Treatment System Reports, Carlin Environmental Consulting, Inc. March 2009 - August 2009. Geotracker.	65.79	18.74	
Circuit_One	11	W-3	P&T	6075079.696	2208925.665	61.12	46.12	Full	1	9/30/2009	3/16/2010	1.23	6	Treatment System Reports, Carlin Environmental Consulting, Inc. Sept 2009 - Jan 2010. Geotracker.	65.79	18.74	No operation month of November 2009
Circuit_One	11	W-3	P&T	6075079.696	2208925.665	61.12	46.12	Full	1	3/16/2010	9/16/2010	1.33	7		65.79	18.74	System was operating, pumping data unknown. Estimated from historical data.
Circuit_One	11	W-3	P&T	6075079.696	2208925.665	61.12	46.12	Full	1	9/16/2010	1/16/2011	1.33	8		65.79	18.74	System was operating, pumping data unknown. Estimated from historical data.
Circuit_One	11	W-3	P&T	6075079.696	2208925.665	61.12	46.12	Full	1	1/16/2011	5/16/2011	1.33	9		65.79	18.74	System was operating, pumping data unknown. Estimated from historical data.
Circuit_One	11	W-3	P&T	6075079.696	2208925.665	61.12	46.12	Full	1	5/16/2011	9/16/2011	1.33	10		65.79	18.74	System was operating, pumping data unknown. Estimated from historical data.
Circuit_One	11	W-3	P&T	6075079.696	2208925.665	61.12	46.12	Full	1	9/16/2011	2/15/2012	1.33	11		65.79	18.74	System was operating, pumping data unknown. Estimated from historical data.
Circuit_One	11	W-3	P&T	6075079.696	2208925.665	61.12	46.12	Full	1	2/15/2012	5/1/2012	1.33	12		65.79	18.74	System was operating, pumping data unknown. Estimated from historical data.
Circuit_One	11	W-3	P&T	6075079.696	2208925.665	61.12	46.12	Full	1	5/16/2012	8/1/2012	0.67	13		65.79	18.74	System was operating, pumping data unknown. Estimated from historical data. No operation May 2012
Troy	12	RW-19	HVDPE	6077134.798	2207128.339	51.30	21.30	Full	1	2/1/2007	3/1/2007	0.00	1		Not modeled	Not modeled	No data available Feb 2007 to March 2007
Troy	12	RW-20	HVDPE	6077212.16	2207189.317	51.78	21.78	Full	1	2/1/2007	3/1/2007	0.00	1		Not modeled	Not modeled	No data available Feb 2007 to March 2007
Troy	12	RW-21	HVDPE	6077116.63	2207065.947	50.54	20.54	Full	1	2/1/2007	3/1/2007	0.00	1		Not modeled	Not modeled	No data available Feb 2007 to March 2007
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	7/1/2007	9/16/2007	3.74	1		80.29	17.39	
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	9/16/2007	4/16/2008	2.10	2		80.29	17.39	
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	4/16/2008	10/16/2008	0.00	3		80.29	17.39	
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	10/16/2008	3/16/2009	3.94	4		80.29	17.39	
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	3/16/2009	9/16/2009	5.29	5		80.29	17.39	
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	9/16/2009	3/16/2010	4.80	6		80.29	17.39	missing 2009 Q4
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	3/16/2010	9/16/2010	5.38	7		80.29	17.39	
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	9/16/2010	1/16/2011	4.87	8		80.29	17.39	
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	1/16/2011	5/16/2011	5.81	9		80.29	17.39	
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	5/16/2011	9/16/2011	5.57	10		80.29	17.39	
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	9/16/2011	2/15/2012	5.67	11		80.29	17.39	
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	2/15/2012	5/16/2012	5.47	12		80.29	17.39	
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	5/16/2012	10/16/2012	5.49	13		80.29	17.39	
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	10/16/2012	3/16/2013	5.44	14		80.29	17.39	
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	3/16/2013	10/16/2013	5.53	15		80.29	17.39	
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	10/16/2013	3/16/2014	5.68	16		80.29	17.39	
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	3/16/2014	9/16/2014	0.00	17		80.29	17.39	

Appendix A-1. Summary of Remedial Extraction Systems, South Basin Groundwater Protection Project Study Area

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	9/16/2014	4/16/2015	0.00	18		80.29	17.39	Missing 2015 Q1Q2
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	4/16/2015	10/16/2015	6.54	19		80.29	17.39	Missing 2015 Q1Q2
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	10/16/2015	2/15/2016	7.85	20		80.29	17.39	
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	2/15/2016	10/16/2016	7.08	21		80.29	17.39	Missing 2016 Q3
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	10/16/2016	3/16/2017	0.00	22		80.29	17.39	
Bell_Industries	13	GWX-1	P&T (MPE)	6077952.153	2210066.246	49.80	24.80	Full	1	3/16/2017	7/1/2017	0.00	23		80.29	17.39	
Bell_Industries	13	GWX-2	P&T (MPE)	6078000.013	2210065.734	49.82	24.82	Full	1	7/1/2007	9/16/2007	3.74	1		80.29	17.39	
Bell_Industries	13	GWX-2	P&T (MPE)	6078000.013	2210065.734	49.82	24.82	Full	1	9/16/2007	4/16/2008	3.21	2		80.29	17.39	
Bell_Industries	13	GWX-3	P&T (MPE)	6078044.669	2210064.58	49.83	24.83	Full	1	7/1/2007	9/16/2007	3.74	1		80.29	17.39	
Bell_Industries	13	GWX-3	P&T (MPE)	6078044.669	2210064.58	49.83	24.83	Full	1	9/16/2007	4/16/2008	3.21	2		80.29	17.39	
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	7/1/2007	9/16/2007	0.00	1		20.49	3.79	
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	9/16/2007	4/16/2008	1.69	2		20.49	3.79	
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	4/16/2008	10/16/2008	0.00	3		20.49	3.79	
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	10/16/2008	3/16/2009	3.60	4		20.49	3.79	
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	3/16/2009	9/16/2009	5.13	5		20.49	3.79	
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	9/16/2009	3/16/2010	4.80	6		20.49	3.79	missing 2009 Q4
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	3/16/2010	9/16/2010	5.38	7		20.49	3.79	
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	9/16/2010	1/16/2011	4.87	8		20.49	3.79	
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	1/16/2011	5/16/2011	5.81	9		20.49	3.79	
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	5/16/2011	9/16/2011	5.57	10		20.49	3.79	
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	9/16/2011	2/15/2012	5.67	11		20.49	3.79	
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	2/15/2012	5/16/2012	5.47	12		20.49	3.79	
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	5/16/2012	10/16/2012	5.49	13		20.49	3.79	
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	10/16/2012	3/16/2013	5.44	14		20.49	3.79	
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	3/16/2013	10/16/2013	5.53	15		20.49	3.79	
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	10/16/2013	3/16/2014	7.95	16		20.49	3.79	
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	3/16/2014	9/16/2014	8.50	17		20.49	3.79	
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	9/16/2014	4/16/2015	8.46	18		20.49	3.79	Missing 2015 Q1Q2
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	4/16/2015	10/16/2015	8.22	19		20.49	3.79	Missing 2015 Q1Q2
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	10/16/2015	2/15/2016	0.00	20		20.49	3.79	
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	2/15/2016	10/16/2016	0.00	21		20.49	3.79	Missing 2016 Q3
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	10/16/2016	3/16/2017	0.00	22		20.49	3.79	
Bell_Industries	13	GWX-6	P&T (MPE)	6077519.02	2209119.129	15.02	5.02	Full	2	3/16/2017	7/1/2017	0.00	23		20.49	3.79	
Bell_Industries	13	MW-19B-P	P&T (MPE)	6077833.694	2209940.167	44.42	19.42	Full	1	9/16/2007	4/16/2008	1.67	2		78.44	16.79	
Bell_Industries	13	MW-19B-P	P&T (MPE)	6077833.694	2209940.167	44.42	19.42	Full	1	4/16/2008	10/16/2008	0.00	3		78.44	16.79	
Bell_Industries	13	MW-19B-P	P&T (MPE)	6077833.694	2209940.167	44.42	19.42	Full	1	10/16/2008	3/16/2009	3.60	4		78.44	16.79	
Bell_Industries	13	MW-19B-P	P&T (MPE)	6077833.694	2209940.167	44.42	19.42	Full	1	3/16/2009	9/16/2009	5.13	5		78.44	16.79	
Bell_Industries	13	MW-19B-P	P&T (MPE)	6077833.694	2209940.167	44.42	19.42	Full	1	9/16/2009	3/16/2010	4.80	6		78.44	16.79	missing 2009 Q4
Bell_Industries	13	MW-19B-P	P&T (MPE)	6077833.694	2209940.167	44.42	19.42	Full	1	3/16/2010	9/16/2010	5.38	7		78.44	16.79	
Bell_Industries	13	MW-19B-P	P&T (MPE)	6077833.694	2209940.167	44.42	19.42	Full	1	9/16/2010	1/16/2011	4.87	8		78.44	16.79	
Bell_Industries	13	MW-19B-P	P&T (MPE)	6077833.694	2209940.167	44.42	19.42	Full	1	1/16/2011	5/16/2011	5.81	9		78.44	16.79	
Bell_Industries	13	MW-19B-P	P&T (MPE)	6077833.694	2209940.167	44.42	19.42	Full	1	5/16/2011	9/16/2011	5.57	10		78.44	16.79	
Bell_Industries	13	MW-19B-P	P&T (MPE)	6077833.694	2209940.167	44.42	19.42	Full	1	9/16/2011	2/15/2012	5.67	11		78.44	16.79	
Bell_Industries	13	MW-19B-P	P&T (MPE)	6077833.694	2209940.167	44.42	19.42	Full	1	2/15/2012	5/16/2012	5.47	12		78.44	16.79	
Bell_Industries	13	MW-19B-P	P&T (MPE)	6077833.694	2209940.167	44.42	19.42	Full	1	5/16/2012	10/16/2012	5.49	13		78.44	16.79	
Bell_Industries	13	MW-19B-P	P&T (MPE)	6077833.694	2209940.167	44.42	19.42	Full	1	10/16/2012	3/16/2013	5.44	14		78.44	16.79	
Bell_Industries	13	MW-19B-P	P&T (MPE)	6077833.694	2209940.167	44.42	19.42	Full	1	3/16/2013	10/16/2013	5.53	15		78.44	16.79	
Bell_Industries	13	MW-19B-P	P&T (MPE)	6077833.694	2209940.167	44.42	19.42	Full	1	10/16/2013	3/16/2014	5.68	16		78.44	16.79	
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	7/1/2007	9/16/2007	0.00	1		20.00	9.73	
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	9/16/2007	4/16/2008	0.00	2		20.00	9.73	
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	4/16/2008	10/16/2008	0.00	3		20.00	9.73	
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	10/16/2008	3/16/2009	0.00	4		20.00	9.73	
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	3/16/2009	9/16/2009	0.00	5		20.00	9.73	
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	9/16/2009	3/16/2010	0.00	6		20.00	9.73	missing 2009 Q4
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	3/16/2010	9/16/2010	0.00	7		20.00	9.73	
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	9/16/2010	1/16/2011	0.00	8		20.00	9.73	

Appendix A-1. Summary of Remedial Extraction Systems, South Basin Groundwater Protection Project Study Area

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	1/16/2011	5/16/2011	0.00	9		20.00	9.73	
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	5/16/2011	9/16/2011	0.00	10		20.00	9.73	
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	9/16/2011	2/15/2012	0.00	11		20.00	9.73	
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	2/15/2012	5/16/2012	0.00	12		20.00	9.73	
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	5/16/2012	10/16/2012	0.00	13		20.00	9.73	
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	10/16/2012	3/16/2013	0.00	14		20.00	9.73	
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	3/16/2013	10/16/2013	0.00	15		20.00	9.73	
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	10/16/2013	3/16/2014	0.00	16		20.00	9.73	
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	3/16/2014	9/16/2014	0.00	17		20.00	9.73	
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	9/16/2014	4/16/2015	0.00	18		20.00	9.73	Missing 2015 Q1Q2
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	4/16/2015	10/16/2015	8.22	19		20.00	9.73	Missing 2015 Q1Q2
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	10/16/2015	2/15/2016	6.84	20		20.00	9.73	
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	2/15/2016	10/16/2016	7.41	21		20.00	9.73	Missing 2016 Q3
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	10/16/2016	3/16/2017	5.94	22		20.00	9.73	
Bell_Industries	13	MW-23B	P&T (MPE)	6077741.515	2209639.18	19.68	9.68	Full	2	3/16/2017	7/1/2017	7.36	23		20.00	9.73	
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	7/1/2007	9/16/2007	0.00	1		21.35	-10.47	
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	9/16/2007	4/16/2008	1.69	2		21.35	-10.47	
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	4/16/2008	10/16/2008	0.00	3		21.35	-10.47	
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	10/16/2008	3/16/2009	3.60	4		21.35	-10.47	
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	3/16/2009	9/16/2009	5.13	5		21.35	-10.47	
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	9/16/2009	3/16/2010	4.80	6		21.35	-10.47	missing 2009 Q4
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	3/16/2010	9/16/2010	5.38	7		21.35	-10.47	
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	9/16/2010	1/16/2011	4.87	8		21.35	-10.47	
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	1/16/2011	5/16/2011	5.81	9		21.35	-10.47	
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	5/16/2011	9/16/2011	5.57	10		21.35	-10.47	
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	9/16/2011	2/15/2012	5.67	11		21.35	-10.47	
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	2/15/2012	5/16/2012	5.47	12		21.35	-10.47	
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	5/16/2012	10/16/2012	5.49	13		21.35	-10.47	
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	10/16/2012	3/16/2013	5.44	14		21.35	-10.47	
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	3/16/2013	10/16/2013	5.53	15		21.35	-10.47	
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	10/16/2013	3/16/2014	7.95	16		21.35	-10.47	
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	3/16/2014	9/16/2014	8.50	17		21.35	-10.47	
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	9/16/2014	4/16/2015	8.46	18		21.35	-10.47	Missing 2015 Q1Q2
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	4/16/2015	10/16/2015	7.81	19		21.35	-10.47	Missing 2015 Q1Q2
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	10/16/2015	2/15/2016	6.84	20		21.35	-10.47	
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	2/15/2016	10/16/2016	7.41	21		21.35	-10.47	Missing 2016 Q3
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	10/16/2016	3/16/2017	5.94	22		21.35	-10.47	
Bell_Industries	13	MW-25C	P&T (MPE)	6077624.349	2209512.318	9.74	-5.26	Full	2	3/16/2017	7/1/2017	7.36	23		21.35	-10.47	
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	9/16/2007	4/16/2008	1.67	2		77.74	17.40	
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	4/16/2008	10/16/2008	0.00	3		77.74	17.40	
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	10/16/2008	3/16/2009	3.60	4		77.74	17.40	
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	3/16/2009	9/16/2009	5.13	5		77.74	17.40	
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	9/16/2009	3/16/2010	4.80	6		77.74	17.40	missing 2009 Q4
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	3/16/2010	9/16/2010	5.38	7		77.74	17.40	
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	9/16/2010	1/16/2011	4.87	8		77.74	17.40	
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	1/16/2011	5/16/2011	5.81	9		77.74	17.40	
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	5/16/2011	9/16/2011	5.57	10		77.74	17.40	
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	9/16/2011	2/15/2012	5.67	11		77.74	17.40	
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	2/15/2012	5/16/2012	5.47	12		77.74	17.40	
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	5/16/2012	10/16/2012	5.49	13		77.74	17.40	
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	10/16/2012	3/16/2013	5.44	14		77.74	17.40	
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	3/16/2013	10/16/2013	5.53	15		77.74	17.40	
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	10/16/2013	3/16/2014	7.95	16		77.74	17.40	
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	3/16/2014	9/16/2014	8.50	17		77.74	17.40	
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	9/16/2014	4/16/2015	8.46	18		77.74	17.40	Missing 2015 Q1Q2
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	4/16/2015	10/16/2015	7.81	19		77.74	17.40	Missing 2015 Q1Q2

Appendix A-1. Summary of Remedial Extraction Systems, South Basin Groundwater Protection Project Study Area

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	10/16/2015	2/15/2016	6.84	20		77.74	17.40	
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	2/15/2016	10/16/2016	7.41	21		77.74	17.40	Missing 2016 Q3
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	10/16/2016	3/16/2017	5.94	22		77.74	17.40	
Bell_Industries	13	MW-26B	P&T (MPE)	6077841.935	2209838.503	32.83	22.83	Full	1	3/16/2017	7/1/2017	7.36	23		77.74	17.40	
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	7/1/2007	9/16/2007	0.00	1		80.29	17.39	
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	9/16/2007	4/16/2008	1.69	2		80.29	17.39	
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	4/16/2008	10/16/2008	0.00	3		80.29	17.39	
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	10/16/2008	3/16/2009	3.94	4		80.29	17.39	
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	3/16/2009	9/16/2009	5.29	5		80.29	17.39	
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	9/16/2009	3/16/2010	4.80	6		80.29	17.39	missing 2009 Q4
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	3/16/2010	9/16/2010	5.38	7		80.29	17.39	
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	9/16/2010	1/16/2011	4.87	8		80.29	17.39	
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	1/16/2011	5/16/2011	5.81	9		80.29	17.39	
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	5/16/2011	9/16/2011	5.57	10		80.29	17.39	
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	9/16/2011	2/15/2012	5.67	11		80.29	17.39	
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	2/15/2012	5/16/2012	5.47	12		80.29	17.39	
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	5/16/2012	10/16/2012	5.49	13		80.29	17.39	
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	10/16/2012	3/16/2013	5.44	14		80.29	17.39	
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	3/16/2013	10/16/2013	5.53	15		80.29	17.39	
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	10/16/2013	3/16/2014	7.95	16		80.29	17.39	
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	3/16/2014	9/16/2014	8.50	17		80.29	17.39	
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	9/16/2014	4/16/2015	8.46	18		80.29	17.39	Missing 2015 Q1Q2
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	4/16/2015	10/16/2015	8.25	19		80.29	17.39	Missing 2015 Q1Q2
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	10/16/2015	2/15/2016	6.44	20		80.29	17.39	
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	2/15/2016	10/16/2016	7.51	21		80.29	17.39	Missing 2016 Q3
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	10/16/2016	3/16/2017	5.94	22		80.29	17.39	
Bell_Industries	13	MW-4B	P&T (MPE)	6077938.579	2210095.422	31.10	26.10	Full	1	3/16/2017	7/1/2017	7.36	23		80.29	17.39	
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	7/1/2007	9/16/2007	0.00	1		79.61	17.45	
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	9/16/2007	4/16/2008	1.67	2		79.61	17.45	
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	4/16/2008	10/16/2008	0.00	3		79.61	17.45	
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	10/16/2008	3/16/2009	3.60	4		79.61	17.45	
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	3/16/2009	9/16/2009	5.13	5		79.61	17.45	
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	9/16/2009	3/16/2010	4.80	6		79.61	17.45	missing 2009 Q4
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	3/16/2010	9/16/2010	5.38	7		79.61	17.45	
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	9/16/2010	1/16/2011	4.87	8		79.61	17.45	
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	1/16/2011	5/16/2011	5.81	9		79.61	17.45	
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	5/16/2011	9/16/2011	5.57	10		79.61	17.45	
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	9/16/2011	2/15/2012	5.67	11		79.61	17.45	
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	2/15/2012	5/16/2012	5.47	12		79.61	17.45	
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	5/16/2012	10/16/2012	5.49	13		79.61	17.45	
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	10/16/2012	3/16/2013	5.44	14		79.61	17.45	
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	3/16/2013	10/16/2013	5.53	15		79.61	17.45	
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	10/16/2013	3/16/2014	7.95	16		79.61	17.45	
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	3/16/2014	9/16/2014	8.50	17		79.61	17.45	
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	9/16/2014	4/16/2015	8.46	18		79.61	17.45	Missing 2015 Q1Q2
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	4/16/2015	10/16/2015	7.81	19		79.61	17.45	Missing 2015 Q1Q2
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	10/16/2015	2/15/2016	6.84	20		79.61	17.45	
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	2/15/2016	10/16/2016	2.63	21		79.61	17.45	Missing 2016 Q3
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	10/16/2016	3/16/2017	0.00	22		79.61	17.45	
Bell_Industries	13	OW-2B	P&T (MPE)	6077917.412	2209836.259	39.16	24.16	Full	1	3/16/2017	7/1/2017	0.00	23		79.61	17.45	
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	7/1/2007	9/16/2007	0.00	1		79.61	17.45	
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	9/16/2007	4/16/2008	1.67	2		79.61	17.45	

Appendix A-1. Summary of Remedial Extraction Systems, South Basin Groundwater Protection Project Study Area

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	4/16/2008	10/16/2008	0.00	3		79.61	17.45	
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	10/16/2008	3/16/2009	3.60	4		79.61	17.45	
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	3/16/2009	9/16/2009	5.13	5		79.61	17.45	
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	9/16/2009	3/16/2010	4.80	6		79.61	17.45	missing 2009 Q4
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	3/16/2010	9/16/2010	5.38	7		79.61	17.45	
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	9/16/2010	1/16/2011	4.87	8		79.61	17.45	
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	1/16/2011	5/16/2011	5.81	9		79.61	17.45	
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	5/16/2011	9/16/2011	5.57	10		79.61	17.45	
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	9/16/2011	2/15/2012	5.67	11		79.61	17.45	
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	2/15/2012	5/16/2012	5.47	12		79.61	17.45	
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	5/16/2012	10/16/2012	5.49	13		79.61	17.45	
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	10/16/2012	3/16/2013	5.44	14		79.61	17.45	
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	3/16/2013	10/16/2013	5.53	15		79.61	17.45	
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	10/16/2013	3/16/2014	5.68	16		79.61	17.45	
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	3/16/2014	9/16/2014	0.00	17		79.61	17.45	
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	9/16/2014	4/16/2015	0.00	18		79.61	17.45	Missing 2015 Q1Q2
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	4/16/2015	10/16/2015	0.00	19		79.61	17.45	Missing 2015 Q1Q2
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	10/16/2015	2/15/2016	0.00	20		79.61	17.45	
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	2/15/2016	10/16/2016	0.00	21		79.61	17.45	Missing 2016 Q3
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	10/16/2016	3/16/2017	0.00	22		79.61	17.45	
Bell_Industries	13	OW-3B	P&T (MPE)	6077965.356	2209843.279	36.34	26.34	Full	1	3/16/2017	7/1/2017	0.00	23		79.61	17.45	
Textron_Cherry	21	SSA-DPE-EW-	DPE	6073487.392	2206748.28	40.00	20.00	Full	1	6/3/2013	10/4/2013	0.09	15	DPE Pilot Test Report (Revised). CDM Smith. 4/4/2014	54.26	11.23	Average flow rate given the total disposal volume over the given time frame. Range = 0.25 - 0.75 gpm
Textron_Cherry	21	SSA-PZ-1	DPE	6073489.562	2206759.998	40.07	20.07	Full	1	6/3/2013	10/4/2013	0.09	15	DPE Pilot Test Report (Revised). CDM Smith. 4/4/2014	54.26	11.23	Average flow rate given the total disposal volume over the given time frame. Range = 0.25 - 0.75 gpm
Textron_Cherry	21	SSA-PZ-2	DPE	6073480.448	2206736.561	39.95	19.95	Full	1	6/3/2013	10/4/2013	0.09	15	DPE Pilot Test Report (Revised). CDM Smith. 4/4/2014	54.26	11.23	Average flow rate given the total disposal volume over the given time frame. Range = 0.25 - 0.75 gpm
Textron_Cherry	21	SSA-PZ-3	DPE	6073470.899	2206754.79	40.30	20.30	Full	1	6/3/2013	10/4/2013	0.09	15	DPE Pilot Test Report (Revised). CDM Smith. 4/4/2014	54.26	11.23	Average flow rate given the total disposal volume over the given time frame. Range = 0.25 - 0.75 gpm
Textron_Cherry	21	SSA-PZ-4	DPE	6073472.201	2206769.547	40.39	20.39	Full	1	6/3/2013	10/4/2013	0.09	15	DPE Pilot Test Report (Revised). CDM Smith. 4/4/2014	54.26	11.23	Average flow rate given the total disposal volume over the given time frame. Range = 0.25 - 0.75 gpm
ITT	22	RW-1	P&T	6073031.195	2203985.966	12.73	-17.27	Partial	2	1/1/2009	3/16/2009	10.00	4	Q1 2008 Groundwater Monitoring Report and 2009 Groundwater Monitoring Plan. Arcadis. 2/13/2009	15.40	-9.15	Average rate for overall system
ITT	22	RW-1	P&T	6073031.195	2203985.966	12.73	-17.27	Partial	2	3/16/2009	9/16/2009	10.00	5	Q1 2008 Groundwater Monitoring Report and 2009 Groundwater Monitoring Plan. Arcadis. 2/13/2009	15.40	-9.15	Average rate for overall system
ITT	22	RW-1	P&T	6073031.195	2203985.966	12.73	-17.27	Partial	2	9/16/2009	3/16/2010	10.00	6	Q1 2008 Groundwater Monitoring Report and 2009 Groundwater Monitoring Plan. Arcadis. 2/13/2009	15.40	-9.15	Average rate for overall system
ITT	22	RW-1	P&T	6073031.195	2203985.966	12.73	-17.27	Partial	2	3/16/2010	9/16/2010	10.00	7	Q1 2008 Groundwater Monitoring Report and 2009 Groundwater Monitoring Plan. Arcadis. 2/13/2009	15.40	-9.15	Average rate for overall system
ITT	22	RW-1	P&T	6073031.195	2203985.966	12.73	-17.27	Partial	2	9/16/2010	12/31/2010	10.00	8	Q1 2008 Groundwater Monitoring Report and 2009 Groundwater Monitoring Plan. Arcadis. 2/13/2009	15.40	-9.15	Average rate for overall system
ITT	22	RW-1	P&T	6073031.195	2203985.966	12.73	-17.27	Partial	2	1/12/2011	5/16/2011	9.88	9	1Q 2011 GW Mon. Report. ARCADIS. 6/23/2011	15.40	-9.15	Previous data found in National Pollution Discharge Elimination System Reports
ITT	22	RW-1	P&T	6073031.195	2203985.966	12.73	-17.27	Partial	2	5/16/2011	9/30/2011	9.50	10	2Q 2011 GW Mon. Report. ARCADIS. 9/13/2011	15.40	-9.15	
ITT	22	RW-1	P&T	6073031.195	2203985.966	12.73	-17.27	Partial	2	10/1/2011	2/15/2012	10.80	11	4Q 2011 GW Mon. Report. ARCADIS. 3/5/2012	15.40	-9.15	
ITT	22	RW-1	P&T	6073031.195	2203985.966	12.73	-17.27	Partial	2	2/15/2012	5/16/2012	9.40	12	1Q 2012 GW Mon. Report. ARCADIS. 6/6/2012	15.40	-9.15	
ITT	22	RW-1	P&T	6073031.195	2203985.966	12.73	-17.27	Partial	2	5/16/2012	9/30/2012	10.41	13	2Q 2012 GW Mon. Report. ARCADIS. 9/28/2012	15.40	-9.15	
ITT	22	RW-1	P&T	6073031.195	2203985.966	12.73	-17.27	Partial	2	10/1/2012	3/31/2013	10.66	14	4Q 2012 GW Mon. Report. ARCADIS. 2/19/2013	15.40	-9.15	
ITT	22	RW-1	P&T	6073031.195	2203985.966	12.73	-17.27	Partial	2	4/1/2013	6/30/2013	11.10	15	2Q 2013 GW Mon. Report. ARCADIS. 8/28/2013	15.40	-9.15	
ITT	22	RW-1	P&T	6073031.195	2203985.966	12.73	-17.27	Partial	2	10/1/2013	3/31/2014	9.85	16	4Q 2013 GW Mon. Report. ARCADIS. 3/26/2014	15.40	-9.15	No 3Q 2013 report found
ITT	22	RW-1	P&T	6073031.195	2203985.966	12.73	-17.27	Partial	2	4/1/2014	9/30/2014	10.01	17	2Q 2014 GW Mon. Report. ARCADIS. 9/17/2014	15.40	-9.15	
ITT	22	RW-1	P&T	6073031.195	2203985.966	12.73	-17.27	Partial	2	10/1/2014	4/16/2015	9.90	18	4Q 2014 GW Mon. Report. ARCADIS. 2/11/2015	15.40	-9.15	
ITT	22	RW-1	P&T	6073031.195	2203985.966	12.73	-17.27	Partial	2	4/16/2015	10/16/2015	10.06	19	(1SA) 1Q-2Q 2015 GW Mon. Report. ARCADIS. 8/27/2015	15.40	-9.15	
ITT	22	RW-1	P&T	6073031.195	2203985.966	12.73	-17.27	Partial	2	10/16/2015	2/15/2016	9.91	20	(2SA) 3Q-4Q 2015 GW Mon. Report. ARCADIS. 2/23/2016	15.40	-9.15	
ITT	22	RW-1	P&T	6073031.195	2203985.966	12.73	-17.27	Partial	2	2/15/2016	10/16/2016	9.05	21	(1SA) 1Q-2Q 2016 GW Mon. Report. ARCADIS. 7/29/2016	15.40	-9.15	
ITT	22	RW-1	P&T	6073031.195	2203985.966	12.73	-17.27	Partial	2	10/16/2016	3/16/2017	8.29	22	(2SA) 3Q-4Q 2016 GW Mon. Report. ARCADIS. 2/24/2017	15.40	-9.15	
ITT	22	RW-1	P&T	6073031.195	2203985.966	12.73	-17.27	Partial	2	3/16/2017	7/1/2017	8.21	23	(1SA) 1Q-2Q 2017 GW Mon. Report. ARCADIS. 11/1/2017	15.40	-9.15	

Appendix A-1. Summary of Remedial Extraction Systems, South Basin Groundwater Protection Project Study Area

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
ITT	22	RW-2	P&T	6073220.437	2203949.605	15.25	-15.25	Partial	2	1/1/2009	3/16/2009	6.40	4	Q1 2008 Groundwater Monitoring Report and 2009 Groundwater Monitoring Plan. Arcadis. 2/13/2009	14.72	-10.54	Average rate for overall system
ITT	22	RW-2	P&T	6073220.437	2203949.605	15.25	-15.25	Partial	2	3/16/2009	9/16/2009	6.40	5	Q1 2008 Groundwater Monitoring Report and 2009 Groundwater Monitoring Plan. Arcadis. 2/13/2009	14.72	-10.54	Average rate for overall system
ITT	22	RW-2	P&T	6073220.437	2203949.605	15.25	-15.25	Partial	2	9/16/2009	3/16/2010	6.40	6	Q1 2008 Groundwater Monitoring Report and 2009 Groundwater Monitoring Plan. Arcadis. 2/13/2009	14.72	-10.54	Average rate for overall system
ITT	22	RW-2	P&T	6073220.437	2203949.605	15.25	-15.25	Partial	2	3/16/2010	9/16/2010	6.40	7	Q1 2008 Groundwater Monitoring Report and 2009 Groundwater Monitoring Plan. Arcadis. 2/13/2009	14.72	-10.54	Average rate for overall system
ITT	22	RW-2	P&T	6073220.437	2203949.605	15.25	-15.25	Partial	2	9/16/2010	12/31/2010	6.40	8	Q1 2008 Groundwater Monitoring Report and 2009 Groundwater Monitoring Plan. Arcadis. 2/13/2009	14.72	-10.54	Average rate for overall system
ITT	22	RW-2	P&T	6073220.437	2203949.605	15.25	-15.25	Partial	2	1/12/2011	5/16/2011	6.77	9	1Q 2011 GW Mon. Report. ARCADIS. 6/23/2011	14.72	-10.54	
ITT	22	RW-2	P&T	6073220.437	2203949.605	15.25	-15.25	Partial	2	5/16/2011	9/30/2011	7.00	10	2Q 2011 GW Mon. Report. ARCADIS. 9/13/2011	14.72	-10.54	
ITT	22	RW-2	P&T	6073220.437	2203949.605	15.25	-15.25	Partial	2	10/1/2011	2/15/2012	5.53	11	4Q 2011 GW Mon. Report. ARCADIS. 3/5/2012	14.72	-10.54	
ITT	22	RW-2	P&T	6073220.437	2203949.605	15.25	-15.25	Partial	2	2/15/2012	5/16/2012	3.50	12	1Q 2012 GW Mon. Report. ARCADIS. 6/6/2012	14.72	-10.54	
ITT	22	RW-2	P&T	6073220.437	2203949.605	15.25	-15.25	Partial	2	5/16/2012	9/30/2012	1.13	13	2Q 2012 GW Mon. Report. ARCADIS. 9/28/2012	14.72	-10.54	
ITT	22	RW-2	P&T	6073220.437	2203949.605	15.25	-15.25	Partial	2	10/1/2012	3/31/2013	2.70	14	4Q 2012 GW Mon. Report. ARCADIS. 2/19/2013	14.72	-10.54	
ITT	22	RW-2	P&T	6073220.437	2203949.605	15.25	-15.25	Partial	2	4/1/2013	6/30/2013	2.10	15	2Q 2013 GW Mon. Report. ARCADIS. 8/28/2013	14.72	-10.54	
ITT	22	RW-2	P&T	6073220.437	2203949.605	15.25	-15.25	Partial	2	10/1/2013	3/31/2014	0.96	16	4Q 2013 GW Mon. Report. ARCADIS. 3/26/2014	14.72	-10.54	
ITT	22	RW-2	P&T	6073220.437	2203949.605	15.25	-15.25	Partial	2	4/1/2014	9/30/2014	1.27	17	2Q 2014 GW Mon. Report. ARCADIS. 9/17/2014	14.72	-10.54	
ITT	22	RW-2	P&T	6073220.437	2203949.605	15.25	-15.25	Partial	2	10/1/2014	4/16/2015	1.46	18	4Q 2014 GW Mon. Report. ARCADIS. 2/11/2015	14.72	-10.54	
ITT	22	RW-2	P&T	6073220.437	2203949.605	15.25	-15.25	Partial	2	4/16/2015	10/16/2015	1.92	19	(1SA) 1Q-2Q 2015 GW Mon. Report. ARCADIS. 8/27/2015	14.72	-10.54	
ITT	22	RW-2	P&T	6073220.437	2203949.605	15.25	-15.25	Partial	2	10/16/2015	2/15/2016	1.87	20	(2SA) 3Q-4Q 2015 GW Mon. Report. ARCADIS. 2/23/2016	14.72	-10.54	
ITT	22	RW-2	P&T	6073220.437	2203949.605	15.25	-15.25	Partial	2	2/15/2016	10/16/2016	1.62	21	(1SA) 1Q-2Q 2016 GW Mon. Report. ARCADIS. 7/29/2016	14.72	-10.54	
ITT	22	RW-2	P&T	6073220.437	2203949.605	15.25	-15.25	Partial	2	10/16/2016	3/16/2017	1.53	22	(2SA) 3Q-4Q 2016 GW Mon. Report. ARCADIS. 2/24/2017	14.72	-10.54	
ITT	22	RW-2	P&T	6073220.437	2203949.605	15.25	-15.25	Partial	2	3/16/2017	7/1/2017	1.00	23	(1SA) 1Q-2Q 2017 GW Mon. Report. ARCADIS. 11/1/2017	14.72	-10.54	
ITT	22	RW-3	P&T	6073139.979	2203967.039	14.08	-16.92	Partial	2	1/1/2009	3/16/2009	31.50	4	Q1 2008 Groundwater Monitoring Report and 2009 Groundwater Monitoring Plan. Arcadis. 2/13/2009	15.14	-9.33	Average rate for overall system
ITT	22	RW-3	P&T	6073139.979	2203967.039	14.08	-16.92	Partial	2	3/16/2009	9/16/2009	31.50	5	Q1 2008 Groundwater Monitoring Report and 2009 Groundwater Monitoring Plan. Arcadis. 2/13/2009	15.14	-9.33	Average rate for overall system
ITT	22	RW-3	P&T	6073139.979	2203967.039	14.08	-16.92	Partial	2	9/16/2009	3/16/2010	31.50	6	Q1 2008 Groundwater Monitoring Report and 2009 Groundwater Monitoring Plan. Arcadis. 2/13/2009	15.14	-9.33	Average rate for overall system
ITT	22	RW-3	P&T	6073139.979	2203967.039	14.08	-16.92	Partial	2	3/16/2010	9/16/2010	31.50	7	Q1 2008 Groundwater Monitoring Report and 2009 Groundwater Monitoring Plan. Arcadis. 2/13/2009	15.14	-9.33	Average rate for overall system
ITT	22	RW-3	P&T	6073139.979	2203967.039	14.08	-16.92	Partial	2	9/16/2010	12/31/2010	31.50	8	Q1 2008 Groundwater Monitoring Report and 2009 Groundwater Monitoring Plan. Arcadis. 2/13/2009	15.14	-9.33	Average rate for overall system
ITT	22	RW-3	P&T	6073139.979	2203967.039	14.08	-16.92	Partial	2	1/12/2011	5/16/2011	30.25	9	1Q 2011 GW Mon. Report. ARCADIS. 6/23/2011	15.14	-9.33	
ITT	22	RW-3	P&T	6073139.979	2203967.039	14.08	-16.92	Partial	2	5/16/2011	9/30/2011	24.58	10	2Q 2011 GW Mon. Report. ARCADIS. 9/13/2011	15.14	-9.33	
ITT	22	RW-3	P&T	6073139.979	2203967.039	14.08	-16.92	Partial	2	10/1/2011	2/15/2012	35.07	11	4Q 2011 GW Mon. Report. ARCADIS. 3/5/2012	15.14	-9.33	
ITT	22	RW-3	P&T	6073139.979	2203967.039	14.08	-16.92	Partial	2	2/15/2012	5/16/2012	40.35	12	1Q 2012 GW Mon. Report. ARCADIS. 6/6/2012	15.14	-9.33	
ITT	22	RW-3	P&T	6073139.979	2203967.039	14.08	-16.92	Partial	2	5/16/2012	9/30/2012	39.96	13	2Q 2012 GW Mon. Report. ARCADIS. 9/28/2012	15.14	-9.33	
ITT	22	RW-3	P&T	6073139.979	2203967.039	14.08	-16.92	Partial	2	10/1/2012	3/31/2013	42.37	14	4Q 2012 GW Mon. Report. ARCADIS. 2/19/2013	15.14	-9.33	
ITT	22	RW-3	P&T	6073139.979	2203967.039	14.08	-16.92	Partial	2	4/1/2013	6/30/2013	44.50	15	2Q 2013 GW Mon. Report. ARCADIS. 8/28/2013	15.14	-9.33	
ITT	22	RW-3	P&T	6073139.979	2203967.039	14.08	-16.92	Partial	2	10/1/2013	3/31/2014	43.36	16	4Q 2013 GW Mon. Report. ARCADIS. 3/26/2014	15.14	-9.33	
ITT	22	RW-3	P&T	6073139.979	2203967.039	14.08	-16.92	Partial	2	4/1/2014	9/30/2014	46.14	17	2Q 2014 GW Mon. Report. ARCADIS. 9/17/2014	15.14	-9.33	
ITT	22	RW-3	P&T	6073139.979	2203967.039	14.08	-16.92	Partial	2	10/1/2014	4/16/2015	43.95	18	4Q 2014 GW Mon. Report. ARCADIS. 2/11/2015	15.14	-9.33	
ITT	22	RW-3	P&T	6073139.979	2203967.039	14.08	-16.92	Partial	2	4/16/2015	10/16/2015	43.01	19	(1SA) 1Q-2Q 2015 GW Mon. Report. ARCADIS. 8/27/2015	15.14	-9.33	
ITT	22	RW-3	P&T	6073139.979	2203967.039	14.08	-16.92	Partial	2	10/16/2015	2/15/2016	40.31	20	(2SA) 3Q-4Q 2015 GW Mon. Report. ARCADIS. 2/23/2016	15.14	-9.33	
ITT	22	RW-3	P&T	6073139.979	2203967.039	14.08	-16.92	Partial	2	2/15/2016	10/16/2016	34.84	21	(1SA) 1Q-2Q 2016 GW Mon. Report. ARCADIS. 7/29/2016	15.14	-9.33	
ITT	22	RW-3	P&T	6073139.979	2203967.039	14.08	-16.92	Partial	2	10/16/2016	3/16/2017	33.64	22	(2SA) 3Q-4Q 2016 GW Mon. Report. ARCADIS. 2/24/2017	15.14	-9.33	
ITT	22	RW-3	P&T	6073139.979	2203967.039	14.08	-16.92	Partial	2	3/16/2017	7/1/2017	35.68	23	(1SA) 1Q-2Q 2017 GW Mon. Report. ARCADIS. 11/1/2017	15.14	-9.33	
Ricoh	24	RMW-4D	P&T(HVDPE)	6072371.139	2201261.324	5.87	-4.13	Partial	2	2/15/2007	9/21/2007	3.65	1	Q1 2007 GWM Report. Mactec. 4/26/2007	12.11	-3.22	
Ricoh	24	RMW-4D	P&T(HVDPE)	6072371.139	2201261.324	5.87	-4.13	Partial	2	9/21/2007	3/26/2008	3.29	2	Q4 2007 GWM Report. Mactec. 1/31/2008	12.11	-3.22	
Ricoh	24	RMW-4D	P&T(HVDPE)	6072371.139	2201261.324	5.87	-4.13	Partial	2	3/26/2008	8/29/2008	3.72	3	Q2 2008 GWM Report. Mactec. 7/15/2008	12.11	-3.22	
Ricoh	24	RMW-4D	P&T(HVDPE)	6072371.139	2201261.324	5.87	-4.13	Partial	2	8/29/2008	3/17/2009	4.19	4	Q4 2008 GWM Report. Mactec. 1/15/2009	12.11	-3.22	
Ricoh	24	RMW-4D	P&T(HVDPE)	6072371.139	2201261.324	5.87	-4.13	Partial	2	3/17/2009	9/9/2009	4.05	5	Q2 2009 GWM Report. Mactec. 7/15/2009	12.11	-3.22	
Ricoh	24	RMW-4D	P&T(HVDPE)	6072371.139	2201261.324	5.87	-4.13	Partial	2	9/9/2009	2/26/2010	3.79	6	Q4 2009 GWM Report. Mactec. 1/15/2010	12.11	-3.22	
Ricoh	24	RMW-4D	P&T(HVDPE)	6072371.139	2201261.324	5.87	-4.13	Partial	2	2/26/2010	4/22/2010	1.95	7	Q2 2010 GWM Report. Mactec. 7/15/2010	12.11	-3.22	
Steelcase Inc.	25	MW-2	DPE	6077348.031	2207611.301	60.73	50.73	Full	1	9/30/2008	10/16/2008	0.04	3	Q4 2008 GWM Report. E2 Environmental. 3/5/2009	66.12	2.48	
Steelcase Inc.	25	MW-2	DPE	6077348.031	2207611.301	60.73	50.73	Full	1	10/16/2008	3/16/2009	0.01	4	Q4 2008 GWM Report. E2 Environmental. 3/5/2009	66.12	2.48	
Steelcase Inc.	25	MW-2	DPE	6077348.031	2207611.301	60.73	50.73	Full	1	3/16/2009	9/16/2009	0.02	5	Semi-Annual GWM Report, Apr 2009 - Sept 2009. E2 Environmental. 12/8/2009	66.12	2.48	
Steelcase Inc.	25	MW-2	DPE	6077348.031	2207611.301	60.73	50.73	Full	1	9/16/2009	3/16/2010	0.01	6	Semi-Annual GWM Report, Apr 2009 - Sept 2009. E2 Environmental. 12/8/2009	66.12	2.48	
Steelcase Inc.	25	MW-2	DPE	6077348.031	2207611.301	60.73	50.73	Full	1	3/16/2010	9/16/2010	0.02	7	Semi-Annual GWM Report, Oct 2009 - June 2010. E2 Environmental. 6/29/2010	66.12	2.48	
Steelcase Inc.	25	MW-2	DPE	6077348.031	2207611.301	60.73	50.73	Full	1	9/16/2010	1/16/2011	0.02	8	Semi-Annual GWM Report, July 2010 - Dec 2010. E2 Environmental. 4/7/2011	66.12	2.48	

Appendix A-1. Summary of Remedial Extraction Systems, South Basin Groundwater Protection Project Study Area

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
Steelcase Inc.	25	MW-2	DPE	6077348.031	2207611.301	60.73	50.73	Full	1	1/16/2011	5/5/2011	0.03	9	Annual GWM Report, Jan 2011 - Dec 2011. E2 Envirnomental. 4/26/2012.	66.12	2.48	
Steelcase Inc.	25	MW-2	DPE	6077348.031	2207611.301	60.73	50.73	Full	1	5/5/2011	9/15/2011	0.11	10	Annual GWM Report, Jan 2011 - Dec 2011. E2 Envirnomental. 4/26/2012.	66.12	2.48	
Steelcase Inc.	25	MW-2	DPE	6077348.031	2207611.301	60.73	50.73	Full	1	9/15/2011	12/5/2011	0.10	11	Annual GWM Report, Jan 2011 - Dec 2011. E2 Envirnomental. 4/26/2012.	66.12	2.48	
Steelcase Inc.	25	MW-22B	P&T	6077419.725	2207574.104	20.78	10.78	Full	1	1/10/2013	3/18/2013	2.36	14	Annual Report 2017. ERM. 5/29/2018	66.12	2.48	
Steelcase Inc.	25	MW-22B	P&T	6077419.725	2207574.104	20.78	10.78	Full	1	3/22/2013	10/16/2013	2.77	15	Annual Report 2017. ERM. 5/29/2018	66.12	2.48	
Steelcase Inc.	25	MW-22B	P&T	6077419.725	2207574.104	20.78	10.78	Full	1	10/18/2013	3/19/2014	2.79	16	Annual Report 2017. ERM. 5/29/2018	66.12	2.48	
Steelcase Inc.	25	MW-22B	P&T	6077419.725	2207574.104	20.78	10.78	Full	1	3/26/2014	9/19/2014	3.42	17	Annual Report 2017. ERM. 5/29/2018	66.12	2.48	
Steelcase Inc.	25	MW-22B	P&T	6077419.725	2207574.104	20.78	10.78	Full	1	9/22/2014	4/13/2015	3.46	18	Annual Report 2017. ERM. 5/29/2018	66.12	2.48	
Steelcase Inc.	25	MW-22B	P&T	6077419.725	2207574.104	20.78	10.78	Full	1	4/20/2015	10/19/2015	3.51	19	Annual Report 2017. ERM. 5/29/2018	66.12	2.48	
Steelcase Inc.	25	MW-22B	P&T	6077419.725	2207574.104	20.78	10.78	Full	1	10/28/2015	2/15/2016	3.48	20	Annual Report 2017. ERM. 5/29/2018	66.12	2.48	
Steelcase Inc.	25	MW-22B	P&T	6077419.725	2207574.104	20.78	10.78	Full	1	2/26/2016	10/17/2016	3.48	21	Annual Report 2017. ERM. 5/29/2018	66.12	2.48	
Steelcase Inc.	25	MW-22B	P&T	6077419.725	2207574.104	20.78	10.78	Full	1	10/28/2016	3/17/2017	2.84	22	Annual Report 2017. ERM. 5/29/2018	66.12	2.48	
Steelcase Inc.	25	MW-22B	P&T	6077419.725	2207574.104	20.78	10.78	Full	1	3/24/2017	6/30/2017	3.94	23	Annual Report 2017. ERM. 5/29/2018	66.12	2.48	
Steelcase Inc.	25	MW-23B	P&T	6077428.635	2207492.373	27.29	12.29	Full	1	1/10/2013	3/18/2013	6.86	14	Annual Report 2017. ERM. 5/29/2018	66.12	2.48	
Steelcase Inc.	25	MW-23B	P&T	6077428.635	2207492.373	27.29	12.29	Full	1	3/22/2013	10/16/2013	7.02	15	Annual Report 2017. ERM. 5/29/2018	66.12	2.48	
Steelcase Inc.	25	MW-23B	P&T	6077428.635	2207492.373	27.29	12.29	Full	1	10/18/2013	3/19/2014	7.03	16	Annual Report 2017. ERM. 5/29/2018	66.12	2.48	
Steelcase Inc.	25	MW-23B	P&T	6077428.635	2207492.373	27.29	12.29	Full	1	3/26/2014	9/19/2014	7.27	17	Annual Report 2017. ERM. 5/29/2018	66.12	2.48	
Steelcase Inc.	25	MW-23B	P&T	6077428.635	2207492.373	27.29	12.29	Full	1	9/22/2014	4/13/2015	7.43	18	Annual Report 2017. ERM. 5/29/2018	66.12	2.48	
Steelcase Inc.	25	MW-23B	P&T	6077428.635	2207492.373	27.29	12.29	Full	1	4/20/2015	10/19/2015	7.50	19	Annual Report 2017. ERM. 5/29/2018	66.12	2.48	
Steelcase Inc.	25	MW-23B	P&T	6077428.635	2207492.373	27.29	12.29	Full	1	10/28/2015	2/15/2016	7.50	20	Annual Report 2017. ERM. 5/29/2018	66.12	2.48	
Steelcase Inc.	25	MW-23B	P&T	6077428.635	2207492.373	27.29	12.29	Full	1	2/26/2016	10/17/2016	7.50	21	Annual Report 2017. ERM. 5/29/2018	66.12	2.48	
Steelcase Inc.	25	MW-23B	P&T	6077428.635	2207492.373	27.29	12.29	Full	1	10/28/2016	3/17/2017	7.16	22	Annual Report 2017. ERM. 5/29/2018	66.12	2.48	
Steelcase Inc.	25	MW-23B	P&T	6077428.635	2207492.373	27.29	12.29	Full	1	3/24/2017	6/30/2017	7.03	23	Annual Report 2017. ERM. 5/29/2018	66.12	2.48	
Steelcase Inc.	25	MW-5	DPE	6077417.393	2207616.538	61.37	46.37	Full	1	9/30/2008	10/16/2008	0.04	3	Q4 2008 GWM Report. E2 Environmental. 3/5/2009	66.12	2.48	
Steelcase Inc.	25	MW-5	DPE	6077417.393	2207616.538	61.37	46.37	Full	1	10/16/2008	3/16/2009	0.04	4	Q4 2008 GWM Report. E2 Environmental. 3/5/2009	66.12	2.48	
Steelcase Inc.	25	MW-5	DPE	6077417.393	2207616.538	61.37	46.37	Full	1	3/16/2009	9/16/2009	0.03	5	Semi-Annual GWM Report, Apr 2009 - Sept 2009. E2 Environmental. 12/8/2009	66.12	2.48	
Steelcase Inc.	25	MW-5	DPE	6077417.393	2207616.538	61.37	46.37	Full	1	9/16/2009	3/16/2010	0.01	6	Semi-Annual GWM Report, Apr 2009 - Sept 2009. E2 Environmental. 12/8/2009	66.12	2.48	
Steelcase Inc.	25	MW-5	DPE	6077417.393	2207616.538	61.37	46.37	Full	1	3/16/2010	9/16/2010	0.01	7	Semi-Annual GWM Report, Oct 2009 - June 2010. E2 Environmental. 6/29/2010	66.12	2.48	
Steelcase Inc.	25	MW-5	DPE	6077417.393	2207616.538	61.37	46.37	Full	1	9/16/2010	1/16/2011	0.01	8	Semi-Annual GWM Report, July 2010 - Dec 2010. E2 Environmental. 4/7/2011	66.12	2.48	
Steelcase Inc.	25	MW-5	DPE	6077417.393	2207616.538	61.37	46.37	Full	1	1/16/2011	5/5/2011	0.02	9	Annual GWM Report, Jan 2011 - Dec 2011. E2 Envirnomental. 4/26/2012.	66.12	2.48	
Steelcase Inc.	25	MW-5	DPE	6077417.393	2207616.538	61.37	46.37	Full	1	5/5/2011	9/15/2011	0.13	10	Annual GWM Report, Jan 2011 - Dec 2011. E2 Envirnomental. 4/26/2012.	66.12	2.48	
Steelcase Inc.	25	MW-5	DPE	6077417.393	2207616.538	61.37	46.37	Full	1	9/15/2011	12/5/2011	0.13	11	Annual GWM Report, Jan 2011 - Dec 2011. E2 Envirnomental. 4/26/2012.	66.12	2.48	
Steelcase Inc.	25	MW-7	DPE	6077438.484	2207599.584	61.55	46.55	Full	1	9/30/2008	10/16/2008	0.04	3	Q4 2008 GWM Report. E2 Environmental. 3/5/2009	66.12	2.48	
Steelcase Inc.	25	MW-7	DPE	6077438.484	2207599.584	61.55	46.55	Full	1	10/16/2008	3/16/2009	0.04	4	Q4 2008 GWM Report. E2 Environmental. 3/5/2009	66.12	2.48	
Steelcase Inc.	25	MW-7	DPE	6077438.484	2207599.584	61.55	46.55	Full	1	3/16/2009	9/16/2009	0.03	5	Semi-Annual GWM Report, Apr 2009 - Sept 2009. E2 Environmental. 12/8/2009	66.12	2.48	
Steelcase Inc.	25	MW-7	DPE	6077438.484	2207599.584	61.55	46.55	Full	1	9/16/2009	3/16/2010	0.01	6	Semi-Annual GWM Report, Apr 2009 - Sept 2009. E2 Environmental. 12/8/2009	66.12	2.48	
Steelcase Inc.	25	MW-7	DPE	6077438.484	2207599.584	61.55	46.55	Full	1	3/16/2010	9/16/2010	0.01	7	Semi-Annual GWM Report, Oct 2009 - June 2010. E2 Environmental. 6/29/2010	66.12	2.48	
Steelcase Inc.	25	MW-7	DPE	6077438.484	2207599.584	61.55	46.55	Full	1	9/16/2010	1/16/2011	0.01	8	Semi-Annual GWM Report, July 2010 - Dec 2010. E2 Environmental. 4/7/2011	66.12	2.48	
Steelcase Inc.	25	MW-7	DPE	6077438.484	2207599.584	61.55	46.55	Full	1	1/16/2011	5/5/2011	0.02	9	Annual GWM Report, Jan 2011 - Dec 2011. E2 Envirnomental. 4/26/2012.	66.12	2.48	
Steelcase Inc.	25	MW-7	DPE	6077438.484	2207599.584	61.55	46.55	Full	1	5/5/2011	9/15/2011	0.13	10	Annual GWM Report, Jan 2011 - Dec 2011. E2 Envirnomental. 4/26/2012.	66.12	2.48	
Steelcase Inc.	25	MW-7	DPE	6077438.484	2207599.584	61.55	46.55	Full	1	9/15/2011	12/5/2011	0.13	11	Annual GWM Report, Jan 2011 - Dec 2011. E2 Environmental. 4/26/2012.	66.12	2.48	
Steelcase Inc.	25	MW-8	DPE	6077474.224	2207566.029	61.09	51.09	Full	1	9/30/2008	10/16/2008	0.04	3	Q4 2008 GWM Report. E2 Environmental. 3/5/2009	66.12	2.48	

Appendix A-1. Summary of Remedial Extraction Systems, South Basin Groundwater Protection Project Study Area

Facility Name	Site	Well ID	Remediation	X	Y	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Penetration	Layer	Start	End	Rate(gpm)	Stress_Period	Source	Layer Top (ft msl)	Layer Bottom (ft msl)	Comments
Steelcase Inc.	25	MW-8	DPE	6077474.224	2207566.029	61.09	51.09	Full	1	10/16/2008	3/16/2009	0.04	4	Q4 2008 GWM Report. E2 Environmental. 3/5/2009	66.12	2.48	
Steelcase Inc.	25	MW-8	DPE	6077474.224	2207566.029	61.09	51.09	Full	1	3/16/2009	9/16/2009	0.03	5	Semi-Annual GWM Report, Apr 2009 - Sept 2009. E2 Environmental. 12/8/2009	66.12	2.48	
Steelcase Inc.	25	MW-8	DPE	6077474.224	2207566.029	61.09	51.09	Full	1	9/16/2009	3/16/2010	0.01	6	Semi-Annual GWM Report, Apr 2009 - Sept 2009. E2 Environmental. 12/8/2009	66.12	2.48	
Steelcase Inc.	25	MW-8	DPE	6077474.224	2207566.029	61.09	51.09	Full	1	3/16/2010	9/16/2010	0.01	7	Semi-Annual GWM Report, Oct 2009 - June 2010. E2 Environmental. 6/29/2010	66.12	2.48	
Steelcase Inc.	25	MW-8	DPE	6077474.224	2207566.029	61.09	51.09	Full	1	9/16/2010	1/16/2011	0.01	8	Semi-Annual GWM Report, July 2010 - Dec 2010. E2 Environmental. 4/7/2011	66.12	2.48	
Steelcase Inc.	25	MW-8	DPE	6077474.224	2207566.029	61.09	51.09	Full	1	1/16/2011	5/5/2011	0.02	9	Annual GWM Report, Jan 2011 - Dec 2011. E2 Environmental. 4/26/2012.	66.12	2.48	
Steelcase Inc.	25	MW-8	DPE	6077474.224	2207566.029	61.09	51.09	Full	1	5/5/2011	9/15/2011	0.13	10	Annual GWM Report, Jan 2011 - Dec 2011. E2 Environmental. 4/26/2012.	66.12	2.48	
Steelcase Inc.	25	MW-8	DPE	6077474.224	2207566.029	61.09	51.09	Full	1	9/15/2011	12/5/2011	0.13	11	Annual GWM Report, Jan 2011 - Dec 2011. E2 Environmental. 4/26/2012.	66.12	2.48	
Steelcase Inc.	25	Trench Sump	Ext.	6077428.88	2207590.97	46.19	33.69	Full	1	9/30/2008	10/16/2008	0.04	3	Q4 2008 GWM Report. E2 Environmental. 3/5/2009	66.12	2.48	
Steelcase Inc.	25	Trench Sump	Ext.	6077428.88	2207590.97	46.19	33.69	Full	1	10/16/2008	3/16/2009	0.04	4	Q4 2008 GWM Report. E2 Environmental. 3/5/2009	66.12	2.48	
Steelcase Inc.	25	Trench Sump	Ext.	6077428.88	2207590.97	46.19	33.69	Full	1	3/16/2009	9/16/2009	0.03	5	Semi-Annual GWM Report, Apr 2009 - Sept 2009. E2 Environmental. 12/8/2009	66.12	2.48	
Steelcase Inc.	25	Trench Sump	Ext.	6077428.88	2207590.97	46.19	33.69	Full	1	9/16/2009	3/16/2010	0.01	6	Semi-Annual GWM Report, Apr 2009 - Sept 2009. E2 Environmental. 12/8/2009	66.12	2.48	
Steelcase Inc.	25	Trench Sump	Ext.	6077428.88	2207590.97	46.19	33.69	Full	1	3/16/2010	9/16/2010	0.01	7	Semi-Annual GWM Report, Oct 2009 - June 2010. E2 Environmental. 6/29/2010	66.12	2.48	
Steelcase Inc.	25	Trench Sump	Ext.	6077428.88	2207590.97	46.19	33.69	Full	1	9/16/2010	1/16/2011	0.01	8	Semi-Annual GWM Report, July 2010 - Dec 2010. E2 Environmental. 4/7/2011	66.12	2.48	
Steelcase Inc.	25	Trench Sump	Ext.	6077428.88	2207590.97	46.19	33.69	Full	1	1/16/2011	5/5/2011	0.02	9	Annual GWM Report, Jan 2011 - Dec 2011. E2 Environmental. 4/26/2012.	66.12	2.48	
Steelcase Inc.	25	Trench Sump	Ext.	6077428.88	2207590.97	46.19	33.69	Full	1	5/5/2011	9/15/2011	0.13	10	Annual GWM Report, Jan 2011 - Dec 2011. E2 Environmental. 4/26/2012.	66.12	2.48	
Steelcase Inc.	25	Trench Sump	Ext.	6077428.88	2207590.97	46.19	33.69	Full	1	9/15/2011	12/5/2011	0.13	11	Annual GWM Report, Jan 2011 - Dec 2011. E2 Environmental. 4/26/2012.	66.12	2.48	

APPENDIX A-2
CALIBRATION TARGETS, SBGPP GROUNDWATER MODEL

Well Name	Time (days)	X (feet)	Y (feet)	Layer	Observed (feet amsl)	Computed (feet amsl)	Residual (feet)	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Group*	Top of Layer (feet amsl)	Bottom of Layer (feet amsl)
103MW41	426	6073321	2211605	1	59.53	56.77	2.76	67.54	47.54	1	76.61	21.23
103MW41	609	6073321	2211605	1	58.23	55.90	2.33	67.54	47.54	1	76.61	21.23
103MW41	760	6073321	2211605	1	58.34	55.30	3.04	67.54	47.54	1	76.61	21.23
103MW41	944	6073321	2211605	1	56.28	54.70	1.58	67.54	47.54	1	76.61	21.23
103MW41	1125	6073321	2211605	1	57	54.21	2.79	67.54	47.54	1	76.61	21.23
103MW41	1309	6073321	2211605	1	55.39	53.81	1.58	67.54	47.54	1	76.61	21.23
103MW41	1431	6073321	2211605	1	58.66	53.58	5.08	67.54	47.54	1	76.61	21.23
103MW41	1551	6073321	2211605	1	57.61	53.40	4.21	67.54	47.54	1	76.61	21.23
103MW41	1674	6073321	2211605	1	56.86	53.23	3.63	67.54	47.54	1	76.61	21.23
103MW41	1826	6073321	2211605	1	56.46	53.07	3.39	67.54	47.54	1	76.61	21.23
103MW41	1917	6073321	2211605	1	56.55	52.98	3.57	67.54	47.54	1	76.61	21.23
103MW41	2070	6073321	2211605	1	56.14	52.80	3.34	67.54	47.54	1	76.61	21.23
103MW41	2221	6073321	2211605	1	55.88	52.58	3.30	67.54	47.54	1	76.61	21.23
103MW41	2435	6073321	2211605	1	55.53	52.19	3.34	67.54	47.54	1	76.61	21.23
103MW41	2586	6073321	2211605	1	54.69	51.86	2.83	67.54	47.54	1	76.61	21.23
103MW41	2770	6073321	2211605	1	53.52	51.40	2.12	67.54	47.54	1	76.61	21.23
103MW41	2982	6073321	2211605	1	52.82	50.81	2.01	67.54	47.54	1	76.61	21.23
103MW41	3287	6073321	2211605	1	50.98	49.87	1.11	67.54	47.54	1	76.61	21.23
103MW41	3531	6073321	2211605	1	49.44	49.14	0.30	67.54	47.54	1	76.61	21.23
103MW41	3682	6073321	2211605	1	49.99	48.79	1.20	67.54	47.54	1	76.61	21.23
103MW41	3788	6073321	2211605	1	49.93	48.59	1.34	67.54	47.54	1	76.61	21.23
22MW3S	426	6073041	2205167	1	39.89	37.98	1.91	40.35	28.35	1	47.87	8.18
22MW3S	609	6073041	2205167	1	39.36	37.31	2.05	40.35	28.35	1	47.87	8.18
22MW3S	760	6073041	2205167	1	39.75	36.73	3.02	40.35	28.35	1	47.87	8.18
22MW3S	944	6073041	2205167	1	39.99	36.19	3.80	40.35	28.35	1	47.87	8.18
22MW3S	1125	6073041	2205167	1	40.86	35.82	5.04	40.35	28.35	1	47.87	8.18
22MW3S	1309	6073041	2205167	1	39.96	35.59	4.37	40.35	28.35	1	47.87	8.18
22MW3S	1431	6073041	2205167	1	40.01	35.50	4.51	40.35	28.35	1	47.87	8.18
22MW3S	1551	6073041	2205167	1	40.06	35.46	4.60	40.35	28.35	1	47.87	8.18
22MW3S	1674	6073041	2205167	1	40.1	35.48	4.62	40.35	28.35	1	47.87	8.18
22MW3S	1826	6073041	2205167	1	39.77	35.52	4.25	40.35	28.35	1	47.87	8.18
22MW3S	1917	6073041	2205167	1	38.71	35.53	3.18	40.35	28.35	1	47.87	8.18
22MW3S	2070	6073041	2205167	1	39.22	35.46	3.76	40.35	28.35	1	47.87	8.18
22MW3S	2221	6073041	2205167	1	39.27	35.28	3.99	40.35	28.35	1	47.87	8.18
22MW3S	2435	6073041	2205167	1	38.79	34.86	3.93	40.35	28.35	1	47.87	8.18
22MW3S	2586	6073041	2205167	1	39.39	34.49	4.90	40.35	28.35	1	47.87	8.18
22MW3S	2770	6073041	2205167	1	37.23	33.96	3.27	40.35	28.35	1	47.87	8.18
22MW3S	2982	6073041	2205167	1	38.89	33.30	5.59	40.35	28.35	1	47.87	8.18
22MW3S	3165	6073041	2205167	1	39	32.71	6.29	40.35	28.35	1	47.87	8.18
22MW3S	3531	6073041	2205167	1	41.07	31.75	9.32	40.35	28.35	1	47.87	8.18
22MW401S	426	6072262	2204068	1	33.35	34.91	-1.56	34.16	24.56	1	44.72	10.23
22MW401S	609	6072262	2204068	1	33.42	34.40	-0.98	34.16	24.56	1	44.72	10.23
22MW401S	760	6072262	2204068	1	34.57	33.88	0.69	34.16	24.56	1	44.72	10.23
22MW401S	944	6072262	2204068	1	32.86	33.43	-0.57	34.16	24.56	1	44.72	10.23
22MW401S	1125	6072262	2204068	1	34.82	33.17	1.65	34.16	24.56	1	44.72	10.23
22MW401S	1309	6072262	2204068	1	34.21	33.04	1.17	34.16	24.56	1	44.72	10.23
22MW401S	1431	6072262	2204068	1	34.62	33.02	1.60	34.16	24.56	1	44.72	10.23
22MW401S	1551	6072262	2204068	1	36.17	33.04	3.13	34.16	24.56	1	44.72	10.23
22MW401S	1674	6072262	2204068	1	35.62	33.13	2.49	34.16	24.56	1	44.72	10.23
22MW401S	1826	6072262	2204068	1	35.65	33.21	2.44	34.16	24.56	1	44.72	10.23
22MW401S	1917	6072262	2204068	1	35.82	33.24	2.58	34.16	24.56	1	44.72	10.23
22MW401S	2070	6072262	2204068	1	35.27	33.15	2.12	34.16	24.56	1	44.72	10.23
22MW401S	2221	6072262	2204068	1	35.6	32.93	2.67	34.16	24.56	1	44.72	10.23
22MW401S	2435	6072262	2204068	1	33.96	32.45	1.51	34.16	24.56	1	44.72	10.23
22MW401S	2586	6072262	2204068	1	34.6	32.05	2.55	34.16	24.56	1	44.72	10.23
22MW401S	2770	6072262	2204068	1	32.95	31.50	1.45	34.16	24.56	1	44.72	10.23
22MW401S	2982	6072262	2204068	1	32.92	30.84	2.08	34.16	24.56	1	44.72	10.23
22MW401S	3165	6072262	2204068	1	32.21	30.27	1.94	34.16	24.56	1	44.72	10.23
5W2	426	6074328	2208275	1	54.44	49.69	4.75	55.93	45.93	1	61.55	15.97
5W2	609	6074328	2208275	1	53.86	49.05	4.81	55.93	45.93	1	61.55	15.97
5W2	760	6074328	2208275	1	53.38	48.53	4.85	55.93	45.93	1	61.55	15.97
5W2	944	6074328	2208275	1	51.56	48.08	3.48	55.93	45.93	1	61.55	15.97
5W2	1125	6074328	2208275	1	53.78	47.83	5.95	55.93	45.93	1	61.55	15.97
5W2	1309	6074328	2208275	1	53.88	47.64	6.24	55.93	45.93	1	61.55	15.97
5W2	1431	6074328	2208275	1	55.03	47.56	7.47	55.93	45.93	1	61.55	15.97
5W2	1551	6074328	2208275	1	54.88	47.53	7.35	55.93	45.93	1	61.55	15.97
5W2	1674	6074328	2208275	1	54.21	47.52	6.69	55.93	45.93	1	61.55	15.97
5W2	1826	6074328	2208275	1	53.33	47.54	5.79	55.93	45.93	1	61.55	15.97
5W2	1917	6074328	2208275	1	53.73	47.53	6.20	55.93	45.93	1	61.55	15.97
5W2	2070	6074328	2208275	1	53.31	47.43	5.88	55.93	45.93	1	61.55	15.97

* Group 1 - Targets are within Study Area and are actual observations
55 - Targets are within Study Area and are synthetic data based on potentiometric surface map projections
66 - Targets area outside of Study Area and are actual observations

Well Name	Time (days)	X (feet)	Y (feet)	Layer	Observed (feet amsl)	Computed (feet amsl)	Residual (feet)	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Group*	Top of Layer (feet amsl)	Bottom of Layer (feet amsl)
5W2	2221	6074328	2208275	1	53.19	47.23	5.96	55.93	45.93	1	61.55	15.97
5W2	2435	6074328	2208275	1	52.28	46.65	5.63	55.93	45.93	1	61.55	15.97
5W2	2586	6074328	2208275	1	50.91	46.11	4.80	55.93	45.93	1	61.55	15.97
5W2	2770	6074328	2208275	1	50.29	45.36	4.93	55.93	45.93	1	61.55	15.97
5W2	2982	6074328	2208275	1	49.16	44.42	4.74	55.93	45.93	1	61.55	15.97
5W2	3165	6074328	2208275	1	48.4	43.56	4.84	55.93	45.93	1	61.55	15.97
5W2	3287	6074328	2208275	1	47.71	42.99	4.72	55.93	45.93	1	61.55	15.97
5W2	3531	6074328	2208275	1	46.33	42.15	4.18	55.93	45.93	1	61.55	15.97
5W2	3682	6074328	2208275	1	51.94	41.96	9.98	55.93	45.93	1	61.55	15.97
5W2	3788	6074328	2208275	1	50.33	41.93	8.40	55.93	45.93	1	61.55	15.97
104OW50	944	6074918	2191235	4	6.98	11.02	-4.04	4.99	-7.01	66	24.79	-20.09
104OW50	1125	6074918	2191235	4	7.04	11.04	-4.00	4.99	-7.01	66	24.79	-20.09
104OW50	1309	6074918	2191235	4	5.06	11.34	-6.28	4.99	-7.01	66	24.79	-20.09
104OW50	1431	6074918	2191235	4	8.31	11.78	-3.47	4.99	-7.01	66	24.79	-20.09
104OW50	1674	6074918	2191235	4	8.27	13.20	-4.93	4.99	-7.01	66	24.79	-20.09
104OW50	1826	6074918	2191235	4	8.47	13.92	-5.45	4.99	-7.01	66	24.79	-20.09
104OW50	2070	6074918	2191235	4	4.66	13.63	-8.97	4.99	-7.01	66	24.79	-20.09
104OW50	2221	6074918	2191235	4	7.82	13.39	-5.57	4.99	-7.01	66	24.79	-20.09
104OW50	2435	6074918	2191235	4	7.28	12.30	-5.02	4.99	-7.01	66	24.79	-20.09
104OW50	2586	6074918	2191235	4	6.23	11.79	-5.56	4.99	-7.01	66	24.79	-20.09
104OW50	2770	6074918	2191235	4	5.9	10.81	-4.91	4.99	-7.01	66	24.79	-20.09
104OW50	2982	6074918	2191235	4	5.49	10.42	-4.93	4.99	-7.01	66	24.79	-20.09
104OW50	3165	6074918	2191235	4	4.99	10.29	-5.30	4.99	-7.01	66	24.79	-20.09
104OW50	3287	6074918	2191235	4	5.08	10.30	-5.22	4.99	-7.01	66	24.79	-20.09
104OW50	3531	6074918	2191235	4	5.47	10.01	-4.54	4.99	-7.01	66	24.79	-20.09
104OW50	3682	6074918	2191235	4	5.76	10.14	-4.38	4.99	-7.01	66	24.79	-20.09
104OW50	3788	6074918	2191235	4	6.22	10.37	-4.15	4.99	-7.01	66	24.79	-20.09
222269-MW-10	609	6074930	2198329	2	22.95	24.54	-1.59	12.78	4.15	1	16.90	-0.43
222269-MW-10	760	6074930	2198329	2	23.5	24.39	-0.89	12.78	4.15	1	16.90	-0.43
222269-MW-10	944	6074930	2198329	2	22.75	24.20	-1.45	12.78	4.15	1	16.90	-0.43
222269-MW-10	1125	6074930	2198329	2	23.95	24.16	-0.21	12.78	4.15	1	16.90	-0.43
222269-MW-10	1309	6074930	2198329	2	23.01	24.26	-1.25	12.78	4.15	1	16.90	-0.43
222269-MW-10	1431	6074930	2198329	2	23.32	24.44	-1.12	12.78	4.15	1	16.90	-0.43
222269-MW-10	1551	6074930	2198329	2	23.32	24.67	-1.35	12.78	4.15	1	16.90	-0.43
222269-MW-10	1674	6074930	2198329	2	23.1	25.02	-1.92	12.78	4.15	1	16.90	-0.43
222269-MW-10	1826	6074930	2198329	2	23.19	25.38	-2.19	12.78	4.15	1	16.90	-0.43
222269-MW-10	1917	6074930	2198329	2	23.21	25.47	-2.26	12.78	4.15	1	16.90	-0.43
222269-MW-10	2070	6074930	2198329	2	23.07	25.30	-2.23	12.78	4.15	1	16.90	-0.43
222269-MW-10	2221	6074930	2198329	2	23.15	25.10	-1.95	12.78	4.15	1	16.90	-0.43
222269-MW-10	2435	6074930	2198329	2	22.84	24.52	-1.68	12.78	4.15	1	16.90	-0.43
222269-MW-10	2586	6074930	2198329	2	23.1	24.14	-1.04	12.78	4.15	1	16.90	-0.43
222269-MW-10	2770	6074930	2198329	2	22.53	23.53	-1.00	12.78	4.15	1	16.90	-0.43
222269-MW-10	2982	6074930	2198329	2	22.61	23.05	-0.44	12.78	4.15	1	16.90	-0.43
222269-MW-10	3165	6074930	2198329	2	22.25	22.73	-0.48	12.78	4.15	1	16.90	-0.43
222269-MW-10	3287	6074930	2198329	2	22.64	22.57	0.07	12.78	4.15	1	16.90	-0.43
222269-MW-10	3531	6074930	2198329	2	22.75	22.34	0.41	12.78	4.15	1	16.90	-0.43
222269-MW-10	3682	6074930	2198329	2	22.68	22.41	0.27	12.78	4.15	1	16.90	-0.43
222269-MW-10	3788	6074930	2198329	2	23.4	22.49	0.91	12.78	4.15	1	16.90	-0.43
22MW104AB	426	6072257	2204044	2	33.05	33.66	-0.61	11.92	0.42	1	10.26	-20.06
22MW104AB	609	6072257	2204044	2	32.72	33.31	-0.59	11.92	0.42	1	10.26	-20.06
22MW104AB	760	6072257	2204044	2	33.27	32.93	0.34	11.92	0.42	1	10.26	-20.06
22MW104AB	944	6072257	2204044	2	31.32	32.80	-1.48	11.92	0.42	1	10.26	-20.06
22MW104AB	1125	6072257	2204044	2	33.67	32.79	0.88	11.92	0.42	1	10.26	-20.06
22MW104AB	1309	6072257	2204044	2	32.39	32.85	-0.46	11.92	0.42	1	10.26	-20.06
22MW104AB	1431	6072257	2204044	2	33.47	32.95	0.52	11.92	0.42	1	10.26	-20.06
22MW104AB	1551	6072257	2204044	2	32.87	33.08	-0.21	11.92	0.42	1	10.26	-20.06
22MW104AB	1674	6072257	2204044	2	32.82	33.22	-0.40	11.92	0.42	1	10.26	-20.06
22MW104AB	1826	6072257	2204044	2	33.44	33.34	0.10	11.92	0.42	1	10.26	-20.06
22MW104AB	1917	6072257	2204044	2	33.37	33.23	0.14	11.92	0.42	1	10.26	-20.06
22MW104AB	2070	6072257	2204044	2	33.02	32.88	0.14	11.92	0.42	1	10.26	-20.06
22MW104AB	2221	6072257	2204044	2	33.17	32.47	0.70	11.92	0.42	1	10.26	-20.06
22MW104AB	2435	6072257	2204044	2	32.03	31.79	0.24	11.92	0.42	1	10.26	-20.06
22MW104AB	2586	6072257	2204044	2	32.34	31.31	1.03	11.92	0.42	1	10.26	-20.06
22MW104AB	2770	6072257	2204044	2	30.91	30.65	0.26	11.92	0.42	1	10.26	-20.06
22MW104AB	2982	6072257	2204044	2	30.6	29.96	0.64	11.92	0.42	1	10.26	-20.06
22MW104AB	3287	6072257	2204044	2	30.07	29.05	1.02	11.92	0.42	1	10.26	-20.06
22MW104AB	3531	6072257	2204044	2	29.52	29.04	0.48	11.92	0.42	1	10.26	-20.06
22MW3DA	426	6073032	2205156	2	36.57	36.33	0.24	16.36	6.36	1	8.18	-10.63
22MW3DA	609	6073032	2205156	2	35.87	35.92	-0.05	16.36	6.36	1	8.18	-10.63
22MW3DA	760	6073032	2205156	2	36.37	35.39	0.98	16.36	6.36	1	8.18	-10.63
22MW3DA	944	6073032	2205156	2	34.31	35.16	-0.85	16.36	6.36	1	8.18	-10.63
22MW3DA	1125	6073032	2205156	2	36.47	35.08	1.39	16.36	6.36	1	8.18	-10.63

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Well Name	Time (days)	X (feet)	Y (feet)	Layer	Observed (feet amsl)	Computed (feet amsl)	Residual (feet)	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Group*	Top of Layer (feet amsl)	Bottom of Layer (feet amsl)
22MW3DA	1309	6073032	2205156	2	35.35	35.06	0.29	16.36	6.36	1	8.18	-10.63
22MW3DA	1431	6073032	2205156	2	35.39	35.12	0.27	16.36	6.36	1	8.18	-10.63
22MW3DA	1551	6073032	2205156	2	36.17	35.21	0.96	16.36	6.36	1	8.18	-10.63
22MW3DA	1674	6073032	2205156	2	36.72	35.33	1.39	16.36	6.36	1	8.18	-10.63
22MW3DA	1826	6073032	2205156	2	36.87	35.40	1.47	16.36	6.36	1	8.18	-10.63
22MW3DA	1917	6073032	2205156	2	36.97	35.29	1.68	16.36	6.36	1	8.18	-10.63
22MW3DA	2070	6073032	2205156	2	36.42	34.98	1.44	16.36	6.36	1	8.18	-10.63
22MW3DA	2221	6073032	2205156	2	36.83	34.58	2.25	16.36	6.36	1	8.18	-10.63
22MW3DA	2435	6073032	2205156	2	35.35	33.92	1.43	16.36	6.36	1	8.18	-10.63
22MW3DA	2586	6073032	2205156	2	35.39	33.45	1.94	16.36	6.36	1	8.18	-10.63
22MW3DA	2770	6073032	2205156	2	33.93	32.78	1.15	16.36	6.36	1	8.18	-10.63
22MW3DA	2982	6073032	2205156	2	33.34	32.06	1.28	16.36	6.36	1	8.18	-10.63
22MW3DA	3165	6073032	2205156	2	32.64	31.44	1.20	16.36	6.36	1	8.18	-10.63
22MW3DA	3531	6073032	2205156	2	31.73	30.98	0.75	16.36	6.36	1	8.18	-10.63
22MW519A	426	6073075	2202361	2	28.34	31.44	-3.10	7.64	2.64	1	11.96	-19.51
22MW519A	609	6073075	2202361	2	28.71	30.97	-2.26	7.64	2.64	1	11.96	-19.51
22MW519A	760	6073075	2202361	2	29.25	30.25	-1.00	7.64	2.64	1	11.96	-19.51
22MW519A	944	6073075	2202361	2	27.85	29.94	-2.09	7.64	2.64	1	11.96	-19.51
22MW519A	1125	6073075	2202361	2	29.6	29.79	-0.19	7.64	2.64	1	11.96	-19.51
22MW519A	1309	6073075	2202361	2	28.7	29.74	-1.04	7.64	2.64	1	11.96	-19.51
22MW519A	1431	6073075	2202361	2	28.6	29.79	-1.19	7.64	2.64	1	11.96	-19.51
22MW519A	1551	6073075	2202361	2	29.1	29.89	-0.79	7.64	2.64	1	11.96	-19.51
22MW519A	1674	6073075	2202361	2	29.05	30.03	-0.98	7.64	2.64	1	11.96	-19.51
22MW519A	1826	6073075	2202361	2	29.45	30.10	-0.65	7.64	2.64	1	11.96	-19.51
22MW519A	1917	6073075	2202361	2	29.23	30.09	-0.86	7.64	2.64	1	11.96	-19.51
22MW519A	2070	6073075	2202361	2	28.99	29.97	-0.98	7.64	2.64	1	11.96	-19.51
22MW519A	2435	6073075	2202361	2	28.34	29.26	-0.92	7.64	2.64	1	11.96	-19.51
22MW519A	2586	6073075	2202361	2	28.59	28.92	-0.33	7.64	2.64	1	11.96	-19.51
22MW519A	2770	6073075	2202361	2	27.87	28.38	-0.51	7.64	2.64	1	11.96	-19.51
22MW519A	2982	6073075	2202361	2	27.61	27.83	-0.22	7.64	2.64	1	11.96	-19.51
22MW519A	3165	6073075	2202361	2	26.88	27.37	-0.49	7.64	2.64	1	11.96	-19.51
22MW519A	3531	6073075	2202361	2	26.81	26.91	-0.10	7.64	2.64	1	11.96	-19.51
22MW519A	3682	6073075	2202361	2	28.64	26.96	1.68	7.64	2.64	1	11.96	-19.51
22MW519A	3788	6073075	2202361	2	27.85	26.95	0.90	7.64	2.64	1	11.96	-19.51
2SAM10A	609	6075371	2201069	2	28.074	30.20	-2.13	-1.05	-11.05	55	18.31	-14.30
2SAM10A	760	6075371	2201069	2	28.454	29.94	-1.48	-1.05	-11.05	55	18.31	-14.30
2SAM10A	944	6075371	2201069	2	27.084	29.75	-2.67	-1.05	-11.05	55	18.31	-14.30
2SAM10A	1125	6075371	2201069	2	29.094	29.67	-0.57	-1.05	-11.05	55	18.31	-14.30
2SAM10A	1309	6075371	2201069	2	28.404	29.66	-1.26	-1.05	-11.05	55	18.31	-14.30
2SAM10A	1551	6075371	2201069	2	29.524	29.88	-0.36	-1.05	-11.05	55	18.31	-14.30
2SAM10A	1674	6075371	2201069	2	28.804	30.08	-1.28	-1.05	-11.05	55	18.31	-14.30
2SAM10A	1826	6075371	2201069	2	29.094	30.30	-1.21	-1.05	-11.05	55	18.31	-14.30
2SAM10A	2070	6075371	2201069	2	28.474	30.23	-1.76	-1.05	-11.05	55	18.31	-14.30
2SAM10A	2221	6075371	2201069	2	28.664	30.04	-1.38	-1.05	-11.05	55	18.31	-14.30
2SAM10A	2435	6075371	2201069	2	27.844	29.57	-1.73	-1.05	-11.05	55	18.31	-14.30
2SAM10A	2586	6075371	2201069	2	27.894	29.22	-1.33	-1.05	-11.05	55	18.31	-14.30
2SAM10A	2770	6075371	2201069	2	26.604	28.67	-2.06	-1.05	-11.05	55	18.31	-14.30
2SAM10A	2982	6075371	2201069	2	27.014	28.14	-1.12	-1.05	-11.05	55	18.31	-14.30
2SAM10A	3165	6075371	2201069	2	25.894	27.74	-1.84	-1.05	-11.05	55	18.31	-14.30
2SAM10A	3287	6075371	2201069	2	26.184	27.49	-1.31	-1.05	-11.05	55	18.31	-14.30
2SAM10A	3531	6075371	2201069	2	26.094	27.22	-1.13	-1.05	-11.05	55	18.31	-14.30
2SAM10A	3788	6075371	2201069	2	27.854	27.26	0.59	-1.05	-11.05	55	18.31	-14.30
2SAM11A	609	6076586	2202819	2	32.783	33.41	-0.62	-7.12	-12.12	55	12.85	-11.75
2SAM11A	760	6076586	2202819	2	33.003	33.14	-0.13	-7.12	-12.12	55	12.85	-11.75
2SAM11A	944	6076586	2202819	2	31.493	32.95	-1.46	-7.12	-12.12	55	12.85	-11.75
2SAM11A	1125	6076586	2202819	2	33.433	32.85	0.58	-7.12	-12.12	55	12.85	-11.75
2SAM11A	1309	6076586	2202819	2	32.693	32.83	-0.14	-7.12	-12.12	55	12.85	-11.75
2SAM11A	1551	6076586	2202819	2	33.213	33.00	0.21	-7.12	-12.12	55	12.85	-11.75
2SAM11A	1674	6076586	2202819	2	33.633	33.17	0.47	-7.12	-12.12	55	12.85	-11.75
2SAM11A	1826	6076586	2202819	2	34.023	33.36	0.66	-7.12	-12.12	55	12.85	-11.75
2SAM11A	2070	6076586	2202819	2	33.773	33.28	0.50	-7.12	-12.12	55	12.85	-11.75
2SAM11A	2435	6076586	2202819	2	32.173	32.61	-0.44	-7.12	-12.12	55	12.85	-11.75
2SAM11A	2586	6076586	2202819	2	32.753	32.24	0.51	-7.12	-12.12	55	12.85	-11.75
2SAM11A	2770	6076586	2202819	2	30.743	31.68	-0.94	-7.12	-12.12	55	12.85	-11.75
2SAM11A	2982	6076586	2202819	2	30.843	31.12	-0.27	-7.12	-12.12	55	12.85	-11.75
2SAM11A	3165	6076586	2202819	2	30.093	30.66	-0.57	-7.12	-12.12	55	12.85	-11.75
2SAM11A	3287	6076586	2202819	2	30.323	30.38	-0.05	-7.12	-12.12	55	12.85	-11.75
2SAM11A	3531	6076586	2202819	2	29.773	30.08	-0.31	-7.12	-12.12	55	12.85	-11.75
2SAM11A	3788	6076586	2202819	2	32.083	30.11	1.97	-7.12	-12.12	55	12.85	-11.75
2SAM2_1	944	6072812	2208121	2	40.57	41.92	-1.35	5.54	-9.46	1	7.27	-13.53
2SAM2_1	1125	6072812	2208121	2	41.86	41.97	-0.11	5.54	-9.46	1	7.27	-13.53

* Group 1 - Targets are within Study Area and are actual observations
55 - Targets are within Study Area and are synthetic data based on potentiometric surface map projections
66 - Targets area outside of Study Area and are actual observations

Well Name	Time (days)	X (feet)	Y (feet)	Layer	Observed (feet amsl)	Computed (feet amsl)	Residual (feet)	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Group*	Top of Layer (feet amsl)	Bottom of Layer (feet amsl)
2SAM2_1	1309	6072812	2208121	2	40.57	42.05	-1.48	5.54	-9.46	1	7.27	-13.53
2SAM2_1	1431	6072812	2208121	2	42.97	42.15	0.82	5.54	-9.46	1	7.27	-13.53
2SAM2_1	1551	6072812	2208121	2	42.16	42.24	-0.08	5.54	-9.46	1	7.27	-13.53
2SAM2_1	1674	6072812	2208121	2	42.84	42.38	0.46	5.54	-9.46	1	7.27	-13.53
2SAM2_1	1826	6072812	2208121	2	43.46	42.53	0.93	5.54	-9.46	1	7.27	-13.53
2SAM2_1	1917	6072812	2208121	2	43.99	42.31	1.68	5.54	-9.46	1	7.27	-13.53
2SAM2_1	2070	6072812	2208121	2	43.41	41.78	1.63	5.54	-9.46	1	7.27	-13.53
2SAM2_1	2435	6072812	2208121	2	41.99	40.28	1.71	5.54	-9.46	1	7.27	-13.53
2SAM2_1	2586	6072812	2208121	2	41.86	39.60	2.26	5.54	-9.46	1	7.27	-13.53
2SAM2_1	2770	6072812	2208121	2	39.52	38.74	0.78	5.54	-9.46	1	7.27	-13.53
2SAM2_1	2982	6072812	2208121	2	38.98	37.78	1.20	5.54	-9.46	1	7.27	-13.53
2SAM2_1	3165	6072812	2208121	2	37.74	36.93	0.81	5.54	-9.46	1	7.27	-13.53
2SAM2_1	3287	6072812	2208121	2	37.76	36.40	1.36	5.54	-9.46	1	7.27	-13.53
2SAM2_1	3531	6072812	2208121	2	36.14	36.45	-0.31	5.54	-9.46	1	7.27	-13.53
2SAM2_1	3682	6072812	2208121	2	38.78	36.97	1.81	5.54	-9.46	1	7.27	-13.53
2SAM2_1	3788	6072812	2208121	2	37.6	37.00	0.60	5.54	-9.46	1	7.27	-13.53
2SAM3_1	944	6074220	2207609	2	41.41	44.26	-2.85	12.76	-7.24	1	27.69	4.38
2SAM3_1	1125	6074220	2207609	2	42.7	44.19	-1.49	12.76	-7.24	1	27.69	4.38
2SAM3_1	1309	6074220	2207609	2	41.29	44.17	-2.88	12.76	-7.24	1	27.69	4.38
2SAM3_1	1431	6074220	2207609	2	43.49	44.21	-0.72	12.76	-7.24	1	27.69	4.38
2SAM3_1	1551	6074220	2207609	2	42.97	44.25	-1.28	12.76	-7.24	1	27.69	4.38
2SAM3_1	1674	6074220	2207609	2	43.45	44.33	-0.88	12.76	-7.24	1	27.69	4.38
2SAM3_1	1826	6074220	2207609	2	44.05	44.44	-0.39	12.76	-7.24	1	27.69	4.38
2SAM3_1	1917	6074220	2207609	2	44.58	44.31	0.27	12.76	-7.24	1	27.69	4.38
2SAM3_1	2070	6074220	2207609	2	44.01	43.94	0.07	12.76	-7.24	1	27.69	4.38
2SAM3_1	2221	6074220	2207609	2	44.2	43.49	0.71	12.76	-7.24	1	27.69	4.38
2SAM3_1	2435	6074220	2207609	2	42.49	42.71	-0.22	12.76	-7.24	1	27.69	4.38
2SAM3_1	2586	6074220	2207609	2	42.38	42.09	0.29	12.76	-7.24	1	27.69	4.38
2SAM3_1	2770	6074220	2207609	2	40.19	41.29	-1.10	12.76	-7.24	1	27.69	4.38
2SAM3_1	2982	6074220	2207609	2	39.38	40.36	-0.98	12.76	-7.24	1	27.69	4.38
2SAM3_1	3165	6074220	2207609	2	38.31	39.51	-1.20	12.76	-7.24	1	27.69	4.38
2SAM3_1	3287	6074220	2207609	2	38.31	38.97	-0.66	12.76	-7.24	1	27.69	4.38
2SAM3_1	3531	6074220	2207609	2	36.65	38.69	-2.04	12.76	-7.24	1	27.69	4.38
2SAM3_1	3682	6074220	2207609	2	39.54	38.93	0.61	12.76	-7.24	1	27.69	4.38
2SAM3_1	3788	6074220	2207609	2	38.34	38.94	-0.60	12.76	-7.24	1	27.69	4.38
2SAM4_1	944	6072906	2206699	2	37.25	37.54	-0.29	2.61	-12.39	1	11.86	-0.73
2SAM4_1	1125	6072906	2206699	2	39.15	37.61	1.54	2.61	-12.39	1	11.86	-0.73
2SAM4_1	1309	6072906	2206699	2	37.6	37.71	-0.11	2.61	-12.39	1	11.86	-0.73
2SAM4_1	1431	6072906	2206699	2	39.93	37.84	2.09	2.61	-12.39	1	11.86	-0.73
2SAM4_1	1551	6072906	2206699	2	39.17	37.95	1.22	2.61	-12.39	1	11.86	-0.73
2SAM4_1	1674	6072906	2206699	2	39.57	38.13	1.44	2.61	-12.39	1	11.86	-0.73
2SAM4_1	1826	6072906	2206699	2	40.17	38.30	1.87	2.61	-12.39	1	11.86	-0.73
2SAM4_1	1917	6072906	2206699	2	40.58	38.11	2.47	2.61	-12.39	1	11.86	-0.73
2SAM4_1	2070	6072906	2206699	2	39.96	37.63	2.33	2.61	-12.39	1	11.86	-0.73
2SAM4_1	2221	6072906	2206699	2	40.14	37.11	3.03	2.61	-12.39	1	11.86	-0.73
2SAM4_1	2435	6072906	2206699	2	38.64	36.26	2.38	2.61	-12.39	1	11.86	-0.73
2SAM4_1	2586	6072906	2206699	2	38.74	35.65	3.09	2.61	-12.39	1	11.86	-0.73
2SAM4_1	2770	6072906	2206699	2	36.52	34.86	1.66	2.61	-12.39	1	11.86	-0.73
2SAM4_1	2982	6072906	2206699	2	35.99	34.02	1.97	2.61	-12.39	1	11.86	-0.73
2SAM4_1	3165	6072906	2206699	2	34.96	33.29	1.67	2.61	-12.39	1	11.86	-0.73
2SAM4_1	3287	6072906	2206699	2	35.11	32.83	2.28	2.61	-12.39	1	11.86	-0.73
2SAM4_1	3531	6072906	2206699	2	33.48	32.91	0.57	2.61	-12.39	1	11.86	-0.73
2SAM4_1	3682	6072906	2206699	2	36.62	33.40	3.22	2.61	-12.39	1	11.86	-0.73
2SAM4_1	3788	6072906	2206699	2	35.33	33.45	1.88	2.61	-12.39	1	11.86	-0.73
2SAM5_1	944	6072894	2205886	2	35.09	36.50	-1.41	-1.69	-11.69	1	13.22	-12.40
2SAM5_1	1125	6072894	2205886	2	37.26	36.56	0.70	-1.69	-11.69	1	13.22	-12.40
2SAM5_1	1309	6072894	2205886	2	35.6	36.65	-1.05	-1.69	-11.69	1	13.22	-12.40
2SAM5_1	1431	6072894	2205886	2	37.8	36.77	1.03	-1.69	-11.69	1	13.22	-12.40
2SAM5_1	1551	6072894	2205886	2	37.02	36.88	0.14	-1.69	-11.69	1	13.22	-12.40
2SAM5_1	1674	6072894	2205886	2	37.41	37.05	0.36	-1.69	-11.69	1	13.22	-12.40
2SAM5_1	1826	6072894	2205886	2	37.86	37.22	0.64	-1.69	-11.69	1	13.22	-12.40
2SAM5_1	1917	6072894	2205886	2	38.04	37.05	0.99	-1.69	-11.69	1	13.22	-12.40
2SAM5_1	2070	6072894	2205886	2	37.44	36.61	0.83	-1.69	-11.69	1	13.22	-12.40
2SAM5_1	2221	6072894	2205886	2	37.65	36.12	1.53	-1.69	-11.69	1	13.22	-12.40
2SAM5_1	2435	6072894	2205886	2	36.3	35.31	0.99	-1.69	-11.69	1	13.22	-12.40
2SAM5_1	2586	6072894	2205886	2	36.32	34.73	1.59	-1.69	-11.69	1	13.22	-12.40
2SAM5_1	2770	6072894	2205886	2	34.42	33.97	0.45	-1.69	-11.69	1	13.22	-12.40
2SAM5_1	3165	6072894	2205886	2	33.07	32.47	0.60	-1.69	-11.69	1	13.22	-12.40
2SAM5_1	3287	6072894	2205886	2	33.35	32.03	1.32	-1.69	-11.69	1	13.22	-12.40
2SAM5_1	3531	6072894	2205886	2	31.95	32.09	-0.14	-1.69	-11.69	1	13.22	-12.40
2SAM5_1	3682	6072894	2205886	2	35.12	32.53	2.59	-1.69	-11.69	1	13.22	-12.40
2SAM5_1	3788	6072894	2205886	2	33.61	32.58	1.03	-1.69	-11.69	1	13.22	-12.40

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Well Name	Time (days)	X (feet)	Y (feet)	Layer	Observed (feet amsl)	Computed (feet amsl)	Residual (feet)	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Group*	Top of Layer (feet amsl)	Bottom of Layer (feet amsl)
2SAM6_1	944	6075457	2205984	2	38.71	41.13	-2.42	4.42	-15.58	1	14.92	-16.69
2SAM6_1	1125	6075457	2205984	2	40.46	40.94	-0.48	4.42	-15.58	1	14.92	-16.69
2SAM6_1	1309	6075457	2205984	2	38.87	40.81	-1.94	4.42	-15.58	1	14.92	-16.69
2SAM6_1	1431	6075457	2205984	2	41.38	40.78	0.60	4.42	-15.58	1	14.92	-16.69
2SAM6_1	1551	6075457	2205984	2	40.36	40.78	-0.42	4.42	-15.58	1	14.92	-16.69
2SAM6_1	1674	6075457	2205984	2	40.83	40.82	0.01	4.42	-15.58	1	14.92	-16.69
2SAM6_1	1826	6075457	2205984	2	41.34	40.88	0.46	4.42	-15.58	1	14.92	-16.69
2SAM6_1	1917	6075457	2205984	2	41.77	40.85	0.92	4.42	-15.58	1	14.92	-16.69
2SAM6_1	2070	6075457	2205984	2	41.17	40.66	0.51	4.42	-15.58	1	14.92	-16.69
2SAM6_1	2221	6075457	2205984	2	41.25	40.39	0.86	4.42	-15.58	1	14.92	-16.69
2SAM6_1	2435	6075457	2205984	2	39.47	39.86	-0.39	4.42	-15.58	1	14.92	-16.69
2SAM6_1	2586	6075457	2205984	2	39.32	39.42	-0.10	4.42	-15.58	1	14.92	-16.69
2SAM6_1	2770	6075457	2205984	2	37.5	38.82	-1.32	4.42	-15.58	1	14.92	-16.69
2SAM6_1	2982	6075457	2205984	2	36.8	38.09	-1.29	4.42	-15.58	1	14.92	-16.69
2SAM6_1	3165	6075457	2205984	2	35.98	37.44	-1.46	4.42	-15.58	1	14.92	-16.69
2SAM6_1	3287	6075457	2205984	2	36.11	37.03	-0.92	4.42	-15.58	1	14.92	-16.69
2SAM6_1	3531	6075457	2205984	2	34.54	36.58	-2.04	4.42	-15.58	1	14.92	-16.69
2SAM6_1	3682	6075457	2205984	2	38.02	36.57	1.45	4.42	-15.58	1	14.92	-16.69
2SAM7A	760	6070810	2202543	2	29.892	29.72	0.17	13.24	3.24	55	19.50	-7.31
2SAM7A	944	6070810	2202543	2	28.942	29.63	-0.69	13.24	3.24	55	19.50	-7.31
2SAM7A	1125	6070810	2202543	2	30.042	29.64	0.40	13.24	3.24	55	19.50	-7.31
2SAM7A	1309	6070810	2202543	2	29.162	29.71	-0.55	13.24	3.24	55	19.50	-7.31
2SAM7A	1431	6070810	2202543	2	30.572	29.81	0.76	13.24	3.24	55	19.50	-7.31
2SAM7A	1674	6070810	2202543	2	29.872	30.09	-0.22	13.24	3.24	55	19.50	-7.31
2SAM7A	1826	6070810	2202543	2	30.202	30.25	-0.05	13.24	3.24	55	19.50	-7.31
2SAM7A	2070	6070810	2202543	2	29.902	29.92	-0.02	13.24	3.24	55	19.50	-7.31
2SAM7A	2221	6070810	2202543	2	29.762	29.60	0.17	13.24	3.24	55	19.50	-7.31
2SAM7A	2435	6070810	2202543	2	29.602	29.01	0.59	13.24	3.24	55	19.50	-7.31
2SAM7A	2770	6070810	2202543	2	28.672	28.02	0.65	13.24	3.24	55	19.50	-7.31
2SAM7A	2982	6070810	2202543	2	28.962	27.42	1.54	13.24	3.24	55	19.50	-7.31
2SAM7A	3165	6070810	2202543	2	28.292	26.92	1.37	13.24	3.24	55	19.50	-7.31
2SAM7A	3287	6070810	2202543	2	28.282	26.61	1.67	13.24	3.24	55	19.50	-7.31
2SAM7A	3531	6070810	2202543	2	27.292	26.55	0.74	13.24	3.24	55	19.50	-7.31
2SAM7A	3682	6070810	2202543	2	29.792	26.79	3.00	13.24	3.24	55	19.50	-7.31
2SAM8A	609	6072801	2199942	2	23.853	25.61	-1.76	1.13	-8.87	55	16.70	-8.99
2SAM8A	760	6072801	2199942	2	24.273	25.42	-1.15	1.13	-8.87	55	16.70	-8.99
2SAM8A	944	6072801	2199942	2	23.703	25.26	-1.56	1.13	-8.87	55	16.70	-8.99
2SAM8A	1125	6072801	2199942	2	24.723	25.23	-0.50	1.13	-8.87	55	16.70	-8.99
2SAM8A	1309	6072801	2199942	2	23.693	25.30	-1.60	1.13	-8.87	55	16.70	-8.99
2SAM8A	1431	6072801	2199942	2	24.383	25.43	-1.04	1.13	-8.87	55	16.70	-8.99
2SAM8A	1551	6072801	2199942	2	24.323	25.59	-1.27	1.13	-8.87	55	16.70	-8.99
2SAM8A	1674	6072801	2199942	2	24.153	25.84	-1.69	1.13	-8.87	55	16.70	-8.99
2SAM8A	1826	6072801	2199942	2	24.053	26.10	-2.05	1.13	-8.87	55	16.70	-8.99
2SAM8A	2070	6072801	2199942	2	24.183	26.00	-1.82	1.13	-8.87	55	16.70	-8.99
2SAM8A	2221	6072801	2199942	2	23.803	25.80	-2.00	1.13	-8.87	55	16.70	-8.99
2SAM8A	2435	6072801	2199942	2	23.633	25.30	-1.67	1.13	-8.87	55	16.70	-8.99
2SAM8A	2586	6072801	2199942	2	23.933	24.95	-1.02	1.13	-8.87	55	16.70	-8.99
2SAM8A	2770	6072801	2199942	2	23.453	24.41	-0.96	1.13	-8.87	55	16.70	-8.99
2SAM8A	2982	6072801	2199942	2	23.803	23.92	-0.12	1.13	-8.87	55	16.70	-8.99
2SAM8A	3165	6072801	2199942	2	23.303	23.57	-0.27	1.13	-8.87	55	16.70	-8.99
2SAM8A	3531	6072801	2199942	2	23.653	23.16	0.49	1.13	-8.87	55	16.70	-8.99
2SAM8A	3788	6072801	2199942	2	24.043	23.28	0.76	1.13	-8.87	55	16.70	-8.99
5MW12	426	6074265	2208272	2	45.28	45.98	-0.70	11.58	1.58	1	15.97	-9.84
5MW12	609	6074265	2208272	2	44.61	45.78	-1.17	11.58	1.58	1	15.97	-9.84
5MW12	760	6074265	2208272	2	44.66	45.58	-0.92	11.58	1.58	1	15.97	-9.84
5MW12	944	6074265	2208272	2	42.88	45.44	-2.56	11.58	1.58	1	15.97	-9.84
5MW12	1125	6074265	2208272	2	43.26	45.42	-2.16	11.58	1.58	1	15.97	-9.84
5MW12	1309	6074265	2208272	2	42.7	45.44	-2.74	11.58	1.58	1	15.97	-9.84
5MW12	1431	6074265	2208272	2	44.16	45.50	-1.34	11.58	1.58	1	15.97	-9.84
5MW12	1551	6074265	2208272	2	44.11	45.56	-1.45	11.58	1.58	1	15.97	-9.84
5MW12	1674	6074265	2208272	2	44.21	45.67	-1.46	11.58	1.58	1	15.97	-9.84
5MW12	1826	6074265	2208272	2	45.26	45.79	-0.53	11.58	1.58	1	15.97	-9.84
5MW12	1917	6074265	2208272	2	45.63	45.60	0.03	11.58	1.58	1	15.97	-9.84
5MW12	2070	6074265	2208272	2	45.26	45.13	0.13	11.58	1.58	1	15.97	-9.84
5MW12	2221	6074265	2208272	2	45.35	44.60	0.75	11.58	1.58	1	15.97	-9.84
5MW12	2435	6074265	2208272	2	43.73	43.70	0.03	11.58	1.58	1	15.97	-9.84
5MW12	2586	6074265	2208272	2	42.9	43.00	-0.10	11.58	1.58	1	15.97	-9.84
5MW12	2770	6074265	2208272	2	41.03	42.13	-1.10	11.58	1.58	1	15.97	-9.84
5MW12	2982	6074265	2208272	2	40.3	41.11	-0.81	11.58	1.58	1	15.97	-9.84
5MW12	3165	6074265	2208272	2	39.12	40.20	-1.08	11.58	1.58	1	15.97	-9.84
5MW12	3287	6074265	2208272	2	39.32	39.62	-0.30	11.58	1.58	1	15.97	-9.84

* Group 1 - Targets are within Study Area and are actual observations
55 - Targets are within Study Area and are synthetic data based on potentiometric surface map projections
66 - Targets area outside of Study Area and are actual observations

Well Name	Time (days)	X (feet)	Y (feet)	Layer	Observed (feet amsl)	Computed (feet amsl)	Residual (feet)	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Group*	Top of Layer (feet amsl)	Bottom of Layer (feet amsl)
5MW12	3531	6074265	2208272	2	37.53	39.48	-1.95	11.58	1.58	1	15.97	-9.84
5MW12	3682	6074265	2208272	2	39.69	39.88	-0.19	11.58	1.58	1	15.97	-9.84
5MW12	3788	6074265	2208272	2	39.06	39.91	-0.85	11.58	1.58	1	15.97	-9.84
103MW11D	1431	6073317	2211614	3	47.51	48.68	-1.17	-17.59	-22.59	1	-13.51	-43.06
103MW11D	1551	6073317	2211614	3	47.58	48.82	-1.24	-17.59	-22.59	1	-13.51	-43.06
103MW11D	1674	6073317	2211614	3	48.75	49.00	-0.25	-17.59	-22.59	1	-13.51	-43.06
103MW11D	1826	6073317	2211614	3	49.46	49.20	0.26	-17.59	-22.59	1	-13.51	-43.06
103MW11D	1917	6073317	2211614	3	49.96	48.76	1.20	-17.59	-22.59	1	-13.51	-43.06
103MW11D	2070	6073317	2211614	3	49.57	47.87	1.70	-17.59	-22.59	1	-13.51	-43.06
103MW11D	2221	6073317	2211614	3	50.27	46.99	3.28	-17.59	-22.59	1	-13.51	-43.06
103MW11D	2435	6073317	2211614	3	49.51	45.65	3.86	-17.59	-22.59	1	-13.51	-43.06
103MW11D	2586	6073317	2211614	3	47.38	44.69	2.69	-17.59	-22.59	1	-13.51	-43.06
103MW11D	2770	6073317	2211614	3	46.27	43.52	2.75	-17.59	-22.59	1	-13.51	-43.06
103MW11D	2982	6073317	2211614	3	43.49	42.20	1.29	-17.59	-22.59	1	-13.51	-43.06
103MW11D	3287	6073317	2211614	3	42.78	40.29	2.49	-17.59	-22.59	1	-13.51	-43.06
103MW11D	3531	6073317	2211614	3	41.65	40.77	0.88	-17.59	-22.59	1	-13.51	-43.06
103MW11D	3682	6073317	2211614	3	41.08	41.76	-0.68	-17.59	-22.59	1	-13.51	-43.06
103MW11D	3788	6073317	2211614	3	41.22	41.81	-0.59	-17.59	-22.59	1	-13.51	-43.06
13MW19C	426	6077824	2209906	3	55.43	51.39	4.04	-13.03	-23.03	1	-13.51	-43.06
13MW19C	609	6077824	2209906	3	54.77	51.49	3.28	-13.03	-23.03	1	10.86	-54.32
13MW19C	760	6077824	2209906	3	52.53	51.22	1.31	-13.03	-23.03	1	10.86	-54.32
13MW19C	944	6077824	2209906	3	50.48	51.16	-0.68	-13.03	-23.03	1	10.86	-54.32
13MW19C	1125	6077824	2209906	3	50.65	51.30	-0.65	-13.03	-23.03	1	10.86	-54.32
13MW19C	1309	6077824	2209906	3	49.2	51.41	-2.21	-13.03	-23.03	1	10.86	-54.32
13MW19C	1551	6077824	2209906	3	51.27	51.63	-0.36	-13.03	-23.03	1	10.86	-54.32
13MW19C	1674	6077824	2209906	3	52.71	51.80	0.91	-13.03	-23.03	1	10.86	-54.32
13MW19C	1917	6077824	2209906	3	53.48	51.77	1.71	-13.03	-23.03	1	10.86	-54.32
13MW19C	2070	6077824	2209906	3	53.29	51.08	2.21	-13.03	-23.03	1	10.86	-54.32
13MW19C	2221	6077824	2209906	3	52.52	50.32	2.20	-13.03	-23.03	1	10.86	-54.32
13MW19C	2435	6077824	2209906	3	50.94	49.11	1.83	-13.03	-23.03	1	10.86	-54.32
13MW19C	2586	6077824	2209906	3	49.11	48.16	0.95	-13.03	-23.03	1	10.86	-54.32
13MW19C	2770	6077824	2209906	3	47.33	47.23	0.10	-13.03	-23.03	1	10.86	-54.32
13MW19C	2982	6077824	2209906	3	46.2	46.01	0.19	-13.03	-23.03	1	10.86	-54.32
13MW19C	3287	6077824	2209906	3	44.93	44.28	0.65	-13.03	-23.03	1	10.86	-54.32
13MW19C	3682	6077824	2209906	3	45	45.27	-0.27	-13.03	-23.03	1	10.86	-54.32
22MW601D	426	6072258	2204076	3	32.58	33.69	-1.11	-46.99	-62.39	1	-18.93	-53.71
22MW601D	609	6072258	2204076	3	31.66	33.52	-1.86	-46.99	-62.39	1	-18.93	-53.71
22MW601D	760	6072258	2204076	3	32.3	33.28	-0.98	-46.99	-62.39	1	-18.93	-53.71
22MW601D	944	6072258	2204076	3	30.27	33.21	-2.94	-46.99	-62.39	1	-18.93	-53.71
22MW601D	1125	6072258	2204076	3	32.91	33.24	-0.33	-46.99	-62.39	1	-18.93	-53.71
22MW601D	1309	6072258	2204076	3	31.98	33.32	-1.34	-46.99	-62.39	1	-18.93	-53.71
22MW601D	1431	6072258	2204076	3	32.24	33.43	-1.19	-46.99	-62.39	1	-18.93	-53.71
22MW601D	1551	6072258	2204076	3	33.82	33.55	0.27	-46.99	-62.39	1	-18.93	-53.71
22MW601D	1674	6072258	2204076	3	34.14	33.72	0.42	-46.99	-62.39	1	-18.93	-53.71
22MW601D	1826	6072258	2204076	3	34.99	33.87	1.12	-46.99	-62.39	1	-18.93	-53.71
22MW601D	1917	6072258	2204076	3	35.34	33.75	1.59	-46.99	-62.39	1	-18.93	-53.71
22MW601D	2070	6072258	2204076	3	34.64	33.38	1.26	-46.99	-62.39	1	-18.93	-53.71
22MW601D	2221	6072258	2204076	3	34.83	32.96	1.87	-46.99	-62.39	1	-18.93	-53.71
22MW601D	2435	6072258	2204076	3	32.97	32.25	0.72	-46.99	-62.39	1	-18.93	-53.71
22MW601D	2586	6072258	2204076	3	32.97	31.75	1.22	-46.99	-62.39	1	-18.93	-53.71
22MW601D	2770	6072258	2204076	3	30.61	31.08	-0.47	-46.99	-62.39	1	-18.93	-53.71
22MW601D	2982	6072258	2204076	3	30.73	30.37	0.36	-46.99	-62.39	1	-18.93	-53.71
22MW601D	3165	6072258	2204076	3	30.2	29.77	0.43	-46.99	-62.39	1	-18.93	-53.71
22MW601D	3287	6072258	2204076	3	28.99	29.40	-0.41	-46.99	-62.39	1	-18.93	-53.71
2SAM1_1	760	6074660	2209328	3	46.1	45.01	1.09	-10.32	-20.32	1	-1.64	-43.93
2SAM1_1	944	6074660	2209328	3	44.84	44.99	-0.15	-10.32	-20.32	1	-1.64	-43.93
2SAM1_1	1125	6074660	2209328	3	45.64	45.08	0.56	-10.32	-20.32	1	-1.64	-43.93
2SAM1_1	1309	6074660	2209328	3	44.49	45.18	-0.69	-10.32	-20.32	1	-1.64	-43.93
2SAM1_1	1431	6074660	2209328	3	46.44	45.31	1.13	-10.32	-20.32	1	-1.64	-43.93
2SAM1_1	1551	6074660	2209328	3	46.26	45.41	0.85	-10.32	-20.32	1	-1.64	-43.93
2SAM1_1	1674	6074660	2209328	3	47.41	45.57	1.84	-10.32	-20.32	1	-1.64	-43.93
2SAM1_1	1826	6074660	2209328	3	48.14	45.74	2.40	-10.32	-20.32	1	-1.64	-43.93
2SAM1_1	1917	6074660	2209328	3	48.88	45.47	3.41	-10.32	-20.32	1	-1.64	-43.93
2SAM1_1	2070	6074660	2209328	3	48.37	44.84	3.53	-10.32	-20.32	1	-1.64	-43.93
2SAM1_1	2221	6074660	2209328	3	48.49	44.17	4.32	-10.32	-20.32	1	-1.64	-43.93
2SAM1_1	2435	6074660	2209328	3	46.38	43.09	3.29	-10.32	-20.32	1	-1.64	-43.93
2SAM1_1	2586	6074660	2209328	3	45.79	42.31	3.48	-10.32	-20.32	1	-1.64	-43.93
2SAM1_1	2770	6074660	2209328	3	43.23	41.34	1.89	-10.32	-20.32	1	-1.64	-43.93
2SAM1_1	2982	6074660	2209328	3	42.31	40.25	2.06	-10.32	-20.32	1	-1.64	-43.93
2SAM1_1	3165	6074660	2209328	3	41.15	39.28	1.87	-10.32	-20.32	1	-1.64	-43.93
2SAM1_1	3287	6074660	2209328	3	41.01	38.68	2.33	-10.32	-20.32	1	-1.64	-43.93
2SAM1_1	3531	6074660	2209328	3	39.26	38.82	0.44	-10.32	-20.32	1	-1.64	-43.93

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Well Name	Time (days)	X (feet)	Y (feet)	Layer	Observed (feet amsl)	Computed (feet amsl)	Residual (feet)	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Group*	Top of Layer (feet amsl)	Bottom of Layer (feet amsl)
2SAM1_1	3682	6074660	2209328	3	41.33	39.48	1.85	-10.32	-20.32	1	-1.64	-43.93
2SAM1_1	3788	6074660	2209328	3	40.56	39.54	1.02	-10.32	-20.32	1	-1.64	-43.93
2SAM10B	609	6075388	2201089	3	30.001	29.93	0.07	-31.02	-36.02	55	-14.30	-40.64
2SAM10B	760	6075388	2201089	3	30.381	29.69	0.69	-31.02	-36.02	55	-14.30	-40.64
2SAM10B	944	6075388	2201089	3	29.011	29.52	-0.51	-31.02	-36.02	55	-14.30	-40.64
2SAM10B	1125	6075388	2201089	3	31.021	29.47	1.55	-31.02	-36.02	55	-14.30	-40.64
2SAM10B	1309	6075388	2201089	3	30.331	29.50	0.83	-31.02	-36.02	55	-14.30	-40.64
2SAM10B	1551	6075388	2201089	3	31.451	29.78	1.67	-31.02	-36.02	55	-14.30	-40.64
2SAM10B	1674	6075388	2201089	3	30.731	30.01	0.72	-31.02	-36.02	55	-14.30	-40.64
2SAM10B	1917	6075388	2201089	3	31.021	30.30	0.72	-31.02	-36.02	55	-14.30	-40.64
2SAM10B	2070	6075388	2201089	3	30.401	30.14	0.26	-31.02	-36.02	55	-14.30	-40.64
2SAM10B	2221	6075388	2201089	3	30.591	29.91	0.68	-31.02	-36.02	55	-14.30	-40.64
2SAM10B	2435	6075388	2201089	3	29.771	29.37	0.41	-31.02	-36.02	55	-14.30	-40.64
2SAM10B	2586	6075388	2201089	3	29.821	28.98	0.84	-31.02	-36.02	55	-14.30	-40.64
2SAM10B	2770	6075388	2201089	3	28.531	28.38	0.15	-31.02	-36.02	55	-14.30	-40.64
2SAM10B	2982	6075388	2201089	3	28.941	27.82	1.12	-31.02	-36.02	55	-14.30	-40.64
2SAM10B	3165	6075388	2201089	3	27.821	27.41	0.41	-31.02	-36.02	55	-14.30	-40.64
2SAM10B	3287	6075388	2201089	3	28.111	27.16	0.95	-31.02	-36.02	55	-14.30	-40.64
2SAM10B	3531	6075388	2201089	3	28.021	26.93	1.10	-31.02	-36.02	55	-14.30	-40.64
2SAM10B	3788	6075388	2201089	3	29.781	27.06	2.72	-31.02	-36.02	55	-14.30	-40.64
2SAM11B	609	6076576	2202828	3	32.945	33.49	-0.55	-27.07	-32.07	55	-11.75	-39.15
2SAM11B	760	6076576	2202828	3	33.165	33.22	-0.06	-27.07	-32.07	55	-11.75	-39.15
2SAM11B	944	6076576	2202828	3	31.655	33.05	-1.39	-27.07	-32.07	55	-11.75	-39.15
2SAM11B	1125	6076576	2202828	3	33.595	32.99	0.60	-27.07	-32.07	55	-11.75	-39.15
2SAM11B	1309	6076576	2202828	3	32.855	32.99	-0.14	-27.07	-32.07	55	-11.75	-39.15
2SAM11B	1551	6076576	2202828	3	33.375	33.20	0.17	-27.07	-32.07	55	-11.75	-39.15
2SAM11B	1674	6076576	2202828	3	33.795	33.39	0.41	-27.07	-32.07	55	-11.75	-39.15
2SAM11B	1917	6076576	2202828	3	34.185	33.59	0.59	-27.07	-32.07	55	-11.75	-39.15
2SAM11B	2070	6076576	2202828	3	33.935	33.41	0.52	-27.07	-32.07	55	-11.75	-39.15
2SAM11B	2435	6076576	2202828	3	32.335	32.60	-0.27	-27.07	-32.07	55	-11.75	-39.15
2SAM11B	2586	6076576	2202828	3	32.915	32.20	0.72	-27.07	-32.07	55	-11.75	-39.15
2SAM11B	2770	6076576	2202828	3	30.905	31.59	-0.68	-27.07	-32.07	55	-11.75	-39.15
2SAM11B	2982	6076576	2202828	3	31.005	30.97	0.03	-27.07	-32.07	55	-11.75	-39.15
2SAM11B	3165	6076576	2202828	3	30.255	30.49	-0.24	-27.07	-32.07	55	-11.75	-39.15
2SAM11B	3287	6076576	2202828	3	30.485	30.19	0.29	-27.07	-32.07	55	-11.75	-39.15
2SAM11B	3531	6076576	2202828	3	29.935	29.95	-0.02	-27.07	-32.07	55	-11.75	-39.15
2SAM11B	3788	6076576	2202828	3	32.245	30.08	2.16	-27.07	-32.07	55	-11.75	-39.15
2SAM13C	609	6073012	2202371	3	30.21	30.99	-0.78	-38.86	-48.86	55	-19.51	-52.31
2SAM13C	760	6073012	2202371	3	30.75	30.50	0.25	-38.86	-48.86	55	-19.51	-52.31
2SAM13C	944	6073012	2202371	3	29.35	30.31	-0.96	-38.86	-48.86	55	-19.51	-52.31
2SAM13C	1125	6073012	2202371	3	31.1	30.25	0.85	-38.86	-48.86	55	-19.51	-52.31
2SAM13C	1309	6073012	2202371	3	30.2	30.27	-0.07	-38.86	-48.86	55	-19.51	-52.31
2SAM13C	1431	6073012	2202371	3	30.1	30.37	-0.27	-38.86	-48.86	55	-19.51	-52.31
2SAM13C	1551	6073012	2202371	3	30.6	30.48	0.12	-38.86	-48.86	55	-19.51	-52.31
2SAM13C	1674	6073012	2202371	3	30.55	30.67	-0.12	-38.86	-48.86	55	-19.51	-52.31
2SAM13C	1826	6073012	2202371	3	30.95	30.80	0.15	-38.86	-48.86	55	-19.51	-52.31
2SAM13C	1917	6073012	2202371	3	30.73	30.76	-0.03	-38.86	-48.86	55	-19.51	-52.31
2SAM13C	2070	6073012	2202371	3	30.49	30.55	-0.06	-38.86	-48.86	55	-19.51	-52.31
2SAM13C	2221	6073012	2202371	3	30.56	30.24	0.32	-38.86	-48.86	55	-19.51	-52.31
2SAM13C	2435	6073012	2202371	3	29.84	29.67	0.17	-38.86	-48.86	55	-19.51	-52.31
2SAM13C	2586	6073012	2202371	3	30.09	29.28	0.81	-38.86	-48.86	55	-19.51	-52.31
2SAM13C	2770	6073012	2202371	3	29.37	28.68	0.69	-38.86	-48.86	55	-19.51	-52.31
2SAM13C	2982	6073012	2202371	3	29.11	28.08	1.03	-38.86	-48.86	55	-19.51	-52.31
2SAM13C	3165	6073012	2202371	3	28.38	27.59	0.79	-38.86	-48.86	55	-19.51	-52.31
2SAM13C	3531	6073012	2202371	3	28.31	27.18	1.13	-38.86	-48.86	55	-19.51	-52.31
2SAM13C	3682	6073012	2202371	3	30.14	27.35	2.79	-38.86	-48.86	55	-19.51	-52.31
2SAM13C	3788	6073012	2202371	3	29.35	27.38	1.97	-38.86	-48.86	55	-19.51	-52.31
2SAM7B	760	6070785	2202544	3	29.996	29.77	0.23	-28.16	-33.16	55	-7.31	-56.90
2SAM7B	944	6070785	2202544	3	29.046	29.71	-0.66	-28.16	-33.16	55	-7.31	-56.90
2SAM7B	1125	6070785	2202544	3	30.146	29.74	0.41	-28.16	-33.16	55	-7.31	-56.90
2SAM7B	1309	6070785	2202544	3	29.266	29.82	-0.56	-28.16	-33.16	55	-7.31	-56.90
2SAM7B	1431	6070785	2202544	3	30.676	29.94	0.74	-28.16	-33.16	55	-7.31	-56.90
2SAM7B	1674	6070785	2202544	3	29.976	30.24	-0.26	-28.16	-33.16	55	-7.31	-56.90
2SAM7B	1826	6070785	2202544	3	30.306	30.41	-0.10	-28.16	-33.16	55	-7.31	-56.90
2SAM7B	2070	6070785	2202544	3	30.006	30.04	-0.03	-28.16	-33.16	55	-7.31	-56.90
2SAM7B	2221	6070785	2202544	3	29.866	29.69	0.18	-28.16	-33.16	55	-7.31	-56.90
2SAM7B	2435	6070785	2202544	3	29.706	29.08	0.63	-28.16	-33.16	55	-7.31	-56.90
2SAM7B	2770	6070785	2202544	3	28.776	28.05	0.73	-28.16	-33.16	55	-7.31	-56.90
2SAM7B	2982	6070785	2202544	3	29.066	27.44	1.63	-28.16	-33.16	55	-7.31	-56.90
2SAM7B	3165	6070785	2202544	3	28.396	26.93	1.47	-28.16	-33.16	55	-7.31	-56.90
2SAM7B	3287	6070785	2202544	3	28.386	26.61	1.78	-28.16	-33.16	55	-7.31	-56.90
2SAM7B	3531	6070785	2202544	3	27.396	26.58	0.82	-28.16	-33.16	55	-7.31	-56.90
2SAM7B	3688	6070785	2202544	3	29.896	26.87	3.03	-28.16	-33.16	55	-7.31	-56.90
2SAM9C	609	6074483	2198350	3	24.911	24.49	0.42	-26.83	-31.83	55	-7.97	-35.51

* Group 1 - Targets are within Study Area and are actual observations
55 - Targets are within Study Area and are synthetic data based on potentiometric surface map projections
66 - Targets area outside of Study Area and are actual observations

Well Name	Time (days)	X (feet)	Y (feet)	Layer	Observed (feet amsl)	Computed (feet amsl)	Residual (feet)	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Group*	Top of Layer (feet amsl)	Bottom of Layer (feet amsl)
2SAM9C	760	6074483	2198350	3	25.461	24.33	1.13	-26.83	-31.83	55	-7.97	-35.51
2SAM9C	944	6074483	2198350	3	24.711	24.15	0.56	-26.83	-31.83	55	-7.97	-35.51
2SAM9C	1125	6074483	2198350	3	25.911	24.12	1.79	-26.83	-31.83	55	-7.97	-35.51
2SAM9C	1309	6074483	2198350	3	24.971	24.22	0.75	-26.83	-31.83	55	-7.97	-35.51
2SAM9C	1431	6074483	2198350	3	25.281	24.40	0.88	-26.83	-31.83	55	-7.97	-35.51
2SAM9C	1551	6074483	2198350	3	25.281	24.64	0.64	-26.83	-31.83	55	-7.97	-35.51
2SAM9C	1674	6074483	2198350	3	25.061	24.98	0.08	-26.83	-31.83	55	-7.97	-35.51
2SAM9C	1826	6074483	2198350	3	25.151	25.35	-0.19	-26.83	-31.83	55	-7.97	-35.51
2SAM9C	1917	6074483	2198350	3	25.171	25.43	-0.26	-26.83	-31.83	55	-7.97	-35.51
2SAM9C	2070	6074483	2198350	3	25.031	25.24	-0.21	-26.83	-31.83	55	-7.97	-35.51
2SAM9C	2221	6074483	2198350	3	25.111	25.03	0.08	-26.83	-31.83	55	-7.97	-35.51
2SAM9C	2435	6074483	2198350	3	24.801	24.44	0.36	-26.83	-31.83	55	-7.97	-35.51
2SAM9C	2586	6074483	2198350	3	25.061	24.04	1.02	-26.83	-31.83	55	-7.97	-35.51
2SAM9C	2770	6074483	2198350	3	24.491	23.43	1.06	-26.83	-31.83	55	-7.97	-35.51
2SAM9C	2982	6074483	2198350	3	25.081	22.94	2.14	-26.83	-31.83	55	-7.97	-35.51
2SAM9C	3165	6074483	2198350	3	24.211	22.62	1.59	-26.83	-31.83	55	-7.97	-35.51
2SAM9C	3287	6074483	2198350	3	24.601	22.45	2.15	-26.83	-31.83	55	-7.97	-35.51
2SAM9C	3531	6074483	2198350	3	24.711	22.23	2.48	-26.83	-31.83	55	-7.97	-35.51
2SAM9C	3788	6074483	2198350	3	25.361	22.41	2.95	-26.83	-31.83	55	-7.97	-35.51
22MW603D	426	6073057	2205166	4	36.07	35.89	0.18	-48.95	-58.65	1	-55.63	-93.62
22MW603D	609	6073057	2205166	4	34.87	35.77	-0.90	-48.95	-58.65	1	-55.63	-93.62
22MW603D	760	6073057	2205166	4	35.42	35.63	-0.21	-48.95	-58.65	1	-55.63	-93.62
22MW603D	944	6073057	2205166	4	33.26	35.58	-2.32	-48.95	-58.65	1	-55.63	-93.62
22MW603D	1125	6073057	2205166	4	35.42	35.63	-0.21	-48.95	-58.65	1	-55.63	-93.62
22MW603D	1309	6073057	2205166	4	34.57	35.72	-1.15	-48.95	-58.65	1	-55.63	-93.62
22MW603D	1431	6073057	2205166	4	36.67	35.84	0.83	-48.95	-58.65	1	-55.63	-93.62
22MW603D	1551	6073057	2205166	4	36.62	35.97	0.65	-48.95	-58.65	1	-55.63	-93.62
22MW603D	1674	6073057	2205166	4	37.02	36.14	0.88	-48.95	-58.65	1	-55.63	-93.62
22MW603D	1826	6073057	2205166	4	38.08	36.31	1.77	-48.95	-58.65	1	-55.63	-93.62
22MW603D	1917	6073057	2205166	4	38.54	36.16	2.38	-48.95	-58.65	1	-55.63	-93.62
22MW603D	2070	6073057	2205166	4	37.67	35.73	1.94	-48.95	-58.65	1	-55.63	-93.62
22MW603D	2221	6073057	2205166	4	38.02	35.27	2.75	-48.95	-58.65	1	-55.63	-93.62
22MW603D	2435	6073057	2205166	4	35.71	34.48	1.23	-48.95	-58.65	1	-55.63	-93.62
22MW603D	2586	6073057	2205166	4	35.51	33.92	1.59	-48.95	-58.65	1	-55.63	-93.62
22MW603D	2770	6073057	2205166	4	33	33.18	-0.18	-48.95	-58.65	1	-55.63	-93.62
22MW603D	2982	6073057	2205166	4	32.98	32.41	0.57	-48.95	-58.65	1	-55.63	-93.62
22MW603D	3165	6073057	2205166	4	32.36	31.74	0.62	-48.95	-58.65	1	-55.63	-93.62
22MW603D	3531	6073057	2205166	4	31.02	31.36	-0.34	-48.95	-58.65	1	-55.63	-93.62
2SAM1_2	944	6074660	2209328	4	37.41	42.53	-5.12	-66.32	-81.32	1	-43.93	-85.77
2SAM1_2	1125	6074660	2209328	4	38.74	42.64	-3.90	-66.32	-81.32	1	-43.93	-85.77
2SAM1_2	1309	6074660	2209328	4	37.89	42.77	-4.88	-66.32	-81.32	1	-43.93	-85.77
2SAM1_2	1431	6074660	2209328	4	40.42	42.91	-2.49	-66.32	-81.32	1	-43.93	-85.77
2SAM1_2	1551	6074660	2209328	4	40.35	43.03	-2.68	-66.32	-81.32	1	-43.93	-85.77
2SAM1_2	1674	6074660	2209328	4	42.48	43.21	-0.73	-66.32	-81.32	1	-43.93	-85.77
2SAM1_2	1826	6074660	2209328	4	43.6	43.39	0.21	-66.32	-81.32	1	-43.93	-85.77
2SAM1_2	1917	6074660	2209328	4	44.45	43.13	1.32	-66.32	-81.32	1	-43.93	-85.77
2SAM1_2	2070	6074660	2209328	4	43.09	42.51	0.58	-66.32	-81.32	1	-43.93	-85.77
2SAM1_2	2221	6074660	2209328	4	43.64	41.86	1.78	-66.32	-81.32	1	-43.93	-85.77
2SAM1_2	2435	6074660	2209328	4	40.2	40.81	-0.61	-66.32	-81.32	1	-43.93	-85.77
2SAM1_2	2586	6074660	2209328	4	39.33	40.06	-0.73	-66.32	-81.32	1	-43.93	-85.77
2SAM1_2	2770	6074660	2209328	4	36.47	39.13	-2.66	-66.32	-81.32	1	-43.93	-85.77
2SAM1_2	2982	6074660	2209328	4	35.93	38.11	-2.18	-66.32	-81.32	1	-43.93	-85.77
2SAM1_2	3165	6074660	2209328	4	34.94	37.20	-2.26	-66.32	-81.32	1	-43.93	-85.77
2SAM1_2	3287	6074660	2209328	4	34.98	36.64	-1.66	-66.32	-81.32	1	-43.93	-85.77
2SAM1_2	3531	6074660	2209328	4	33.4	36.83	-3.43	-66.32	-81.32	1	-43.93	-85.77
2SAM1_2	3682	6074660	2209328	4	35.9	37.50	-1.60	-66.32	-81.32	1	-43.93	-85.77
2SAM1_2	3788	6074660	2209328	4	35.32	37.56	-2.24	-66.32	-81.32	1	-43.93	-85.77
2SAM10D	609	6075379	2201079	4	30.62	29.75	0.87	-50.99	-55.99	55	-40.64	-58.15
2SAM10D	760	6075379	2201079	4	31	29.56	1.44	-50.99	-55.99	55	-40.64	-58.15
2SAM10D	944	6075379	2201079	4	29.63	29.40	0.23	-50.99	-55.99	55	-40.64	-58.15
2SAM10D	1125	6075379	2201079	4	31.64	29.37	2.27	-50.99	-55.99	55	-40.64	-58.15
2SAM10D	1309	6075379	2201079	4	30.95	29.44	1.51	-50.99	-55.99	55	-40.64	-58.15
2SAM10D	1551	6075379	2201079	4	32.07	29.77	2.30	-50.99	-55.99	55	-40.64	-58.15
2SAM10D	1674	6075379	2201079	4	31.35	30.04	1.31	-50.99	-55.99	55	-40.64	-58.15
2SAM10D	1917	6075379	2201079	4	31.64	30.37	1.27	-50.99	-55.99	55	-40.64	-58.15
2SAM10D	2070	6075379	2201079	4	31.02	30.18	0.84	-50.99	-55.99	55	-40.64	-58.15
2SAM10D	2221	6075379	2201079	4	31.21	29.94	1.27	-50.99	-55.99	55	-40.64	-58.15
2SAM10D	2435	6075379	2201079	4	30.39	29.34	1.05	-50.99	-55.99	55	-40.64	-58.15
2SAM10D	2586	6075379	2201079	4	30.44	28.92	1.52	-50.99	-55.99	55	-40.64	-58.15

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Well Name	Time (days)	X (feet)	Y (feet)	Layer	Observed (feet amsl)	Computed (feet amsl)	Residual (feet)	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Group*	Top of Layer (feet amsl)	Bottom of Layer (feet amsl)
2SAM10D	2770	6075379	2201079	4	29.15	28.29	0.86	-50.99	-55.99	55	-40.64	-58.15
2SAM10D	2982	6075379	2201079	4	29.56	27.72	1.84	-50.99	-55.99	55	-40.64	-58.15
2SAM10D	3165	6075379	2201079	4	28.44	27.30	1.14	-50.99	-55.99	55	-40.64	-58.15
2SAM10D	3287	6075379	2201079	4	28.73	27.06	1.67	-50.99	-55.99	55	-40.64	-58.15
2SAM10D	3531	6075379	2201079	4	28.64	26.85	1.79	-50.99	-55.99	55	-40.64	-58.15
2SAM10D	3788	6075379	2201079	4	30.4	27.03	3.37	-50.99	-55.99	55	-40.64	-58.15
2SAM11D	609	6076596	2202811	4	33.344	33.53	-0.19	-49.70	-59.70	55	-37.67	-60.84
2SAM11D	760	6076596	2202811	4	33.564	33.35	0.22	-49.70	-59.70	55	-37.67	-60.84
2SAM11D	944	6076596	2202811	4	32.054	33.20	-1.15	-49.70	-59.70	55	-37.67	-60.84
2SAM11D	1125	6076596	2202811	4	33.994	33.19	0.81	-49.70	-59.70	55	-37.67	-60.84
2SAM11D	1309	6076596	2202811	4	33.254	33.24	0.02	-49.70	-59.70	55	-37.67	-60.84
2SAM11D	1551	6076596	2202811	4	33.774	33.51	0.26	-49.70	-59.70	55	-37.67	-60.84
2SAM11D	1674	6076596	2202811	4	34.194	33.73	0.46	-49.70	-59.70	55	-37.67	-60.84
2SAM11D	1826	6076596	2202811	4	34.584	33.98	0.61	-49.70	-59.70	55	-37.67	-60.84
2SAM11D	2070	6076596	2202811	4	34.334	33.73	0.60	-49.70	-59.70	55	-37.67	-60.84
2SAM11D	2435	6076596	2202811	4	32.734	32.81	-0.08	-49.70	-59.70	55	-37.67	-60.84
2SAM11D	2586	6076596	2202811	4	33.314	32.36	0.95	-49.70	-59.70	55	-37.67	-60.84
2SAM11D	2770	6076596	2202811	4	31.304	31.71	-0.41	-49.70	-59.70	55	-37.67	-60.84
2SAM11D	2982	6076596	2202811	4	31.404	31.07	0.33	-49.70	-59.70	55	-37.67	-60.84
2SAM11D	3165	6076596	2202811	4	30.654	30.56	0.09	-49.70	-59.70	55	-37.67	-60.84
2SAM11D	3287	6076596	2202811	4	30.884	30.26	0.63	-49.70	-59.70	55	-37.67	-60.84
2SAM11D	3531	6076596	2202811	4	30.334	30.07	0.26	-49.70	-59.70	55	-37.67	-60.84
2SAM11D	3788	6076596	2202811	4	32.644	30.31	2.34	-49.70	-59.70	55	-37.67	-60.84
2SAM-13D	609	6073031	2202355	4	30.66	31.05	-0.39	-53.92	-63.92	55	-52.31	-67.72
2SAM-13D	760	6073031	2202355	4	31.2	30.88	0.32	-53.92	-63.92	55	-52.31	-67.72
2SAM-13D	944	6073031	2202355	4	29.8	30.79	-0.99	-53.92	-63.92	55	-52.31	-67.72
2SAM-13D	1125	6073031	2202355	4	31.55	30.81	0.74	-53.92	-63.92	55	-52.31	-67.72
2SAM-13D	1309	6073031	2202355	4	30.65	30.89	-0.24	-53.92	-63.92	55	-52.31	-67.72
2SAM-13D	1431	6073031	2202355	4	30.55	31.02	-0.47	-53.92	-63.92	55	-52.31	-67.72
2SAM-13D	1551	6073031	2202355	4	31.05	31.15	-0.10	-53.92	-63.92	55	-52.31	-67.72
2SAM-13D	1674	6073031	2202355	4	31	31.36	-0.36	-53.92	-63.92	55	-52.31	-67.72
2SAM-13D	1826	6073031	2202355	4	31.4	31.55	-0.15	-53.92	-63.92	55	-52.31	-67.72
2SAM-13D	1917	6073031	2202355	4	31.18	31.49	-0.31	-53.92	-63.92	55	-52.31	-67.72
2SAM-13D	2070	6073031	2202355	4	30.94	31.18	-0.24	-53.92	-63.92	55	-52.31	-67.72
2SAM-13D	2221	6073031	2202355	4	31.01	30.82	0.19	-53.92	-63.92	55	-52.31	-67.72
2SAM-13D	2435	6073031	2202355	4	30.29	30.16	0.13	-53.92	-63.92	55	-52.31	-67.72
2SAM-13D	2586	6073031	2202355	4	30.54	29.70	0.84	-53.92	-63.92	55	-52.31	-67.72
2SAM-13D	2770	6073031	2202355	4	29.82	29.06	0.76	-53.92	-63.92	55	-52.31	-67.72
2SAM-13D	2982	6073031	2202355	4	29.56	28.43	1.13	-53.92	-63.92	55	-52.31	-67.72
2SAM-13D	3165	6073031	2202355	4	28.83	27.90	0.93	-53.92	-63.92	55	-52.31	-67.72
2SAM-13D	3531	6073031	2202355	4	28.76	27.53	1.23	-53.92	-63.92	55	-52.31	-67.72
2SAM-13D	3682	6073031	2202355	4	30.59	27.81	2.78	-53.92	-63.92	55	-52.31	-67.72
2SAM-13D	3788	6073031	2202355	4	29.8	27.86	1.94	-53.92	-63.92	55	-52.31	-67.72
2SAM2_2	944	6072812	2208121	4	36.56	39.37	-2.81	-63.46	-73.46	1	-40.10	-112.20
2SAM2_2	1125	6072812	2208121	4	38.23	39.47	-1.24	-63.46	-73.46	1	-40.10	-112.20
2SAM2_2	1309	6072812	2208121	4	37.29	39.58	-2.29	-63.46	-73.46	1	-40.10	-112.20
2SAM2_2	1431	6072812	2208121	4	39.86	39.72	0.14	-63.46	-73.46	1	-40.10	-112.20
2SAM2_2	1674	6072812	2208121	4	41.28	40.02	1.26	-63.46	-73.46	1	-40.10	-112.20
2SAM2_2	1917	6072812	2208121	4	42.87	39.96	2.91	-63.46	-73.46	1	-40.10	-112.20
2SAM2_2	2070	6072812	2208121	4	41.81	39.41	2.40	-63.46	-73.46	1	-40.10	-112.20
2SAM2_2	2221	6072812	2208121	4	42.18	38.83	3.35	-63.46	-73.46	1	-40.10	-112.20
2SAM2_2	2435	6072812	2208121	4	39.43	37.89	1.54	-63.46	-73.46	1	-40.10	-112.20
2SAM2_2	2586	6072812	2208121	4	38.92	37.23	1.69	-63.46	-73.46	1	-40.10	-112.20
2SAM2_2	2770	6072812	2208121	4	36.16	36.38	-0.22	-63.46	-73.46	1	-40.10	-112.20
2SAM2_2	2982	6072812	2208121	4	35.55	35.46	0.09	-63.46	-73.46	1	-40.10	-112.20
2SAM2_2	3165	6072812	2208121	4	34.49	34.65	-0.16	-63.46	-73.46	1	-40.10	-112.20
2SAM2_2	3287	6072812	2208121	4	34.69	34.15	0.54	-63.46	-73.46	1	-40.10	-112.20
2SAM2_2	3531	6072812	2208121	4	33.04	34.30	-1.26	-63.46	-73.46	1	-40.10	-112.20
2SAM2_2	3682	6072812	2208121	4	35.58	34.89	0.69	-63.46	-73.46	1	-40.10	-112.20
2SAM2_2	3788	6072812	2208121	4	34.78	34.94	-0.16	-63.46	-73.46	1	-40.10	-112.20
2SAM3_2	944	6074220	2207609	4	36.26	39.60	-3.34	-61.24	-81.24	1	-49.70	-89.14
2SAM3_2	1125	6074220	2207609	4	38.11	39.69	-1.58	-61.24	-81.24	1	-49.70	-89.14
2SAM3_2	1309	6074220	2207609	4	36.93	39.81	-2.88	-61.24	-81.24	1	-49.70	-89.14
2SAM3_2	1431	6074220	2207609	4	39.49	39.94	-0.45	-61.24	-81.24	1	-49.70	-89.14
2SAM3_2	1551	6074220	2207609	4	39.2	40.06	-0.86	-61.24	-81.24	1	-49.70	-89.14
2SAM3_2	1674	6074220	2207609	4	40.74	40.24	0.50	-61.24	-81.24	1	-49.70	-89.14
2SAM3_2	1826	6074220	2207609	4	41.92	40.42	1.50	-61.24	-81.24	1	-49.70	-89.14
2SAM3_2	1917	6074220	2207609	4	42.6	40.21	2.39	-61.24	-81.24	1	-49.70	-89.14
2SAM3_2	2070	6074220	2207609	4	41.46	39.67	1.79	-61.24	-81.24	1	-49.70	-89.14
2SAM3_2	2221	6074220	2207609	4	41.93	39.10	2.83	-61.24	-81.24	1	-49.70	-89.14
2SAM3_2	2435	6074220	2207609	4	39	38.17	0.83	-61.24	-81.24	1	-49.70	-89.14

* Group 1 - Targets are within Study Area and are actual observations
55 - Targets are within Study Area and are synthetic data based on potentiometric surface map projections
66 - Targets area outside of Study Area and are actual observations

Well Name	Time (days)	X (feet)	Y (feet)	Layer	Observed (feet amsl)	Computed (feet amsl)	Residual (feet)	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Group*	Top of Layer (feet amsl)	Bottom of Layer (feet amsl)
2SAM3_2	2586	6074220	2207609	4	38.48	37.50	0.98	-61.24	-81.24	1	-49.70	-89.14
2SAM3_2	2770	6074220	2207609	4	35.91	36.66	-0.75	-61.24	-81.24	1	-49.70	-89.14
2SAM3_2	2982	6074220	2207609	4	35.22	35.74	-0.52	-61.24	-81.24	1	-49.70	-89.14
2SAM3_2	3165	6074220	2207609	4	34.2	34.94	-0.74	-61.24	-81.24	1	-49.70	-89.14
2SAM3_2	3287	6074220	2207609	4	34.39	34.45	-0.06	-61.24	-81.24	1	-49.70	-89.14
2SAM3_2	3531	6074220	2207609	4	32.75	34.56	-1.81	-61.24	-81.24	1	-49.70	-89.14
2SAM3_2	3682	6074220	2207609	4	35.4	35.12	0.28	-61.24	-81.24	1	-49.70	-89.14
2SAM3_2	3788	6074220	2207609	4	34.66	35.18	-0.52	-61.24	-81.24	1	-49.70	-89.14
2SAM4_2	944	6072906	2206699	4	34.71	37.57	-2.86	-67.39	-82.39	1	-48.11	-108.81
2SAM4_2	1125	6072906	2206699	4	36.74	37.64	-0.90	-67.39	-82.39	1	-48.11	-108.81
2SAM4_2	1309	6072906	2206699	4	35.65	37.75	-2.10	-67.39	-82.39	1	-48.11	-108.81
2SAM4_2	1431	6072906	2206699	4	38.2	37.87	0.33	-67.39	-82.39	1	-48.11	-108.81
2SAM4_2	1551	6072906	2206699	4	37.77	37.99	-0.22	-67.39	-82.39	1	-48.11	-108.81
2SAM4_2	1674	6072906	2206699	4	39.21	38.17	1.04	-67.39	-82.39	1	-48.11	-108.81
2SAM4_2	1826	6072906	2206699	4	40.16	38.33	1.83	-67.39	-82.39	1	-48.11	-108.81
2SAM4_2	1917	6072906	2206699	4	40.8	38.15	2.65	-67.39	-82.39	1	-48.11	-108.81
2SAM4_2	2070	6072906	2206699	4	39.72	37.66	2.06	-67.39	-82.39	1	-48.11	-108.81
2SAM4_2	2221	6072906	2206699	4	40.11	37.14	2.97	-67.39	-82.39	1	-48.11	-108.81
2SAM4_2	2435	6072906	2206699	4	37.6	36.28	1.32	-67.39	-82.39	1	-48.11	-108.81
2SAM4_2	2586	6072906	2206699	4	37.21	35.67	1.54	-67.39	-82.39	1	-48.11	-108.81
2SAM4_2	2770	6072906	2206699	4	34.75	34.88	-0.13	-67.39	-82.39	1	-48.11	-108.81
2SAM4_2	2982	6072906	2206699	4	34.11	34.03	0.08	-67.39	-82.39	1	-48.11	-108.81
2SAM4_2	3165	6072906	2206699	4	33.09	33.29	-0.20	-67.39	-82.39	1	-48.11	-108.81
2SAM4_2	3287	6072906	2206699	4	33.37	32.83	0.54	-67.39	-82.39	1	-48.11	-108.81
2SAM4_2	3531	6072906	2206699	4	31.77	32.92	-1.15	-67.39	-82.39	1	-48.11	-108.81
2SAM4_2	3682	6072906	2206699	4	34.5	33.42	1.08	-67.39	-82.39	1	-48.11	-108.81
2SAM4_2	3788	6072906	2206699	4	33.63	33.47	0.16	-67.39	-82.39	1	-48.11	-108.81
2SAM5_2	944	6072894	2205886	4	33.9	36.46	-2.56	-64.69	-79.69	1	-55.34	-107.54
2SAM5_2	1125	6072894	2205886	4	36	36.53	-0.53	-64.69	-79.69	1	-55.34	-107.54
2SAM5_2	1309	6072894	2205886	4	34.97	36.63	-1.66	-64.69	-79.69	1	-55.34	-107.54
2SAM5_2	1431	6072894	2205886	4	37.58	36.75	0.83	-64.69	-79.69	1	-55.34	-107.54
2SAM5_2	1551	6072894	2205886	4	37.03	36.87	0.16	-64.69	-79.69	1	-55.34	-107.54
2SAM5_2	1674	6072894	2205886	4	38.45	37.04	1.41	-64.69	-79.69	1	-55.34	-107.54
2SAM5_2	1826	6072894	2205886	4	39.34	37.21	2.13	-64.69	-79.69	1	-55.34	-107.54
2SAM5_2	1917	6072894	2205886	4	39.95	37.04	2.91	-64.69	-79.69	1	-55.34	-107.54
2SAM5_2	2070	6072894	2205886	4	38.85	36.59	2.26	-64.69	-79.69	1	-55.34	-107.54
2SAM5_2	2221	6072894	2205886	4	39.15	36.10	3.05	-64.69	-79.69	1	-55.34	-107.54
2SAM5_2	2435	6072894	2205886	4	36.65	35.28	1.37	-64.69	-79.69	1	-55.34	-107.54
2SAM5_2	2586	6072894	2205886	4	36.58	34.70	1.88	-64.69	-79.69	1	-55.34	-107.54
2SAM5_2	2770	6072894	2205886	4	33.68	33.94	-0.26	-64.69	-79.69	1	-55.34	-107.54
2SAM5_2	2982	6072894	2205886	4	33.34	33.13	0.21	-64.69	-79.69	1	-55.34	-107.54
2SAM5_2	3165	6072894	2205886	4	32.42	32.43	-0.01	-64.69	-79.69	1	-55.34	-107.54
2SAM5_2	3287	6072894	2205886	4	32.72	32.00	0.72	-64.69	-79.69	1	-55.34	-107.54
2SAM5_2	3531	6072894	2205886	4	31.18	32.06	-0.88	-64.69	-79.69	1	-55.34	-107.54
2SAM5_2	3682	6072894	2205886	4	33.99	32.51	1.48	-64.69	-79.69	1	-55.34	-107.54
2SAM5_2	3788	6072894	2205886	4	33	32.56	0.44	-64.69	-79.69	1	-55.34	-107.54
2SAM6_2	944	6075457	2205984	4	34.4	37.95	-3.55	-60.58	-80.58	1	-49.64	-95.48
2SAM6_2	1125	6075457	2205984	4	36.29	38.01	-1.72	-60.58	-80.58	1	-49.64	-95.48
2SAM6_2	1309	6075457	2205984	4	35.2	38.09	-2.89	-60.58	-80.58	1	-49.64	-95.48
2SAM6_2	1431	6075457	2205984	4	38.14	38.22	-0.08	-60.58	-80.58	1	-49.64	-95.48
2SAM6_2	1551	6075457	2205984	4	37.55	38.35	-0.80	-60.58	-80.58	1	-49.64	-95.48
2SAM6_2	1674	6075457	2205984	4	39.35	38.54	0.81	-60.58	-80.58	1	-49.64	-95.48
2SAM6_2	1826	6075457	2205984	4	40.23	38.72	1.51	-60.58	-80.58	1	-49.64	-95.48
2SAM6_2	1917	6075457	2205984	4	40.91	38.58	2.33	-60.58	-80.58	1	-49.64	-95.48
2SAM6_2	2070	6075457	2205984	4	39.77	38.14	1.63	-60.58	-80.58	1	-49.64	-95.48
2SAM6_2	2221	6075457	2205984	4	39.96	37.66	2.30	-60.58	-80.58	1	-49.64	-95.48
2SAM6_2	2435	6075457	2205984	4	36.8	36.82	-0.02	-60.58	-80.58	1	-49.64	-95.48
2SAM6_2	2586	6075457	2205984	4	36.35	36.22	0.13	-60.58	-80.58	1	-49.64	-95.48
2SAM6_2	2770	6075457	2205984	4	33.88	35.43	-1.55	-60.58	-80.58	1	-49.64	-95.48
2SAM6_2	2982	6075457	2205984	4	33.5	34.61	-1.11	-60.58	-80.58	1	-49.64	-95.48
2SAM6_2	3165	6075457	2205984	4	32.8	33.89	-1.09	-60.58	-80.58	1	-49.64	-95.48
2SAM6_2	3287	6075457	2205984	4	32.9	33.46	-0.56	-60.58	-80.58	1	-49.64	-95.48
2SAM6_2	3531	6075457	2205984	4	31.31	33.46	-2.15	-60.58	-80.58	1	-49.64	-95.48
2SAM6_2	3682	6075457	2205984	4	33.99	33.90	0.09	-60.58	-80.58	1	-49.64	-95.48
2SAM7D	760	6070771	2202544	4	30.184	29.81	0.38	-68.18	-73.18	55	-56.90	-80.63
2SAM7D	1125	6070771	2202544	4	30.334	29.81	0.53	-68.18	-73.18	55	-56.90	-80.63
2SAM7D	1309	6070771	2202544	4	29.454	29.90	-0.45	-68.18	-73.18	55	-56.90	-80.63
2SAM7D	1431	6070771	2202544	4	30.864	30.02	0.85	-68.18	-73.18	55	-56.90	-80.63
2SAM7D	1674	6070771	2202544	4	30.164	30.32	-0.16	-68.18	-73.18	55	-56.90	-80.63
2SAM7D	1826	6070771	2202544	4	30.494	30.50	-0.01	-68.18	-73.18	55	-56.90	-80.63
2SAM7D	2070	6070771	2202544	4	30.194	30.10	0.09	-68.18	-73.18	55	-56.90	-80.63

* Group 1 - Targets are within Study Area and are actual observations
55 - Targets are within Study Area and are synthetic data based on potentiometric surface map projections
66 - Targets area outside of Study Area and are actual observations

Well Name	Time (days)	X (feet)	Y (feet)	Layer	Observed (feet amsl)	Computed (feet amsl)	Residual (feet)	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Group*	Top of Layer (feet amsl)	Bottom of Layer (feet amsl)
2SAM7D	2221	6070771	2202544	4	30.054	29.74	0.31	-68.18	-73.18	55	-56.90	-80.63
2SAM7D	2435	6070771	2202544	4	29.894	29.11	0.78	-68.18	-73.18	55	-56.90	-80.63
2SAM7D	2770	6070771	2202544	4	28.964	28.07	0.90	-68.18	-73.18	55	-56.90	-80.63
2SAM7D	2982	6070771	2202544	4	28.584	27.45	1.13	-68.18	-73.18	55	-56.90	-80.63
2SAM7D	3287	6070771	2202544	4	28.574	26.62	1.96	-68.18	-73.18	55	-56.90	-80.63
2SAM7D	3531	6070771	2202544	4	27.584	26.61	0.98	-68.18	-73.18	55	-56.90	-80.63
2SAM7D	3682	6070771	2202544	4	30.084	26.91	3.17	-68.18	-73.18	55	-56.90	-80.63
2SAM8D	609	6072796	2199951	4	27.081	26.21	0.87	-47.90	-57.90	55	-30.77	-55.21
2SAM8D	760	6072796	2199951	4	27.501	26.07	1.43	-47.90	-57.90	55	-30.77	-55.21
2SAM8D	944	6072796	2199951	4	26.931	25.97	0.97	-47.90	-57.90	55	-30.77	-55.21
2SAM8D	1125	6072796	2199951	4	27.951	25.97	1.98	-47.90	-57.90	55	-30.77	-55.21
2SAM8D	1309	6072796	2199951	4	26.921	26.07	0.85	-47.90	-57.90	55	-30.77	-55.21
2SAM8D	1431	6072796	2199951	4	27.611	26.21	1.40	-47.90	-57.90	55	-30.77	-55.21
2SAM8D	1551	6072796	2199951	4	27.551	26.38	1.17	-47.90	-57.90	55	-30.77	-55.21
2SAM8D	1674	6072796	2199951	4	27.381	26.63	0.75	-47.90	-57.90	55	-30.77	-55.21
2SAM8D	1826	6072796	2199951	4	27.281	26.89	0.39	-47.90	-57.90	55	-30.77	-55.21
2SAM8D	2070	6072796	2199951	4	27.411	26.65	0.76	-47.90	-57.90	55	-30.77	-55.21
2SAM8D	2221	6072796	2199951	4	27.031	26.37	0.66	-47.90	-57.90	55	-30.77	-55.21
2SAM8D	2435	6072796	2199951	4	26.861	25.79	1.08	-47.90	-57.90	55	-30.77	-55.21
2SAM8D	2586	6072796	2199951	4	27.161	25.38	1.78	-47.90	-57.90	55	-30.77	-55.21
2SAM8D	2770	6072796	2199951	4	26.681	24.80	1.88	-47.90	-57.90	55	-30.77	-55.21
2SAM8D	2982	6072796	2199951	4	27.031	24.26	2.77	-47.90	-57.90	55	-30.77	-55.21
2SAM8D	3165	6072796	2199951	4	26.531	23.86	2.67	-47.90	-57.90	55	-30.77	-55.21
2SAM8D	3531	6072796	2199951	4	26.881	23.51	3.37	-47.90	-57.90	55	-30.77	-55.21
2SAM8D	3788	6072796	2199951	4	27.271	23.77	3.50	-47.90	-57.90	55	-30.77	-55.21
2SAM9D	609	6074458	2198353	4	26.613	24.34	2.28	-40.42	-50.42	55	-36.17	-49.37
2SAM9D	760	6074458	2198353	4	26.213	24.19	2.02	-40.42	-50.42	55	-36.17	-49.37
2SAM9D	944	6074458	2198353	4	25.463	24.01	1.45	-40.42	-50.42	55	-36.17	-49.37
2SAM9D	1125	6074458	2198353	4	26.663	23.98	2.68	-40.42	-50.42	55	-36.17	-49.37
2SAM9D	1309	6074458	2198353	4	25.723	24.09	1.63	-40.42	-50.42	55	-36.17	-49.37
2SAM9D	1431	6074458	2198353	4	26.033	24.29	1.75	-40.42	-50.42	55	-36.17	-49.37
2SAM9D	1551	6074458	2198353	4	26.033	24.54	1.49	-40.42	-50.42	55	-36.17	-49.37
2SAM9D	1674	6074458	2198353	4	25.813	24.91	0.90	-40.42	-50.42	55	-36.17	-49.37
2SAM9D	1826	6074458	2198353	4	25.903	25.29	0.61	-40.42	-50.42	55	-36.17	-49.37
2SAM9D	1917	6074458	2198353	4	25.923	25.38	0.54	-40.42	-50.42	55	-36.17	-49.37
2SAM9D	2070	6074458	2198353	4	25.783	25.18	0.60	-40.42	-50.42	55	-36.17	-49.37
2SAM9D	2221	6074458	2198353	4	25.863	24.97	0.89	-40.42	-50.42	55	-36.17	-49.37
2SAM9D	2435	6074458	2198353	4	25.553	24.35	1.21	-40.42	-50.42	55	-36.17	-49.37
2SAM9D	2586	6074458	2198353	4	25.813	23.94	1.87	-40.42	-50.42	55	-36.17	-49.37
2SAM9D	2770	6074458	2198353	4	25.243	23.31	1.94	-40.42	-50.42	55	-36.17	-49.37
2SAM9D	2982	6074458	2198353	4	25.833	22.82	3.01	-40.42	-50.42	55	-36.17	-49.37
2SAM9D	3165	6074458	2198353	4	25.043	22.51	2.54	-40.42	-50.42	55	-36.17	-49.37
2SAM9D	3287	6074458	2198353	4	25.353	22.34	3.01	-40.42	-50.42	55	-36.17	-49.37
2SAM9D	3531	6074458	2198353	4	25.463	22.13	3.34	-40.42	-50.42	55	-36.17	-49.37
2SAM9D	3788	6074458	2198353	4	26.113	22.32	3.80	-40.42	-50.42	55	-36.17	-49.37
5D1	426	6074307	2208302	4	39.75	40.81	-1.06	-51.65	-61.65	1	-45.71	-89.72
5D1	609	6074307	2208302	4	39.42	40.77	-1.35	-51.65	-61.65	1	-45.71	-89.72
5D1	760	6074307	2208302	4	39.29	40.70	-1.41	-51.65	-61.65	1	-45.71	-89.72
5D1	944	6074307	2208302	4	37.53	40.68	-3.15	-51.65	-61.65	1	-45.71	-89.72
5D1	1125	6074307	2208302	4	38.65	40.78	-2.13	-51.65	-61.65	1	-45.71	-89.72
5D1	1309	6074307	2208302	4	38.57	40.90	-2.33	-51.65	-61.65	1	-45.71	-89.72
5D1	1431	6074307	2208302	4	40.1	41.04	-0.94	-51.65	-61.65	1	-45.71	-89.72
5D1	1551	6074307	2208302	4	39.25	41.16	-1.91	-51.65	-61.65	1	-45.71	-89.72
5D1	1674	6074307	2208302	4	41	41.34	-0.34	-51.65	-61.65	1	-45.71	-89.72
5D1	1826	6074307	2208302	4	42.83	41.52	1.31	-51.65	-61.65	1	-45.71	-89.72
5D1	1917	6074307	2208302	4	43.7	41.29	2.41	-51.65	-61.65	1	-45.71	-89.72
5D1	2070	6074307	2208302	4	42.48	40.71	1.77	-51.65	-61.65	1	-45.71	-89.72
5D1	2221	6074307	2208302	4	42.65	40.11	2.54	-51.65	-61.65	1	-45.71	-89.72
2SAM1_3	944	6074660	2209328	6	14.48	11.00	3.48	-125.32	-130.32	1	-98.55	-198.55
2SAM1_3	1125	6074660	2209328	6	16.85	16.99	-0.14	-125.32	-130.32	1	-98.55	-198.55
2SAM1_3	1309	6074660	2209328	6	19.5	19.09	0.41	-125.32	-130.32	1	-98.55	-198.55
2SAM1_3	1431	6074660	2209328	6	27.32	27.06	0.26	-125.32	-130.32	1	-98.55	-198.55
2SAM1_3	1551	6074660	2209328	6	29.95	29.95	0.00	-125.32	-130.32	1	-98.55	-198.55
2SAM1_3	1674	6074660	2209328	6	46.29	39.82	6.47	-125.32	-130.32	1	-98.55	-198.55
2SAM1_3	1826	6074660	2209328	6	46.01	43.09	2.92	-125.32	-130.32	1	-98.55	-198.55
2SAM1_3	1917	6074660	2209328	6	48.28	45.16	3.12	-125.32	-130.32	1	-98.55	-198.55
2SAM1_3	2070	6074660	2209328	6	40.55	39.50	1.05	-125.32	-130.32	1	-98.55	-198.55
2SAM1_3	2221	6074660	2209328	6	40.63	39.55	1.08	-125.32	-130.32	1	-98.55	-198.55
2SAM1_3	2435	6074660	2209328	6	20.75	24.94	-4.19	-125.32	-130.32	1	-98.55	-198.55
2SAM1_3	2586	6074660	2209328	6	17.04	21.22	-4.18	-125.32	-130.32	1	-98.55	-198.55
2SAM1_3	2770	6074660	2209328	6	7.23	9.00	-1.77	-125.32	-130.32	1	-98.55	-198.55
2SAM1_3	2982	6074660	2209328	6	9.36	12.42	-3.06	-125.32	-130.32	1	-98.55	-198.55

* Group 1 - Targets are within Study Area and are actual observations
55 - Targets are within Study Area and are synthetic data based on potentiometric surface map projections
66 - Targets area outside of Study Area and are actual observations

Well Name	Time (days)	X (feet)	Y (feet)	Layer	Observed (feet amsl)	Computed (feet amsl)	Residual (feet)	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Group*	Top of Layer (feet amsl)	Bottom of Layer (feet amsl)
2SAM1_3	3165	6074660	2209328	6	11.57	11.70	-0.13	-125.32	-130.32	1	-98.55	-198.55
2SAM1_3	3287	6074660	2209328	6	11.93	13.10	-1.17	-125.32	-130.32	1	-98.55	-198.55
2SAM1_3	3531	6074660	2209328	6	9.38	8.43	0.95	-125.32	-130.32	1	-98.55	-198.55
2SAM1_3	3682	6074660	2209328	6	15.35	14.14	1.21	-125.32	-130.32	1	-98.55	-198.55
2SAM1_3	3788	6074660	2209328	6	19.58	15.14	4.44	-125.32	-130.32	1	-98.55	-198.55
2SAM2_3	944	6072812	2208121	6	8.23	6.36	1.87	-146.46	-156.46	1	-121.33	-221.33
2SAM2_3	1125	6072812	2208121	6	11.61	12.65	-1.04	-146.46	-156.46	1	-121.33	-221.33
2SAM2_3	1309	6072812	2208121	6	14.52	14.71	-0.19	-146.46	-156.46	1	-121.33	-221.33
2SAM2_3	1431	6072812	2208121	6	24.14	22.92	1.22	-146.46	-156.46	1	-121.33	-221.33
2SAM2_3	1551	6072812	2208121	6	26.57	25.79	0.78	-146.46	-156.46	1	-121.33	-221.33
2SAM2_3	1674	6072812	2208121	6	42.78	35.79	6.99	-146.46	-156.46	1	-121.33	-221.33
2SAM2_3	1826	6072812	2208121	6	41.8	38.87	2.93	-146.46	-156.46	1	-121.33	-221.33
2SAM2_3	1917	6072812	2208121	6	44.05	41.00	3.05	-146.46	-156.46	1	-121.33	-221.33
2SAM2_3	2070	6072812	2208121	6	33.75	35.07	-1.32	-146.46	-156.46	1	-121.33	-221.33
2SAM2_3	2221	6072812	2208121	6	35.25	35.26	-0.01	-146.46	-156.46	1	-121.33	-221.33
2SAM2_3	2435	6072812	2208121	6	18.15	20.75	-2.60	-146.46	-156.46	1	-121.33	-221.33
2SAM2_3	2586	6072812	2208121	6	13.76	17.61	-3.85	-146.46	-156.46	1	-121.33	-221.33
2SAM2_3	2770	6072812	2208121	6	3.13	5.04	-1.91	-146.46	-156.46	1	-121.33	-221.33
2SAM2_3	2982	6072812	2208121	6	6.86	8.83	-1.97	-146.46	-156.46	1	-121.33	-221.33
2SAM2_3	3165	6072812	2208121	6	7.1	8.03	-0.93	-146.46	-156.46	1	-121.33	-221.33
2SAM2_3	3287	6072812	2208121	6	10.24	9.84	0.40	-146.46	-156.46	1	-121.33	-221.33
2SAM2_3	3531	6072812	2208121	6	5.19	4.91	0.28	-146.46	-156.46	1	-121.33	-221.33
2SAM2_3	3682	6072812	2208121	6	14.08	10.85	3.23	-146.46	-156.46	1	-121.33	-221.33
2SAM2_3	3788	6072812	2208121	6	17.23	11.73	5.50	-146.46	-156.46	1	-121.33	-221.33
2SAM4_3	944	6072906	2206699	6	10.28	4.29	5.99	-132.39	-142.39	1	-124.85	-224.85
2SAM4_3	1125	6072906	2206699	6	12.14	10.50	1.64	-132.39	-142.39	1	-124.85	-224.85
2SAM4_3	1309	6072906	2206699	6	14.63	12.53	2.10	-132.39	-142.39	1	-124.85	-224.85
2SAM4_3	1431	6072906	2206699	6	23.92	20.62	3.30	-132.39	-142.39	1	-124.85	-224.85
2SAM4_3	1551	6072906	2206699	6	25.2	23.47	1.73	-132.39	-142.39	1	-124.85	-224.85
2SAM4_3	1674	6072906	2206699	6	40.71	33.28	7.43	-132.39	-142.39	1	-124.85	-224.85
2SAM4_3	1826	6072906	2206699	6	40.68	36.21	4.47	-132.39	-142.39	1	-124.85	-224.85
2SAM4_3	1917	6072906	2206699	6	43.11	38.29	4.82	-132.39	-142.39	1	-124.85	-224.85
2SAM4_3	2070	6072906	2206699	6	33.65	32.38	1.27	-132.39	-142.39	1	-124.85	-224.85
2SAM4_3	2221	6072906	2206699	6	34.75	32.59	2.16	-132.39	-142.39	1	-124.85	-224.85
2SAM4_3	2435	6072906	2206699	6	17.51	18.43	-0.92	-132.39	-142.39	1	-124.85	-224.85
2SAM4_3	2586	6072906	2206699	6	13.82	15.57	-1.75	-132.39	-142.39	1	-124.85	-224.85
2SAM4_3	2770	6072906	2206699	6	3.44	3.15	0.29	-132.39	-142.39	1	-124.85	-224.85
2SAM4_3	2982	6072906	2206699	6	6.82	6.98	-0.16	-132.39	-142.39	1	-124.85	-224.85
2SAM4_3	3165	6072906	2206699	6	7.51	6.17	1.34	-132.39	-142.39	1	-124.85	-224.85
2SAM4_3	3287	6072906	2206699	6	9.73	8.09	1.64	-132.39	-142.39	1	-124.85	-224.85
2SAM4_3	3531	6072906	2206699	6	4.35	3.12	1.23	-132.39	-142.39	1	-124.85	-224.85
2SAM4_3	3682	6072906	2206699	6	13.46	8.97	4.49	-132.39	-142.39	1	-124.85	-224.85
2SAM4_3	3788	6072906	2206699	6	16.25	9.80	6.45	-132.39	-142.39	1	-124.85	-224.85
2SAM5_3	944	6072894	2205840	6	15.89	2.95	12.94	-131.69	-141.69	1	-122.65	-222.65
2SAM5_3	1125	6072894	2205840	6	17.98	9.09	8.89	-131.69	-141.69	1	-122.65	-222.65
2SAM5_3	1309	6072894	2205840	6	19.32	11.11	8.21	-131.69	-141.69	1	-122.65	-222.65
2SAM5_3	1431	6072894	2205840	6	27.3	19.12	8.18	-131.69	-141.69	1	-122.65	-222.65
2SAM5_3	1551	6072894	2205840	6	27.7	21.96	5.74	-131.69	-141.69	1	-122.65	-222.65
2SAM5_3	1674	6072894	2205840	6	39.09	31.64	7.45	-131.69	-141.69	1	-122.65	-222.65
2SAM5_3	1826	6072894	2205840	6	39.09	34.48	4.61	-131.69	-141.69	1	-122.65	-222.65
2SAM5_3	1917	6072894	2205840	6	41.08	36.53	4.55	-131.69	-141.69	1	-122.65	-222.65
2SAM5_3	2070	6072894	2205840	6	33.87	30.65	3.22	-131.69	-141.69	1	-122.65	-222.65
2SAM5_3	2221	6072894	2205840	6	33.1	30.86	2.24	-131.69	-141.69	1	-122.65	-222.65
2SAM5_3	2435	6072894	2205840	6	20.69	16.94	3.75	-131.69	-141.69	1	-122.65	-222.65
2SAM5_3	2586	6072894	2205840	6	17.53	14.25	3.28	-131.69	-141.69	1	-122.65	-222.65
2SAM5_3	2770	6072894	2205840	6	7.88	1.92	5.96	-131.69	-141.69	1	-122.65	-222.65
2SAM5_3	2982	6072894	2205840	6	10.57	5.77	4.80	-131.69	-141.69	1	-122.65	-222.65
2SAM5_3	3165	6072894	2205840	6	10.62	4.96	5.66	-131.69	-141.69	1	-122.65	-222.65
2SAM5_3	3287	6072894	2205840	6	13	6.95	6.05	-131.69	-141.69	1	-122.65	-222.65
2SAM5_3	3531	6072894	2205840	6	8.51	1.95	6.56	-131.69	-141.69	1	-122.65	-222.65
2SAM5_3	3682	6072894	2205840	6	16.34	7.75	8.59	-131.69	-141.69	1	-122.65	-222.65
2SAM5_3	3788	6072894	2205840	6	18.38	8.55	9.83	-131.69	-141.69	1	-122.65	-222.65
2SAM6_3	944	6075457	2205984	6	12.03	7.08	4.95	-122.58	-132.58	1	-98.34	-198.34
2SAM6_3	1125	6075457	2205984	6	14.88	12.77	2.11	-122.58	-132.58	1	-98.34	-198.34
2SAM6_3	1309	6075457	2205984	6	16.52	14.81	1.71	-122.58	-132.58	1	-98.34	-198.34
2SAM6_3	1551	6075457	2205984	6	26.29	25.27	1.02	-122.58	-132.58	1	-98.34	-198.34
2SAM6_3	1674	6075457	2205984	6	40.17	34.62	5.55	-122.58	-132.58	1	-98.34	-198.34
2SAM6_3	1826	6075457	2205984	6	40.01	37.58	2.43	-122.58	-132.58	1	-98.34	-198.34
2SAM6_3	1917	6075457	2205984	6	42.07	39.51	2.56	-122.58	-132.58	1	-98.34	-198.34
2SAM6_3	2070	6075457	2205984	6	34.72	33.97	0.75	-122.58	-132.58	1	-98.34	-198.34
2SAM6_3	2221	6075457	2205984	6	35.31	34.02	1.29	-122.58	-132.58	1	-98.34	-198.34
2SAM6_3	2435	6075457	2205984	6	19.51	20.29	-0.78	-122.58	-132.58	1	-98.34	-198.34
2SAM6_3	2770	6075457	2205984	6	5.94	5.42	0.52	-122.58	-132.58	1	-98.34	-198.34
2SAM6_3	2982	6075457	2205984	6	7.91	8.82	-0.91	-122.58	-132.58	1	-98.34	-198.34
2SAM6_3	3165	6075457	2205984	6	9.52	8.09	1.43	-122.58	-132.58	1	-98.34	-198.34
2SAM6_3	3287	6075457	2205984	6	10.81	9.71	1.10	-122.58	-132.58	1	-98.34	-198.34
2SAM6_3	3531	6075457	2205984	6	6.41	4.99	1.42	-122.58	-132.58	1	-98.34	-198.34
2SAM6_3	3682	6075457	2205984	6	13.69	10.44	3.25	-122.58	-132.58	1	-98.34	-198.34

* Group 1 - Targets are within Study Area and are actual observations
55 - Targets are within Study Area and are synthetic data based on potentiometric surface map projections
66 - Targets area outside of Study Area and are actual observations

Well Name	Time (days)	X (feet)	Y (feet)	Layer	Observed (feet amsl)	Computed (feet amsl)	Residual (feet)	Top of Screened Interval (ft amsl)	Bottom of Screened Interval (ft amsl)	Group*	Top of Layer (feet amsl)	Bottom of Layer (feet amsl)
GM_Oil21-MW3	426	6063895	2194822	4	15.09	15.24	-0.15	21.29	7.29	66	-14.42	-44.04
GM_Oil21-MW3	1826	6063895	2194822	4	16.17	15.63	0.54	21.29	7.29	66	-14.42	-44.04
GM_Oil21-MW3	3287	6063895	2194822	4	15.02	13.50	1.52	21.29	7.29	66	-14.42	-44.04
Mobil18_MW5S	426	6086141	2214390	1	65.85	65.64	0.21	79.37	49.37	66	103.14	35.56
Mobil18_MW5S	1826	6086141	2214390	1	65.85	65.06	0.79	79.37	49.37	66	103.14	35.56
Mobil18_MW5S	3287	6086141	2214390	1	57.07	64.17	-7.10	79.37	49.37	66	103.14	35.56
Mobil18_MW5D	426	6086139	2214344	3	65.82	55.04	10.78	4.36	-0.64	66	17.85	-42.66
Mobil18_MW5D	1826	6086139	2214344	3	64.33	56.45	7.88	4.36	-0.64	66	17.85	-42.66
Mobil18_MW5D	3287	6086139	2214344	3	56.96	48.96	8.00	4.36	-0.64	66	17.85	-42.66
7-1_MW2	426	6064410	2214838	1	65.73	63.09	2.64	71.51	51.51	66	74.20	19.59
7-1_MW2	1826	6064410	2214838	1	65.3	61.91	3.39	71.51	51.51	66	74.20	19.59
7-1_MW2	3287	6064410	2214838	1	60.24	61.19	-0.95	71.51	51.51	66	74.20	19.59
SL_862_MW17	426	6074072	2192937	4	24.77	17.03	7.74	21.75	10.55	66	7.35	-37.02
L_994_MW-5	426	6079843	2190893	4	22.07	20.36	1.71	25.90	-4.10	66	18.76	-12.72
L_994_MW-5	1826	6079843	2190893	4	23.21	22.02	1.19	25.90	-4.10	66	18.76	-12.72
L_994_MW-5	3287	6079843	2190893	4	15.45	18.95	-3.50	25.90	-4.10	66	18.76	-12.72
L_994_MW6	426	6080899	2190510	4	30.81	25.04	5.77	37.29	7.29	66	38.69	-4.12
L_994_MW6	1826	6080899	2190510	4	31.78	26.01	5.77	37.29	7.29	66	38.69	-4.12
L_994_MW6	3287	6080899	2190510	4	28.64	24.11	4.53	37.29	7.29	66	38.69	-4.12
T06_792_MW1	426	6079776	2193947	4	20.68	24.11	-3.43	31.40	1.40	66	-6.84	-52.35
T06_792_MW1	1826	6079776	2193947	4	20.3	25.50	-5.20	31.40	1.40	66	-6.84	-52.35
T06_792_MW1	3287	6079776	2193947	4	20.16	22.48	-2.32	31.40	1.40	66	-6.84	-52.35
T06_641_MW3	426	6064502	2202322	4	27.17	23.60	3.57	28.01	8.01	66	-67.93	-111.22
T06_641_MW3	1826	6064502	2202322	4	27.42	24.43	2.99	28.01	8.01	66	-67.93	-111.22
T06_641_MW3	3287	6064502	2202322	4	27.11	21.49	5.62	28.01	8.01	66	-67.93	-111.22

* Group 1 - Targets are within Study Area and are actual observations
55 - Targets are within Study Area and are synthetic data based on potentiometric surface map projections
66 - Targets area outside of Study Area and are actual observations

ATTACHMENT A
MODEL INPUT AND OUTPUT FILES
(PORTABLE EXTERNAL HARD DRIVE)

APPENDIX E, PART II
NUMERICAL GROUNDWATER FLOW MODEL
PART II – REMEDIAL SIMULATIONS

NUMERICAL GROUNDWATER FLOW MODEL
PART II - REMEDIAL SIMULATIONS

South Basin Groundwater Protection Project
Operable Unit 2

Prepared for:

Orange County Water District

18700 Ward Street

Fountain Valley, California

92708

For Internal Use Only

Prepared by:

Engineering Analytics, Inc.

9820 Willow Creek Road, Suite 395
San Diego, California 92131
(858) 221-0264

Project No. 151099

April 1, 2022

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ACRONYMS AND ABBREVIATIONS

Feasibility Study	FS
Feasibility Study Detailed Evaluation	FSDE
Feasibility Study Extraction Sites	FSES
Operable Unit 2	OU2
Orange County Water District	OCWD
Orange County Groundwater Basin	Basin
Remedial Investigation/Feasibility Study	RI/FS
South Basin Groundwater Protection Project	SBGPP
Study area of interest	Study Area

1.0 SOUTH BASIN GROUNDWATER PROTECTION PLAN GROUNDWATER FLOW MODELING-REMEDIAL SIMULATIONS

A numerical groundwater flow model was developed to support the South Basin Groundwater Protection Project (SBGPP) Remedial Investigation/Feasibility Study (RI/FS) being conducted by Orange County Water District (OCWD). The RI/FS is being conducted to address groundwater contamination in Operable Unit 2 (OU2) in the south-central portion of the Orange County Groundwater Basin (the Basin) in Orange County, California (Study Area) (Figure 1.1). OU2 is groundwater contamination in the Shallow Aquifer System (SAS) off-property of numerous groundwater contamination source sites (source sites) located within the Study Area where groundwater contaminant plumes emanating from individual source sites have migrated and commingled.

The groundwater flow model is being utilized to support OCWD's evaluation of remedial alternatives identified in the Feasibility Study (FS) screening process that implement groundwater containment as a General Response Action (GRA). Specifically, the model is used to evaluate groundwater extraction as a remedial technology to mitigate groundwater contamination in OU2 within the SBGPP. Results of the modeling are incorporated into the Feasibility Study Detailed Evaluation (FSDE) (Engineering Analytics [EA], 2021a).

The numerical modeling is based on the current site hydrogeologic conceptual model of the regional and local groundwater flow system. The groundwater flow model is calibrated to transient conditions representative of the low and high potentiometric cycles observed in area monitoring wells. The SBGPP model includes historical, ongoing, and planned source site remedial system groundwater extraction. Development and calibration of the flow model is described in the document "*Numerical Groundwater Flow Model- Part I-Development and Calibration, South Basin Groundwater Protection Plan, Operable Unit 2*" that is in Appendix E of the FSDE (EA, 2021b).

The calibrated SBGPP model is used to simulate groundwater extraction alternatives identified in the FS screening process that are intended to address OU2 groundwater contamination within the SAS. The model is also used to simulate disposal of extracted water (following treatment) via injection into the Basal Sand of the SAS.

This report describes the following:

- setup of the remedial extraction and reinjection simulations;
- results of the extraction (and reinjection) simulations;
- evaluation of the effectiveness of the conceptual OU2 interim remedial measure (IRM) groundwater extraction in achieving hydraulic containment of OU2 groundwater contamination (using flowpath analysis);
- assessment of potential impacts to groundwater flux and groundwater flow direction at existing and planned source site remediation systems; and
- sensitivity analysis of key model parameters on remedial extraction simulation results.

2.0 MODEL SETUP

The calibrated SBGPP model is used to simulate groundwater extraction alternatives identified in the FS screening process. MODFLOW-SURFACT, Version 3 (HydroGeologic 1996) is the model code used to simulate groundwater extraction from OU2. Pre- and post-processing of model input and output was performed using Groundwater Vistas, Version 7 (Environmental Simulations, Inc. 2020). Model output figures were generated using Surfer-Surface Mapping System, Version 16.0 (Golden Software 2019).

The following modifications were incorporated into the calibrated SBGPP model to facilitate simulation of groundwater extraction from OU2.

- The calibrated SBGPP model was converted from transient to steady-state groundwater flow conditions. The high potentiometric condition was used to represent steady-state groundwater flow conditions. This is considered a conservative approach because the high potentiometric condition represents a period of maximum groundwater flux through the SBGPP Study Area and requires the maximum extraction rate for hydraulic containment of OU2 contaminated groundwater.
- Eight locations (identified as G-1 through G-8) are included as conceptual groundwater extraction alignments for addressing OU2 groundwater contamination within the SBGPP (Figure 2.1). These conceptual OU2 IRM groundwater extraction alignments are referred to in this document as Feasibility Study Extraction Sites (FSES).
- Active source site groundwater extraction systems were simulated using the most current available extraction rates downloaded from the California State Water Resources Board Control Geotracker website (as of May 2021). Table 2-1 provides a summary of the extraction rates used as model input for the source site extraction systems.
- Planned source site groundwater extraction systems that are not yet active were estimated and included in the steady state simulation.

Figure 2.1 shows the location of the active and planned source site groundwater extraction systems that are included in the model simulations. Table 2-1 provides a summary of the extraction rates used as model input for those groundwater extraction systems. The locations of source site in-situ remedial systems are also shown on the figure. The in-situ sites are not explicitly modeled in the groundwater extraction simulations; however, the model-simulated hydraulic effects of extraction at each FSES potentially impacting source sites with ongoing or planned in-situ programs is evaluated.

Monitor areas and locations were placed in the model to evaluate the potential hydraulic effects from operation of the FSES that could influence the performance of source site remedial systems. The monitor areas are used to evaluate potential effects of the FSES on groundwater flux through source site areas, and the monitor locations are used to assess potential effects on groundwater flow direction in those same areas. The monitor areas are generally positioned near the downgradient edge of each source site. Those monitor areas and locations are shown on Figure 2.2 and listed in Table 2-2.

The SAS is characterized by various lenses, layers, interbeds, and mixtures of interfingered fine and coarse-grained material. Based on detailed lithologic evaluation and Figures 5-17A through 5-17N in the SRI Report (Hargis + Associates, Inc, 2020), the SAS, with increasing depth, is subdivided into the following four layers:

- Layer 1: an uppermost fine-grained portion at and below the water table;
- Layer 2: a generally laterally continuous predominantly coarse upper sand zone;
- Layer 3: a mixed zone of sands and fine-grained materials; and
- Layer 4: a laterally continuous and relatively coarse-grained basal sand (Basal Sand).

Water quality data presented in the FSDE (EA, 2021a) indicate that OU2 groundwater contamination is generally limited to Layers 1, 2 and 3 of the SAS model. Details of the simulation of the FSES are provided in the following section.

3.0 GROUNDWATER EXTRACTION SIMULATIONS

3.1 Baseline Conditions

The modified SBGPP model was initially used to run a Baseline Simulation. The Baseline Simulation incorporates the high potentiometric groundwater flow condition, the most recently documented source site extraction rates, and planned source site extraction rates (Table 2-1). The Baseline Simulation was run as a steady state model that does not include operation of the FSES (G-1 through G-8). The potentiometric surface for model Layers 1, 2, and 3 of the Baseline Simulation are shown in Figures 3.1 through 3.3, respectively. Groundwater generally flows from the northeast to the southwest across the SBGPP. Localized drawdown resulting from operation of source site groundwater extraction systems is evident, particularly in Layers 1 and 2.

Simulated groundwater flux and groundwater flow direction at each of the source site remedial systems without extraction from the FSES are summarized in Table 3-1. The monitor areas used to calculate groundwater flux from the Baseline Simulation, and the monitor locations used to estimate groundwater flow direction, are shown on Figure 2.2. Groundwater flux and groundwater flow direction are calculated separately for Layers 1, 2 and 3 for each monitor area and monitor location, respectively. Groundwater flux values in Table 3-1 are presented as the groundwater flow rate through the model cross-sectional area at each monitor area illustrated on Figure 2-2. These data provide a baseline for comparison to the simulations with extraction from the FSES.

3.2 Feasibility Study Groundwater Extraction Simulation

Extraction from the eight FSES is included in the FS Groundwater Extraction Simulation. Extraction rates were iteratively adjusted until hydraulic containment was achieved in the vicinity of each of the FSES. All other conditions from the Baseline Simulation are unchanged. The simulated potentiometric surface for 2006, 2012 and 2016 for model Layers 1, 2, and 3 for the FS Groundwater Extraction Simulation are shown in Figures 3.4 through 3.6, respectively.

Table 3-2 summarizes the model-simulated number of wells and extraction rates for each of the FSES (G-1 through G-8) in the FS Groundwater Extraction Simulation. The model structure limits the spacing of the simulated extraction well locations, which are therefore different than the number of extraction wells identified in the FSDE (EA, 2021a). However, the extraction rate from each FSES and the total combined extraction rate from the FSES in the model simulations are equal to those calculated and identified in the FSDE and associated cost elements. Total extraction rates for the individual FSES range from 1.3 to 12.9 gallons per minute (gpm). All FSES are simulated as operating concurrently for this simulation to confirm that well interference between the FSES does not compromise hydraulic containment at any of the individual FSES. The combined extraction rate for the eight FSES is 343.3 gpm.

3.3 Hydraulic Containment Assessment

Hydraulic containment for each FSES is assessed using capture zone analysis of groundwater flowpaths. The particle tracking code MODPATH Version 3 (Pollack 1994) is used to evaluate the capture zone for each FSES. MODPATH was utilized because it readily incorporates information collected from the groundwater flow model and provides computations of groundwater seepage velocities and groundwater flow direction along flowpaths. The code is capable of calculating particle velocity changes over time in three dimensions. Full documentation of the MODPATH code is provided in the MODPATH users guide (Pollock, 1994).

To evaluate hydraulic containment (defined as the capture of groundwater as it reaches the FSES, preventing further downgradient migration), particles are placed along each FSES and are tracked in reverse. This methodology indicates the flowpaths of groundwater that is captured by the extraction well(s). Particles are placed within each layer that require hydraulic containment (based on water quality data), and are tracked for a period of 10 years. Figures 3.7 through 3.14 illustrate the capture zones for the individual FSES. Flowpaths are color coded based on which Layer they reside in at a specific location. In many cases, particles move vertically from one layer into another in response to the hydraulic stresses (drawdown) caused by extraction.

The capture zone for the simulated extraction rate of 29.1 gpm at FSES G-1 is shown on Figure 3.7. Based on review of available water quality data, it is determined that hydraulic containment in the vicinity of G-1 is only necessary for Layers 1 and 2. Extraction wells were placed in Layers 1 and 2 at G-1. The particle tracking indicates that hydraulic containment is exhibited in Layers 1 and 2. The figure also illustrates that groundwater upgradient of G-1 initially in Layer 1 (flowpaths shown in blue), migrates downward into Layer 2 in response to the drawdown associated with G-1 extraction and is eventually captured at G-1.

The capture zone for the simulated extraction rate of 28.6 gpm at FSES G-2 is shown on Figure 3.8. Extraction wells are completed in Layers 2 and 3 at this location. Hydraulic containment is exhibited for Layers 1 through 3. Particles in Layer 1 rapidly move downward into Layer 2 in response to the drawdown caused by extraction from Layer 2. The longer flowpath length for Layer 2 compared to Layer 3 is primarily a result of the higher hydraulic conductivity in Layer 2 relative to Layer 3 at G-2.

The capture zone for the simulated extraction rate of 68.6 gpm at FSES G-3 is shown in Figure 3.9. Hydraulic containment is exhibited for Layers 1 through 3. Extraction wells are included in all three model layers at G-3. The 10-year particle tracking indicates relatively short travel distances within Layer 1 over that period, generally less than 200 feet. Several factors cause the shorter travel distance, including: the hydraulic conductivity associated with Layer 1 is much lower than in Layers 2 and 3 at this location; the extraction rates assigned to Layer 1 extraction wells are much lower than for the other layers; and many of the particles in Layer 1 move downward toward Layer 2 in response to the extraction.

The capture zone for the simulated extraction rate of 1.3 gpm at FSES G-4 is shown on Figure 3.10. Available water quality data suggest that hydraulic containment in the vicinity of G-4 is only necessary for Layer 1. Hydraulic containment is exhibited for Layer 1.

The capture zone for the simulated extraction rate of 21.6 gpm at FSES G-5 is shown on Figure 3.11. Extraction wells are only simulated in Layer 2 for G-5. Hydraulic containment is exhibited for Layers 1 and 2 from a total extraction rate of 21.6 gpm. Available water quality data suggest that hydraulic containment in the vicinity of G-5 is not necessary for Layer 3 (although some groundwater from Layer 3 travel vertically into Layer 2 and are captured at G-5. Particles within Layer 1 in the vicinity of G-5 move rapidly downward into Layer 2 in response to the extraction and are not visible on the figure.

The capture zone for the simulated extraction rate of 102.9 gpm at FSES G-6 is shown on Figure 3.12. Extraction wells are only simulated in Layer 2 at G-6. Hydraulic containment is exhibited for Layers 1 through 3. Groundwater within Layers 1 and 3 in the vicinity of G-6 moves into Layer 2 in response to the extraction and is captured at the extraction wells.

The capture zone for the simulated total extraction rate of 83.1 gpm at FSES G-7 is shown on Figure 3.13. Extraction wells are simulated in model Layers 2 and 3 at G-7. Hydraulic containment is exhibited for Layers 1 through 3. Groundwater within Layer 1 in the vicinity of G-7 moves downward into Layer 2 in response to the extraction.

The capture zone for the simulated total extraction rate of 8.1 gpm at FSES G-8 is shown on Figure 3.14. Extraction wells are simulated in model Layers 2 and 3 at G-8. Hydraulic containment is exhibited for Layers 1 through 3.

Based on flowpath analysis of the FS Remedial Extraction Simulation, hydraulic containment (hydraulic capture of impacted groundwater) was demonstrated for each FSES. The total simulated extraction rate to achieve hydraulic containment, using the calibrated SBGPP model, was 343.3 gpm.

3.4 Potential Hydraulic Effects on Existing/Planned Source Site Remedial Systems

Operation (groundwater extraction) of the FSES may result in changes to the groundwater flux and/or groundwater flow direction in the vicinity of nearby existing and planned source site remedial systems. The SBGPP model is used to assess changes in groundwater flux and groundwater flow direction within Layers 1, 2 and 3 at the source sites in response to simulated extraction from the FSES. The locations where the simulated groundwater flux and groundwater flow direction are monitored are shown on Figure 2.2.

Table 3-3 summarizes the change in simulated groundwater flux at each of the source sites in response to operation of the FSES. Groundwater flux values in Table 3-3 are presented as the groundwater flow rate through the model cross-sectional area at each monitor area illustrated on Figure 2-2.The table also provides a cross reference for each model-simulation monitoring location to the source site identifier. A scaling factor is calculated for each source site. The scaling factor is the ratio of the groundwater flux when the FSES is operating to the flux when the FSES is not operating. In the vast majority of the cases, groundwater flux across a source site increases in response to operation of the FSES. This is primarily because of the increased hydraulic gradients induced by drawdown at the FSES in response to groundwater extraction. The average scaling factor for the 72 monitored sites is 1.26. In other words, the groundwater flux across the source sites increased by an average of 26 percent in response to FSES operation. Twelve sites saw an increase of over 50 percent (scaling factor greater than 1.5). Groundwater flux more than doubled at seven of the source sites. Figure 3.15 graphically presents the scaling factor for each of the model monitor sites.

Table 3-4 provides a summary of the change in simulated groundwater flow direction resulting from operation of the FSES. The simulated groundwater flow direction is calculated at the downgradient edge of each source site, as illustrated on Figure 2.2. Flow vectors were calculated at the model-simulated monitoring locations at each source site for the baseline conditions and for FSES operating conditions. The flow direction is reported on the table as degrees. Due east is zero degrees and increases counter clockwise. Simulated groundwater flow direction changed by less than 10 degrees at 55 of the 72 source site monitor points in response to FSES operation. Eight source site monitor points recorded a change in groundwater flow direction of greater than 20 degrees and two of those were greater than 40 degrees. In most cases, the changes in groundwater flow direction at the source sites in response to FSES operation were toward the south. The change in groundwater flow direction for Layers 1, 2 and 3 at each of the source sites is shown of Figure 3.16.

3.5 Reinjection of Extracted Groundwater

The SBGPP model was also used to evaluate potential disposal capacity of the Basal Sand unit of the SAS (Layer 4 in the model) for groundwater that conceptually would be captured by the FSES, treated, and reinjected into the Basal Sand. A simulation was run wherein the volume of water equivalent to the total flux recovered from the FSES (approximately 343 gpm) was injected into ten wells that are completed in the Basal Sand unit (Layer 4). The injection rate was equally divided between the ten wells. The orientation of the injection wells is shown in Figure 3.17. The net difference (increase) in the potentiometric surface within Layer 4 resulting from the simulated reinjection, is also shown on Figure 3.17. A recharge mound develops within the immediate vicinity of the injection wells with an overall increase in the potentiometric surface of 1 to 2 feet.

The maximum net change in the potentiometric surface in Layer 4 in response to the injection of 343 gpm is an increase of approximately 2.8 feet. Overall, the net rise is small as a result of the relatively high estimated transmissivity of the Basal Sand unit (4,800 to 22,400 square feet per day). Based on the simulation results, reinjection of water recovered from the FSES appears to be a hydraulically feasible alternative for disposal.

4.0 SENSITIVITY ANALYSIS

Sensitivity analysis of key model parameters or conditions was conducted using the SBGPP model. Parameters/conditions that are included in the sensitivity analyses are: low potentiometric versus high potentiometric condition, aquifer recharge, horizontal and vertical hydraulic conductivity, and extraction rate of the source sites. The sensitivity analysis was limited to evaluation of hydraulic containment under the various simulated scenarios. Hydraulic containment is assessed through capture zone analysis that incorporates reverse particle tracking to each FSES extraction well for a simulated period of 10 years.

With the exception of the parameter being evaluated, each sensitivity analysis simulation was run with the same parameter values as the FS Remedial Extraction Simulation previously described. Except for the low potentiometric condition simulation, all sensitivity analysis simulations were run under the high potentiometric condition. Table 4-1 lists the multiplier for each parameter that was assessed in the sensitivity analysis simulations.

4.1 Low versus High Potentiometric Condition

The FS groundwater extraction simulation was rerun using the SBGPP model under the low potentiometric condition. All extraction rates and parameter values were unchanged with the exception of the boundary condition (constant heads) located along the perimeter of the model. The low potentiometric condition is simulated by implementing lower hydraulic heads at those boundaries. Figure 4.1 illustrates the capture zone simulated at FSES G-1 through G-5, and G-8 for the low and high potentiometric conditions. The particle tracks represent 10-year groundwater flowpaths. There are some differences in the simulated capture zones at distance from the FSES. However, within a few hundred feet upgradient of the FSES, the capture zone exhibited by the flowpaths is almost identical between the low and high potentiometric conditions. The simulated capture zone for FSES G-6 and G-7, presented on Figure 4.2, also shows minimal difference between the low and high conditions. Hydraulic containment is simulated under both low and high potentiometric conditions.

4.2 Aquifer Recharge

The sensitivity of aquifer recharge on hydraulic containment was evaluated by increasing and decreasing the base recharge value by a factor of two (Table 4-1). Figures 4.3 and 4.4 show the capture zones from these simulations. Differences between the capture zones are negligible. Hydraulic containment is not sensitive to the simulated range of aquifer recharge.

4.3 Horizontal Hydraulic Conductivity

The sensitivity of the SBGPP model to horizontal hydraulic conductivity (K_h) on simulated hydraulic containment was evaluated by increasing and decreasing the base value by a factor of three (Table 4-1). The K_h of model Layers 1 through 3 was simulated independently as described below. Only the K_h zones that are within the SBGPP study area were modified.

Figures 4.5 and 4.6 present the simulated capture zones when K_h of Layer 1 is increased and decreased by a factor of three. Changes in the K_h of Layer 2 result in the simulated capture zones shown on Figures 4.7 and 4.8. Simulated capture zones for changes in K_h of Layer 3, are shown on Figures 4.9 and 4.10. The model is generally more sensitive to changes in K_h of Layer 2 than for the other layers because most of the extracted water is derived from Layer 2.

Although there is some variability in the maximum capture distance (over the 10-year travel period) in response to changes in K_h, hydraulic containment is maintained throughout the simulated ranges in each of the model Layers.

4.4 Vertical Hydraulic Conductivity

The sensitivity of the SBGPP model to vertical hydraulic conductivity (K_v) on simulated hydraulic containment was evaluated by increasing and decreasing the base value by a factor of three (Table 4-1). The K_v of each model Layer (1, 2 and 3) was simulated independently and only the K_v zones that are within the SBGPP study area were modified.

Figures 4.11 and 4.12 present the simulated capture zones when K_v of Layer 1 is modified. Changes in the K_v of Layer 2 result in the simulated capture zones shown on Figures 4.13 and 4.14. Simulated capture zones for changes in K_v of Layer 3, are shown on Figures 4.15 and 4.16. The model is generally insensitive to changes to K_v in Layers 1 and 2. Increasing the K_v of Layer 3 by a factor of three resulted in longer capture distance upgradient of the FSES. However, hydraulic containment is maintained throughout the simulated ranges of K_v in each of the model layers.

4.5 Source Site Groundwater Extraction Rates

The sensitivity of source site groundwater extraction rates on hydraulic containment of the proposed FSES was evaluated by increasing and decreasing the extraction rate of all source site groundwater extraction systems by a factor of two (Table 4-1).

Figures 4.17 and 4.18 show the capture zones from these simulations. The capture zones show minimal difference between the increased and decreased source site extraction rates. Hydraulic containment is demonstrated under the range of simulated source site extraction rates.

5.0 SUMMARY AND CONCLUSIONS

A numerical groundwater flow model was developed to support the SBGPP RI/FS being conducted by OCWD to address groundwater contamination in OU2 in the south-central portion of the Basin in Orange County, California. The numerical modeling is based on the current hydrogeologic conceptual model of the regional and local groundwater flow system. Development and calibration of the flow model is described in a separate report (EA, 2021b).

The calibrated SBGPP model is used to simulate remedial groundwater extraction alternatives identified in the FS screening process with the following modifications.

- The model was converted from transient to steady-state groundwater flow conditions.
- The high potentiometric condition was used to represent steady-state groundwater flow conditions.
- Active source site remediation systems are simulated using the most current available extraction rates.
- Planned source site remediation extraction systems that are not yet active are estimated and included in the steady state simulation.
- Eight FSES locations (G-1 through G-8) are included as conceptual groundwater extraction sites for addressing OU2 groundwater contamination within the SBGPP.

The FS Groundwater Extraction Simulation is assessed for hydraulic containment in the immediate area of each FSES. Hydraulic containment for each FSES is assessed using capture zone analysis of groundwater flowpaths. Based on flowpath analysis of the FS Groundwater Extraction Simulation, hydraulic containment was demonstrated for each FSES. The total simulated extraction rate to achieve hydraulic containment, using the calibrated SBGPP model, was 343.3 gpm.

The SBGPP model is used to assess changes in groundwater flux and groundwater flow direction within Layers 1, 2 and 3 at the source sites in response to simulated extraction from the FSES. Groundwater flux across the source sites increased by an average factor (multiplier) of 1.26 in response to FSES operation. The increased groundwater flux primarily results from increased hydraulic gradients induced by drawdown at the FSES in response to groundwater extraction.

Flow vectors were calculated for each source site for the baseline conditions and for FSES operating conditions. Simulated groundwater flow direction changed by less than 10 degrees at 55 of the 72 source site monitor points in response to FSES operation. Eight source site monitor points recorded a change in groundwater flow direction of greater than 20 degrees. In most cases, the changes in groundwater flow direction at the source sites were toward the south.

Simulation of reinjection of water recovered from the FSES into the Basal Sand indicates minimal hydraulic impacts to the Basal Sand unit of the SAS. The model results suggest that reinjection of water extracted from the FSES is a hydraulically feasible alternative for disposal.

Results of the sensitivity analysis simulations indicate that hydraulic containment can be achieved at each of the proposed FSES under a wide range of site conditions.

6.0 REFERENCES

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TABLES

Table 2-1. Simulated Rates for Source Site Groundwater Extraction Systems, SBGPP Model

Active Source Site	Well Identification	Easting (feet)	Northing (feet)	Model Layer(s)	Simulated Extraction Rate (gpm)	Simulated Extraction Rate (ft^3/d)
Gallade Chemical	E-13[a]	6073608	2208918	1	4.00	770.0
GE_Plastics	EX-2[b]	6076908	2206344	1	6.00	1155.1
Steelcase Inc.	MW-22B[c]	6077420	2207574	1	9.60	1848.1
AllenCampbell	AC-1	6074780	2208996	1	1.00	192.5
Gallade Chemical	MW-24	6073732	2208911	2	0.21	40.4
Astech	EX-1[d]	6075244	2202606	2	6.40	1232.1
Bell_Industries	GWX-6	6077519	2209119	2	9.00	1732.6
Bell_Industries	MW-23B	6077742	2209639	2	5.20	1001.1
Bell_Industries	MW-25C	6077624	2209512	2	9.00	1732.6
ITT Canon	RW-1	6073031	2203986	2	8.12	1563.2
ITT Canon	RW-2	6073270	2203950	2	4.23	814.3
ITT Canon	RW-3	6073140	2203967	2	28.94	5571.2
AllenCampbell	AC-1_5	6074780	2208996	1& 2	1.00	192.5
Cherry Aero/Textron	CAT_1	6073027	2206747	1 & 2	0.50	96.3
Cherry Aero/Textron	CAT_2	6073150	2206748	1 & 2	0.50	96.3
Cherry Aero/Textron	CAT_3	6073283	2206745	1 & 2	0.50	96.3
Cherry Aero/Textron	CAT_4	6073156	2206865	1 & 2	0.50	96.3
Cherry Aero/Textron	CAT_5	2206865	2206865	1 & 2	0.50	96.3
Cherry Aero/Textron	CAT_6	6073156	2206629	2	0.50	96.3
Cherry Aero/Textron	CAT_7	6073285	2206623	2	0.50	96.3
Cherry Aero/Textron	CAT_8	6072785	2205999	1	0.50	96.3
Cherry Aero/Textron	CAT_9	6072909	2205993	1	0.50	96.3
Cherry Aero/Textron	CAT_10	6072790	2205869	2	0.50	96.3
Cherry Aero/Textron	CAT_11	6072903	2205864	2	0.50	96.3

Notes:

[a] - average extraction rate for 13 wells divided into 4 model wells

[b] - combined extraction rate of 7 wells

[c] - combined extraction rate of MW22B and MW23B

[d] - combined extraction rate EX-1 and EX-2

SBGPP - South Basin Groundwater Protection Project

gpm - gallons per minute

ft^3/d - cubic feet per day

Table 2-2. Model Monitor Areas and Locations for Source Site Remedial Systems, SBGPP Model

Monitor Area/Location[a]	Company	Type of Remedial System	Active or Planned?	Nearest FSES
ISRA1	Embee Plating	Well Extraction	Active	G-3
ISRA2	Holchem/SOCO West	Well Extraction	Active	G-1
ISRA3	Diceon-2	Well Extraction	Active	G-1
ISRA4	Diceon-1	Well Extraction	Active	G-4
ISRA5	Troy Computer	Well Extraction	Active	G-5
ISRA6	Dyer Business Park	Well Extraction	Active	G-5, G-6
ISRA7	ITT Cannon-1	Insitu	Active	G-2, G-3
ISRA8	ITT Cannon-2	Insitu	Active	G-2, G-3
ISRA9	ITT Cannon-3	Insitu	Active	G-2, G-3
ISRA10	GE Plastics	Insitu	Active	G-3
ISRA11	GE Plastics	Insitu	Active	G-4
ISRA1	BFM	Insitu	Active	G-5
ISRA13	GE Plastics	Insitu	Active	G-5
ISRA14	Ricoh	Insitu	Active	G-5, G-6
ISRA15	Baxter Healtcare	Insitu	Active	G-5, G-6
PGET1	Allen Campbell Trust	Insitu	Active	G-5
PGET1	Allen Campbell Trust	Insitu	Active	G-5
PGET1	Allen Campbell Trust	Insitu	Active	G-5
PGET2	Cherry Aero/Textron	Insitu	Active	G-5
PGET2	Cherry Aero/Textron	Insitu	Active	G-5
PGET3	Cherry Aero/Textron	Insitu	Active	G-5, G-6
SSGET1	Gallade	Insitu	Active	G-5, G-6
SSGET2	Bell	Insitu	Active	G-6
SSGET3	Steelcase	Insitu	Active	G-7
SSGET4	GE Plastics	Well Extraction	Planned	G-2
SSGET5	ITT Cannon	Well Extraction	Planned	G-3, G-8
SSGET6	Astech	Well Extraction	Planned	G-3, G-5

Notes:
a-Monitor Areas and Locations are shown on Figure 2.2
SBGPP - South Basin Groundwater Protection Project
FSES - Feasibility Study Groundwater Extraction Site

Table 3-1. Simulated Groundwater Flux and Groundwater Flow Direction at Source Site Remedial Systems, Baseline Conditions, SBGPP Model

Monitor Area/ Location	Monitored Model Layer	Company	Nearest FSES	Groundwater Flux[a] - Baseline (cubic feet per day)	Groundwater Flux[a] - Baseline (gallons per minute)	Groundwater Flow Direction[b]- Baseline (degrees)	Compass Quadrant
ISRA1	1	Embee Plating	G-3	770	4.0	216	Southwest
ISRA1	2	Embee Plating	G-3	2225	11.6	209	Southwest
ISRA1	3	Embee Plating	G-3	1083	5.6	259	Southwest
ISRA2	1	Holchem/SOCO West	G-1	1766	9.2	204	Southwest
ISRA2	2	Holchem/SOCO West	G-1	3347	17.4	247	Southwest
ISRA2	3	Holchem/SOCO West	G-1	6245	32.4	258	Southwest
ISRA3	1	Diceon-2	G-1	2020	10.5	147	Southwest
ISRA3	2	Diceon-2	G-1	846	4.4	228	Southwest
ISRA3	3	Diceon-2	G-1	136	0.7	233	Southwest
ISRA4	1	Diceon-1	G-4	344	1.8	170	Southwest
ISRA4	2	Diceon-1	G-4	1516	7.9	227	Southwest
ISRA4	3	Diceon-1	G-4	278	1.4	232	Southwest
ISRA5	1	Troy Computer	G-5	126	0.7	229	Southwest
ISRA5	2	Troy Computer	G-5	7949	41.3	224	Southwest
ISRA5	3	Troy Computer	G-5	209	1.1	225	Southwest
ISRA6	1	Dyer Business Park	G-5, G-6	46	0.2	290	Southeast
ISRA6	2	Dyer Business Park	G-5, G-6	4595	23.9	240	Southwest
ISRA6	3	Dyer Business Park	G-5, G-6	1922	10.0	240	Southwest
ISRA7	1	ITT Cannon-1	G-2, G-3	512	2.7	238	Southwest
ISRA7	2	ITT Cannon-1	G-2, G-3	1642	8.5	227	Southwest
ISRA7	3	ITT Cannon-1	G-2, G-3	1275	6.6	251	Southwest
ISRA8	1	ITT Cannon-2	G-2, G-3	179	0.9	124	Northwest
ISRA8	2	ITT Cannon-2	G-2, G-3	331	1.7	120	Northwest

Table 3-1. Simulated Groundwater Flux and Groundwater Flow Direction at Source Site Remedial Systems, Baseline Conditions, SBGPP Model

Monitor Area/ Location	Monitored Model Layer	Company	Nearest FSES	Groundwater Flux[a] - Baseline (cubic feet per day)	Groundwater Flux[a] - Baseline (gallons per minute)	Groundwater Flow Direction[b]- Baseline (degrees)	Compass Quadrant
ISRA8	3	ITT Cannon-2	G-2, G-3	266	1.4	247	Southwest
ISRA9	1	ITT Cannon-3	G-2, G-3	34	0.2	242	Southwest
ISRA9	2	ITT Cannon-3	G-3	1384	7.2	245	Southwest
ISRA9	3	ITT Cannon-3	G-3	467	2.4	247	Southwest
ISRA10	1	GE Plastics	G-3	31	0.2	240	Southwest
ISRA10	2	GE Plastics	G-3	1014	5.3	243	Southwest
ISRA10	3	GE Plastics	G-3	463	2.4	255	Southwest
ISRA11	1	GE Plastics	G-4	71	0.4	252	Southwest
ISRA11	2	GE Plastics	G-4	1764	9.2	248	Southwest
ISRA11	3	GE Plastics	G-4	307	1.6	260	Southwest
ISRA12	1	BFM	G-5	68	0.4	230	Southwest
ISRA12	2	BFM	G-5	611	3.2	222	Southwest
ISRA12	3	BFM	G-5	8154	42.4	256	Southwest
ISRA13	1	GE Plastics	G-5	126	0.7	218	Southwest
ISRA13	2	GE Plastics	G-5	7949	41.3	222	Southwest
ISRA13	3	GE Plastics	G-5	209	1.1	251	Southwest
ISRA14	1	Ricoh	G-5, G-6	16	0.1	256	Southwest
ISRA14	2	Ricoh	G-5, G-6	669	3.5	258	Southwest
ISRA14	3	Ricoh	G-5, G-6	96	0.5	254	Southwest
ISRA15	1	Baxter Healtcare	G-5, G-6	13	0.1	256	Southwest
ISRA15	2	Baxter Healtcare	G-5, G-6	560	2.9	252	Southwest
ISRA15	3	Baxter Healtcare	G-5, G-6	78	0.4	248	Southwest
PGET1	1	Allen Campbell Trust	G-5	37	0.2	234	Southwest

Table 3-1. Simulated Groundwater Flux and Groundwater Flow Direction at Source Site Remedial Systems, Baseline Conditions, SBGPP Model

Monitor Area/ Location	Monitored Model Layer	Company	Nearest FSES	Groundwater Flux[a] - Baseline (cubic feet per day)	Groundwater Flux[a] - Baseline (gallons per minute)	Groundwater Flow Direction[b]- Baseline (degrees)	Compass Quadrant
PGET1	2	Allen Campbell Trust	G-5	2166	11.3	234	Southwest
PGET1	3	Allen Campbell Trust	G-5	1349	7.0	232	Southwest
PGET2	1	Cherry Aero/Textron	G-5	31	0.2	244	Southwest
PGET2	2	Cherry Aero/Textron	G-5	1883	9.8	223	Southwest
PGET2	3	Cherry Aero/Textron	G-5	1456	7.6	211	Southwest
PGET3	1	Cherry Aero/Textron	G-5, G-6	9	0.0	276	Southeast
PGET3	2	Cherry Aero/Textron	G-5, G-6	2198	11.4	246	Southwest
PGET3	3	Cherry Aero/Textron	G-5, G-6	793	4.1	245	Southwest
SSGET1	1	Gallade	G-5, G-6	3	0.0	284	Southeast
SSGET1	2	Gallade	G-5, G-6	1533	8.0	233	Southwest
SSGET1	3	Gallade	G-5, G-6	475	2.5	257	Southwest
SSGET2	1	Bell	G-6	25	0.1	238	Southwest
SSGET2	2	Bell	G-6	894	4.6	240	Southwest
SSGET2	3	Bell	G-6	189	1.0	237	Southwest
SSGET3	1	Steelcase	G-7	13	0.1	208	Southwest
SSGET3	2	Steelcase	G-7	2215	11.5	218	Southwest
SSGET3	3	Steelcase	G-7	645	3.3	221	Southwest
SSGET4	1	GE Plastics	G-2	628	3.3	106	Northwest
SSGET4	2	GE Plastics	G-2	1317	6.8	220	Southwest
SSGET4	3	GE Plastics	G-2	173	0.9	221	Southwest
SSGET5	1	ITT Cannon	G-3, G-8	153	0.8	265	Southwest
SSGET5	2	ITT Cannon	G-3, G-8	1324	6.9	266	Southwest

Table 3-1. Simulated Groundwater Flux and Groundwater Flow Direction at Source Site Remedial Systems, Baseline Conditions, SBGPP Model

Monitor Area/ Location	Monitored Model Layer	Company	Nearest FSES	Groundwater Flux[a] - Baseline (cubic feet per day)	Groundwater Flux[a] - Baseline (gallons per minute)	Groundwater Flow Direction[b]- Baseline (degrees)	Compass Quadrant
SSGET5	3	ITT Cannon	G-3, G-8	694	3.6	261	Southwest
SSGET6	1	Astech	G-3, G-5	197	1.0	238	Southwest
SSGET6	2	Astech	G-3, G-5	318	1.7	230	Southwest
SSGET6	3	Astech	G-3, G-5	4115	21.4	256	Southwest

Notes:

a = Groundwater flux values are presented as the groundwater flow rate through the model cross-sectional area at each monitor area illustrated on figure 2.2

b = Groundwater flow direction calculated at the monitor location indicated on Figure 2.2
degrees measured counterclockwise from due east equal to zero degree

Table 3-2. Simulated Groundwater Extraction Wells and Rates at Proposed Feasibility Study Groundwater Extraction Sites, SBGPP Model

	Simulated Feasibility Study Groundwater Extraction Site								Totals
	G-1	G-2	G-3	G-4	G-5	G-6	G-7	G-8	
Total Number of Extraction Wells	4	2	6	3	5	10	5	3	38
Number of Wells in Layer 1	0	0	2	3	0	0	0	0	5
Number of Wells in Layer 2	0	0	0	0	5	10	0	0	15
Number of Wells in Layer 2 and 3	4	2	4	0	0	0	5	3	18
Extraction Rate Layer 1 (gpm)	0.00	0.00	2.08	1.31	0.00	0.00	0.00	0.00	3.39
Extraction Rate Layer 2 (gpm)	21.86	25.46	33.58	0.00	21.61	102.85	67.56	5.18	278.10
Extraction Rate Layer 3 (gpm)	7.23	3.15	32.91	0.00	0.00	0.00	15.55	2.95	61.79
Total Extraction Rate (gpm)	29.09	28.61	68.57	1.31	21.61	102.85	83.11	8.12	343.28

Notes:
SBGPP - South Basin Groundwater Protection Project
gpm - gallons per minute

Table 3-3. Simulated Change in Groundwater Flux at Source Site Remedial Systems from Operation of Feasibility Study Groundwater Extraction Sites, SBGPP Model

Monitor Area	Monitored Model Layer	Company	Nearest FSES	Groundwater Flux[a] Without FSES (cubic feet per day)	Groundwater Flux[a] With FSES (cubic feet per day)	Scaling Factor[b]
SSGET1	1	Gallade	G-3	770	770	1.00
SSGET1	2	Gallade	G-3	2225	3024	1.36
SSGET1	3	Gallade	G-3	1083	1849	1.71
SSGET2	1	Bell	G-1	1766	1944	1.10
SSGET2	2	Bell	G-1	3347	3515	1.05
SSGET2	3	Bell	G-1	6245	7038	1.13
SSGET3	1	Steelcase	G-1	2020	2180	1.08
SSGET3	2	Steelcase	G-1	846	1057	1.25
SSGET3	3	Steelcase	G-1	136	149	1.10
SSGET4	1	GE Plastics	G-4	344	345	1.00
SSGET4	2	GE Plastics	G-4	1516	1599	1.06
SSGET4	3	GE Plastics	G-4	278	345	1.24
SSGET5	1	ITT Cannon	G-5	126	120	0.95
SSGET5	2	ITT Cannon	G-5	7949	7949	1.00
SSGET5	3	ITT Cannon	G-5	209	228	1.09
SSGET6	1	Astech	G-5, G-6	46	45	0.97
SSGET6	2	Astech	G-5, G-6	4595	5024	1.09
SSGET6	3	Astech	G-5, G-6	1922	2009	1.05
ISRA1	1	Embee Plating	G-2, G-3	512	687	1.34
ISRA1	2	Embee Plating	G-2, G-3	1642	2579	1.57
ISRA1	3	Embee Plating	G-2, G-3	1275	2560	2.01
ISRA2	1	Holchem/SOCO West	G-2, G-3	179	240	1.34
ISRA2	2	Holchem/SOCO West	G-2, G-3	331	789	2.38
ISRA2	3	Holchem/SOCO West	G-2, G-3	266	593	2.23
ISRA3	1	Diceon-2	G-2, G-3	34	27	0.79
ISRA3	2	Diceon-2	G-3	1384	2048	1.48
ISRA3	3	Diceon-2	G-3	467	1074	2.30
ISRA4	1	Diceon-1	G-3	31	37	1.18
ISRA4	2	Diceon-1	G-3	1014	1612	1.59
ISRA4	3	Diceon-1	G-3	463	1143	2.47
ISRA5	1	Troy Computer	G-4	71	259	3.65
ISRA5	2	Troy Computer	G-4	1764	2113	1.20
ISRA5	3	Troy Computer	G-4	307	317	1.03
ISRA6	1	Dyer Business Park	G-5	68	68	1.01

Table 3-3. Simulated Change in Groundwater Flux at Source Site Remedial Systems from Operation of Feasibility Study Groundwater Extraction Sites, SBGPP Model

Monitor Area	Monitored Model Layer	Company	Nearest FSES	Groundwater Flux[a] Without FSES (cubic feet per day)	Groundwater Flux[a] With FSES (cubic feet per day)	Scaling Factor[b]
ISRA6	2	Dyer Business Park	G-5	611	598	0.98
ISRA6	3	Dyer Business Park	G-5	8154	7910	0.97
ISRA7	1	ITT Cannon-1	G-5	126	120	0.95
ISRA7	2	ITT Cannon-1	G-5	7949	7949	1.00
ISRA7	3	ITT Cannon-1	G-5	209	228	1.09
ISRA8	1	ITT Cannon-2	G-5, G-6	16	14	0.90
ISRA8	2	ITT Cannon-2	G-5, G-6	669	626	0.94
ISRA8	3	ITT Cannon-2	G-5, G-6	96	108	1.13
ISRA9	1	ITT Cannon-3	G-5, G-6	13	16	1.20
ISRA9	2	ITT Cannon-3	G-5, G-6	560	892	1.59
ISRA9	3	ITT Cannon-3	G-5, G-6	78	109	1.39
ISRA10	1	GE Plastics	G-5	37	35	0.96
ISRA10	2	GE Plastics	G-5	2166	2242	1.04
ISRA10	3	GE Plastics	G-5	1349	1363	1.01
ISRA11	1	GE Plastics	G-5	31	29	0.95
ISRA11	2	GE Plastics	G-5	1883	1892	1.00
ISRA11	3	GE Plastics	G-5	1456	1466	1.01
ISRA12	1	BFM	G-5, G-6	9	9	0.99
ISRA12	2	BFM	G-5, G-6	2198	2358	1.07
ISRA12	3	BFM	G-5, G-6	793	817	1.03
ISRA13	1	GE Plastics	G-5, G-6	3	3	0.99
ISRA13	2	GE Plastics	G-5, G-6	1533	1648	1.07
ISRA13	3	GE Plastics	G-5, G-6	475	490	1.03
ISRA14	1	Ricoh	G-6	25	32	1.28
ISRA14	2	Ricoh	G-6	894	2486	2.78
ISRA14	3	Ricoh	G-6	189	311	1.64
ISRA15	1	Baxter Healtcare	G-7	13	13	1.02
ISRA15	2	Baxter Healtcare	G-7	2215	3176	1.43
ISRA15	3	Baxter Healtcare	G-7	645	817	1.27
PGET1	1	Allen Campbell Trust	G-2	628	891	1.42
PGET1	2	Allen Campbell Trust	G-2	1317	2107	1.60
PGET1	3	Allen Campbell Trust	G-2	173	239	1.38
PGET2	1	Cherry Aero/Textron	G-3, G-8	153	81	0.53
PGET2	2	Cherry Aero/Textron	G-3, G-8	1324	659	0.50

Table 3-3. Simulated Change in Groundwater Flux at Source Site Remedial Systems from Operation of Feasibility Study Groundwater Extraction Sites, SBGPP Model

Monitor Area	Monitored Model Layer	Company	Nearest FSES	Groundwater Flux[a] Without FSES (cubic feet per day)	Groundwater Flux[a] With FSES (cubic feet per day)	Scaling Factor[b]
PGET2	3	Cherry Aero/Textron	G-3, G-8	694	659	0.95
PGET3	1	Cherry Aero/Textron	G-3, G-5	197	196	1.00
PGET3	2	Cherry Aero/Textron	G-3, G-5	318	336	1.06
PGET3	3	Cherry Aero/Textron	G-3, G-5	4115	4167	1.01
					Average Scaling Factor	1.26

Notes:

[a] Groundwater flux values are presented as the groundwater flow rate through the model cross-sectional area at each monitor area illustrated on Figure 2.2

[b] Scaling Factor - ratio of groundwater flux with FSES operating to groundwater flux without FSES

FSES = Feasibility Study groundwater extraction site

Table 3-4. Simulated Change in Groundwater Flow Direction at Source Site Remedial Systems from Operation of Feasibility Study Groundwater Extraction Sites, SBGPP Model

Monitor Location[a]	Monitored Model Layer	Company	Nearest FSES	Groundwater Flow Direction without FSES (degrees)	Compass Quadrant (without FSES)	Groundwater Flow Direction with FSES (degrees)	Compass Quadrant (with FSES)	Net change (degrees)
ISRA1	1	Embee Plating	G-3	207.1	SW	216.0	Southwest	8.8
ISRA1	2	Embee Plating	G-3	209.5	SW	257.4	Southwest	47.9
ISRA1	3	Embee Plating	G-3	259.1	SW	259.8	Southwest	0.6
ISRA2	1	Holchem/SOCO West	G-1	204.4	SW	211.1	Southwest	6.8
ISRA2	2	Holchem/SOCO West	G-1	246.8	SW	275.0	Southeast	28.2
ISRA2	3	Holchem/SOCO West	G-1	258.3	SW	255.0	Southwest	-3.3
ISRA3	1	Diceon-2	G-1	147.0	NW	179.8	Northwest	32.8
ISRA3	2	Diceon-2	G-1	228.4	SW	238.9	Southwest	10.5
ISRA3	3	Diceon-2	G-1	232.7	SW	273.0	Southeast	40.2
ISRA4	1	Diceon-1	G-4	169.6	NW	194.9	Southwest	25.3
ISRA4	2	Diceon-1	G-4	227.1	SW	240.1	Southwest	13.0
ISRA4	3	Diceon-1	G-4	232.0	SW	270.5	Southeast	38.5
ISRA5	1	Troy Computer	G-5	228.6	SW	235.7	Southwest	7.1
ISRA5	2	Troy Computer	G-5	224.4	SW	217.5	Southwest	-6.9
ISRA5	3	Troy Computer	G-5	224.5	SW	220.3	Southwest	-4.2
ISRA6	1	Dyer Business Park	G-5, G-6	289.9	SE	292.3	Southeast	2.4
ISRA6	2	Dyer Business Park	G-5, G-6	240.2	SW	243.3	Southwest	3.1
ISRA6	3	Dyer Business Park	G-5, G-6	239.6	SW	242.6	Southwest	3.0
ISRA7	1	ITT Cannon-1	G-2, G-3	237.6	SW	240.4	Southwest	2.8
ISRA7	2	ITT Cannon-1	G-2, G-3	227.3	SW	228.7	Southwest	1.4
ISRA7	3	ITT Cannon-1	G-2, G-3	250.5	SW	259.2	Southwest	8.7
ISRA8	1	ITT Cannon-2	G-2, G-3	124.3	NW	120.9	Northwest	-3.3
ISRA8	2	ITT Cannon-2	G-2, G-3	120.3	NW	117.4	Northwest	-2.9

Table 3-4. Simulated Change in Groundwater Flow Direction at Source Site Remedial Systems from Operation of Feasibility Study Groundwater Extraction Sites, SBGPP Model

Monitor Location[a]	Monitored Model Layer	Company	Nearest FSES	Groundwater Flow Direction without FSES (degrees)	Compass Quadrant (without FSES)	Groundwater Flow Direction with FSES (degrees)	Compass Quadrant (with FSES)	Net change (degrees)
ISRA8	3	ITT Cannon-2	G-2, G-3	246.6	SW	255.0	Southwest	8.4
ISRA9	1	ITT Cannon-3	G-2, G-3	242.0	SW	237.1	Southwest	-4.9
ISRA9	2	ITT Cannon-3	G-3	245.4	SW	239.7	Southwest	-5.7
ISRA9	3	ITT Cannon-3	G-3	247.1	SW	245.4	Southwest	-1.7
ISRA10	1	GE Plastics	G-3	239.5	SW	233.6	Southwest	-6.0
ISRA10	2	GE Plastics	G-3	242.7	SW	235.6	Southwest	-7.1
ISRA10	3	GE Plastics	G-3	255.0	SW	253.4	Southwest	-1.7
ISRA11	1	GE Plastics	G-4	251.9	SW	245.9	Southwest	-6.0
ISRA11	2	GE Plastics	G-4	248.2	SW	243.5	Southwest	-4.7
ISRA11	3	GE Plastics	G-4	259.6	SW	257.9	Southwest	-1.7
ISRA12	1	BFM	G-5	229.6	SW	224.3	Southwest	-5.3
ISRA12	2	BFM	G-5	222.1	SW	217.3	Southwest	-4.8
ISRA12	3	BFM	G-5	255.9	SW	254.4	Southwest	-1.5
ISRA13	1	GE Plastics	G-5	218.5	SW	214.3	Southwest	-4.1
ISRA13	2	GE Plastics	G-5	221.5	SW	217.1	Southwest	-4.5
ISRA13	3	GE Plastics	G-5	250.5	SW	249.1	Southwest	-1.4
ISRA14	1	Ricoh	G-5, G-6	256.2	SW	236.9	Southwest	-19.3
ISRA14	2	Ricoh	G-5, G-6	258.4	SW	236.7	Southwest	-21.6
ISRA14	3	Ricoh	G-5, G-6	253.7	SW	253.9	Southwest	0.2
ISRA15	1	Baxter Healtcare	G-5, G-6	256.2	SW	241.5	Southwest	-14.7
ISRA15	2	Baxter Healtcare	G-5, G-6	252.2	SW	237.9	Southwest	-14.3
ISRA15	3	Baxter Healtcare	G-5, G-6	248.4	SW	240.3	Southwest	-8.1
PGET1	1	Allen Campbell Trust	G-5	233.6	SW	237.3	Southwest	3.7

Table 3-4. Simulated Change in Groundwater Flow Direction at Source Site Remedial Systems from Operation of Feasibility Study Groundwater Extraction Sites, SBGPP Model

Monitor Location[a]	Monitored Model Layer	Company	Nearest FSES	Groundwater Flow Direction without FSES (degrees)	Compass Quadrant (without FSES)	Groundwater Flow Direction with FSES (degrees)	Compass Quadrant (with FSES)	Net change (degrees)
PGET1	2	Allen Campbell Trust	G-5	233.5	SW	246.1	Southwest	12.5
PGET1	3	Allen Campbell Trust	G-5	231.6	SW	232.5	Southwest	0.9
PGET2	1	Cherry Aero/Textron	G-5	244.0	SW	244.2	Southwest	0.2
PGET2	2	Cherry Aero/Textron	G-5	222.8	SW	247.6	Southwest	24.8
PGET2	3	Cherry Aero/Textron	G-5	210.7	SW	240.2	Southwest	29.5
PGET3	1	Cherry Aero/Textron	G-5, G-6	276.1	SE	281.0	Southeast	4.9
PGET3	2	Cherry Aero/Textron	G-5, G-6	245.8	SW	251.7	Southwest	5.9
PGET3	3	Cherry Aero/Textron	G-5, G-6	245.3	SW	249.8	Southwest	4.6
SSGET1	1	Gallade	G-5, G-6	283.6	SE	283.7	Southeast	0.1
SSGET1	2	Gallade	G-5, G-6	232.5	SW	251.6	Southwest	19.0
SSGET1	3	Gallade	G-5, G-6	257.1	SW	263.6	Southwest	6.5
SSGET2	1	Bell	G-6	238.3	SW	238.2	Southwest	0.0
SSGET2	2	Bell	G-6	240.0	SW	239.8	Southwest	-0.2
SSGET2	3	Bell	G-6	237.4	SW	237.5	Southwest	0.1
SSGET3	1	Steelcase	G-7	207.7	SW	207.9	Southwest	0.1
SSGET3	2	Steelcase	G-7	217.6	SW	213.2	Southwest	-4.4
SSGET3	3	Steelcase	G-7	220.9	SW	218.3	Southwest	-2.6
SSGET4	1	GE Plastics	G-2	106.4	NW	107.6	Northwest	1.2
SSGET4	2	GE Plastics	G-2	219.7	SW	213.9	Southwest	-5.8
SSGET4	3	GE Plastics	G-2	220.9	SW	215.8	Southwest	-5.1
SSGET5	1	ITT Cannon	G-3, G-8	264.9	SW	271.0	Southeast	6.1
SSGET5	2	ITT Cannon	G-3, G-8	265.6	SW	268.5	Southwest	2.9
SSGET5	3	ITT Cannon	G-3, G-8	261.0	SW	271.6	Southeast	10.6

Table 3-4. Simulated Change in Groundwater Flow Direction at Source Site Remedial Systems from Operation of Feasibility Study Groundwater Extraction Sites, SBGPP Model

Monitor Location[a]	Monitored Model Layer	Company	Nearest FSES	Groundwater Flow Direction without FSES (degrees)	Compass Quadrant (without FSES)	Groundwater Flow Direction with FSES (degrees)	Compass Quadrant (with FSES)	Net change (degrees)
SSGET6	1	Astech	G-3, G-5	238.3	SW	228.5	Southwest	-9.8
SSGET6	2	Astech	G-3, G-5	230.2	SW	222.9	Southwest	-7.3
SSGET6	3	Astech	G-3, G-5	256.2	SW	255.1	Southwest	-1.1

Notes:

[a] Groundwater flux values are presented as the groundwater flow rate through the model cross-sectional area at each monitor area illustrated on Figure 2.2

SBGPP = South Basin Groundwater Protection Project

FSES = Feasibility Study groundwater extraction site (G-1 to G-8)

degrees - measured counterclockwise with due east equal to zero degrees

Table 4-1. Model Parameter Multipliers for the Sensitivity Analysis Simulations, SBGPP Model

Model Parameter	Parameter Multiplier		
	Low Value	**Base Value***	**High Value**
Aquifer Recharge	1/2 X	1X	2X
K_h-Layer 1[a]	1/3 X	1X	3X
K_h-Layer 2[a]	1/3 X	1X	3X
K_h-Layer 3[a]	1/3 X	1X	3X
K_v-Layer 1[b]	1/3 X	1X	3X
K_v-Layer 2[b]	1/3 X	1X	3X
K_v-Layer 3[b]	1/3 X	1X	3X
Source Site Extraction Rate[c]	1/2 X	1X	2X

<u>Notes:</u>
SBGPP = South Basin Groundwater Protection Project
* Base value used in original calibrated SBGPP Model and Feasibility Study Groundwater Extraction Simulation
K_h Horizontal Hydraulic Conductivity
K_v Vertical Hydraulic Conductivity
[a] Parameter multiplier only applied to K_h zones within Study Area
[b] Parameter multiplier only applied to K_v zones within Study Area
[c] Parameter multiplier applied to each source site extraction well

FIGURES

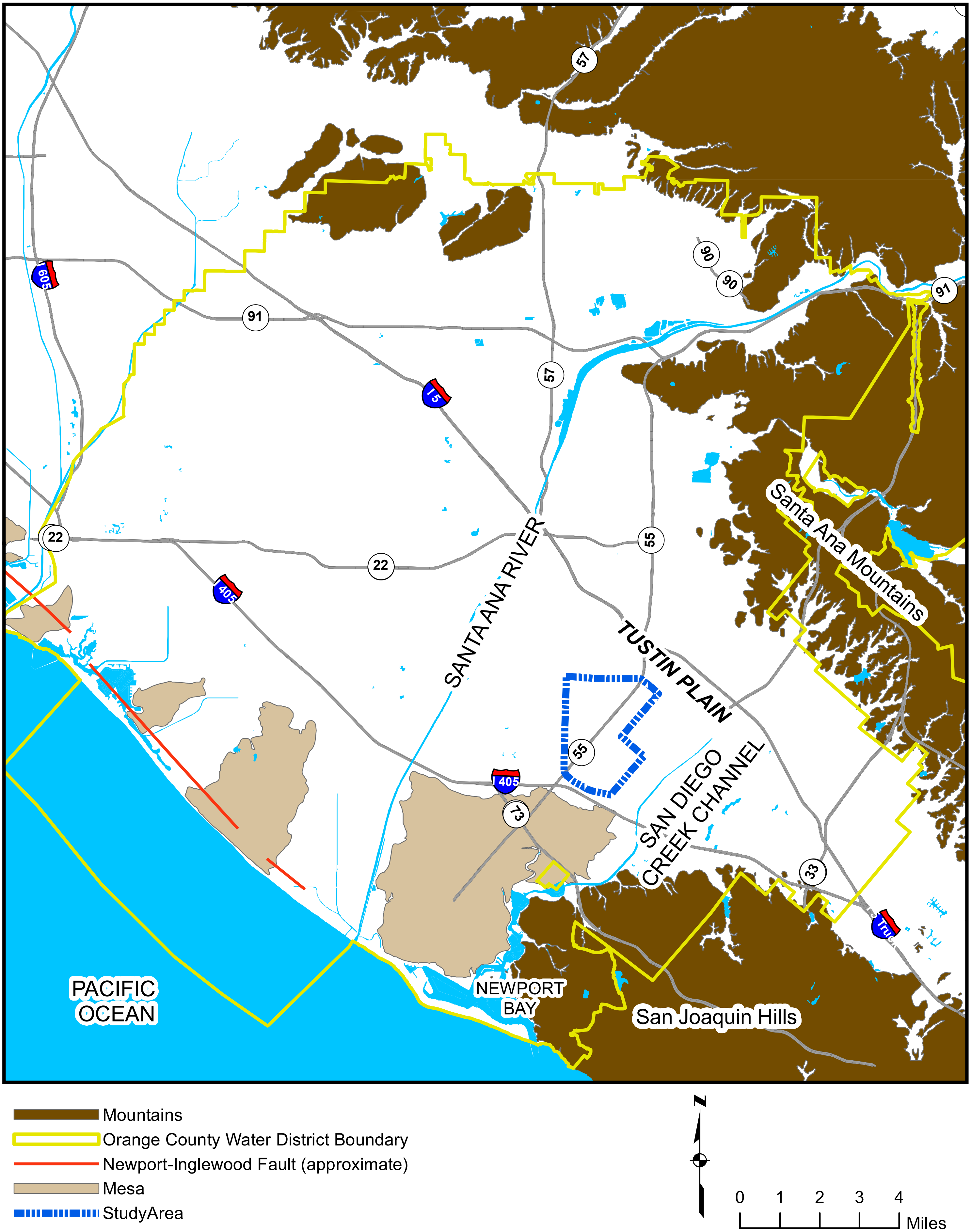

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FIGURE 1-1. PROJECT STUDY AREA

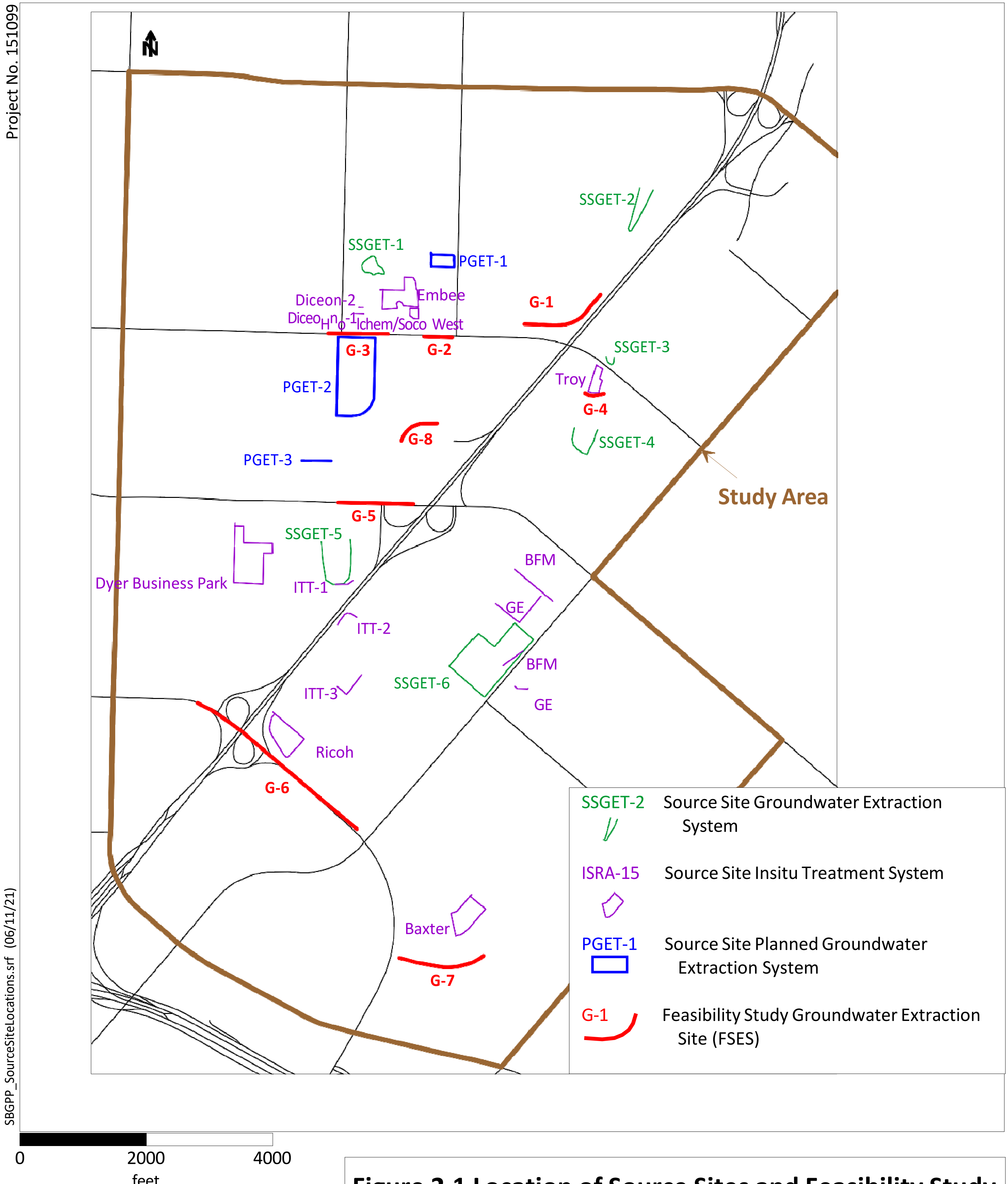

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Figure 2.1 Location of Source Sites and Feasibility Study Groundwater Extraction Sites, SBGPP Model

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South Basin Groundwater Protection Project

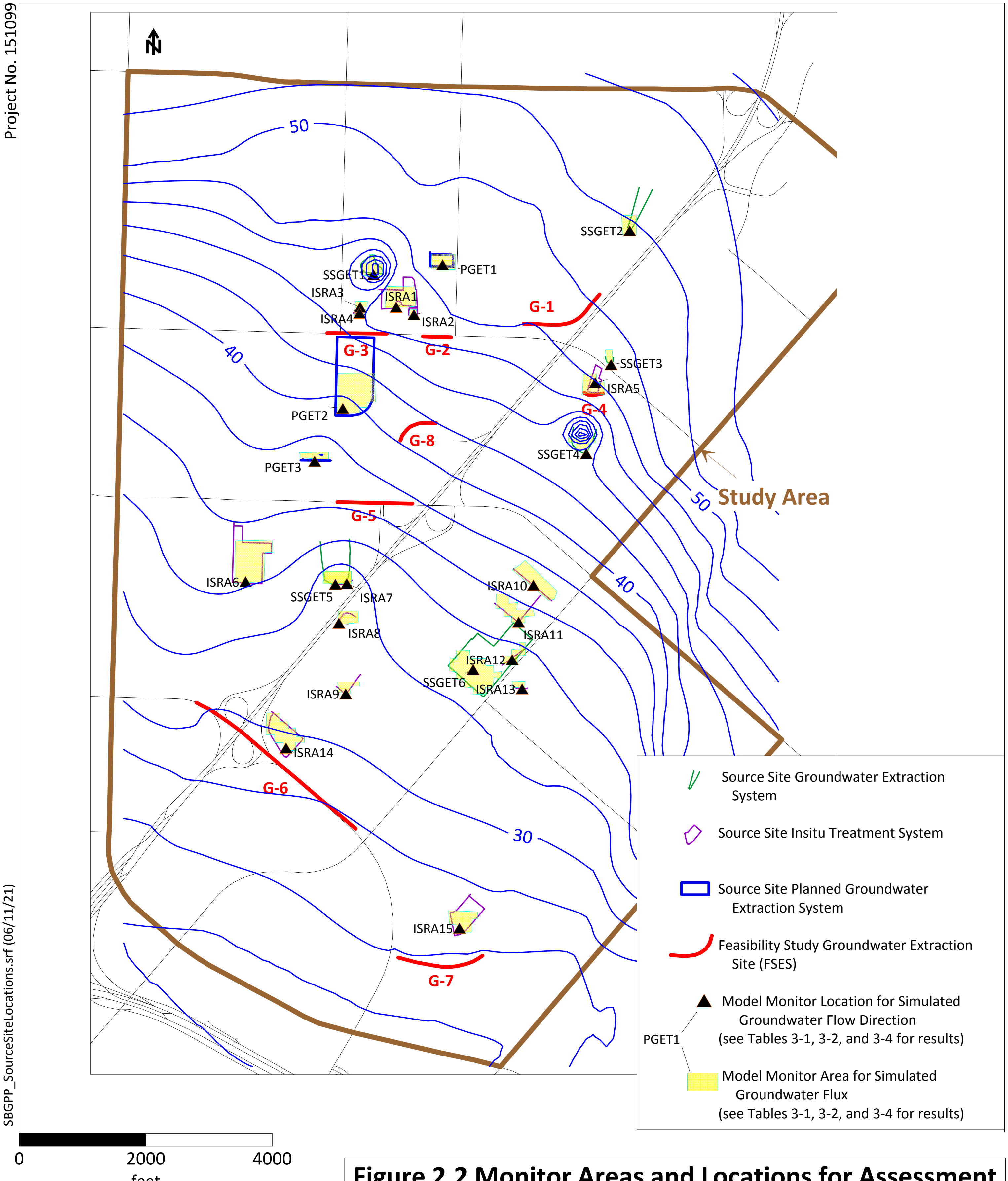

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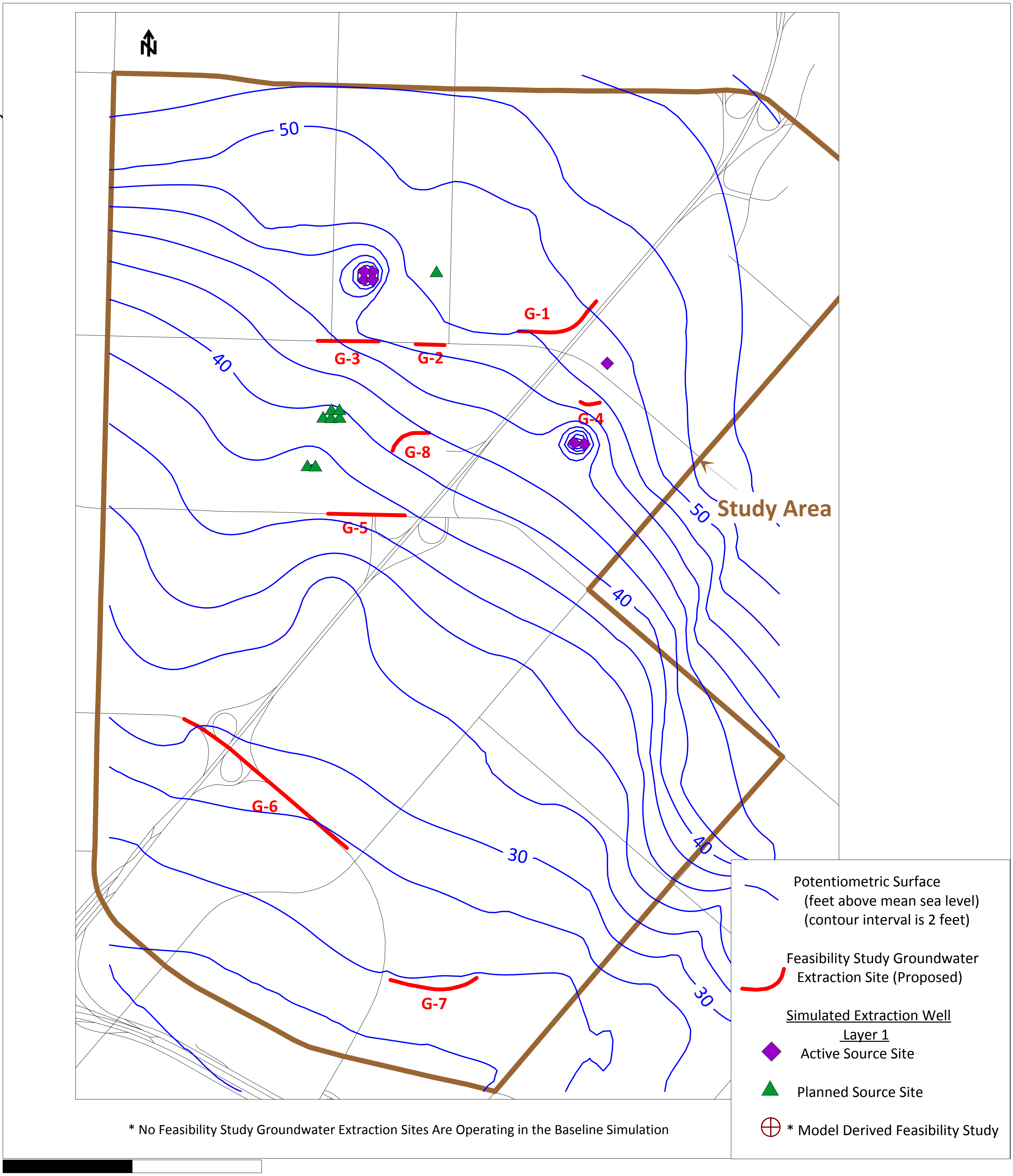
Figure 2.2 Monitor Areas and Locations for Assessment of Simulated Groundwater Flux and Flow Direction SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



SBGPP_SourceSiteLocations.srf (06/11/21)

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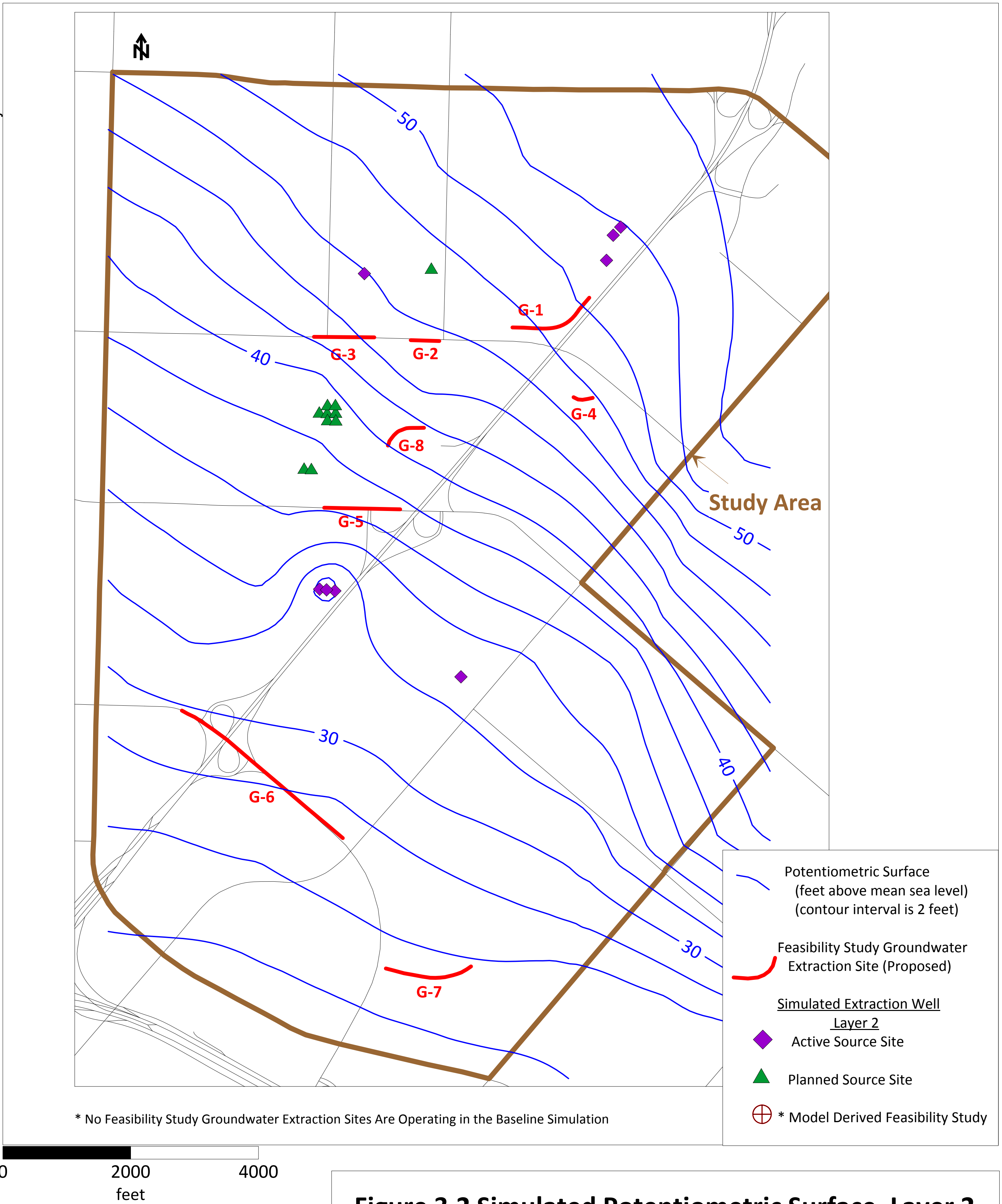
Figure 3.1 Simulated Potentiometric Surface, Layer 1 Baseline Conditions, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project



* No Feasibility Study Groundwater Extraction Sites Are Operating in the Baseline Simulation

SBGPP_SourceSiteLocations.srf (06/11/21)

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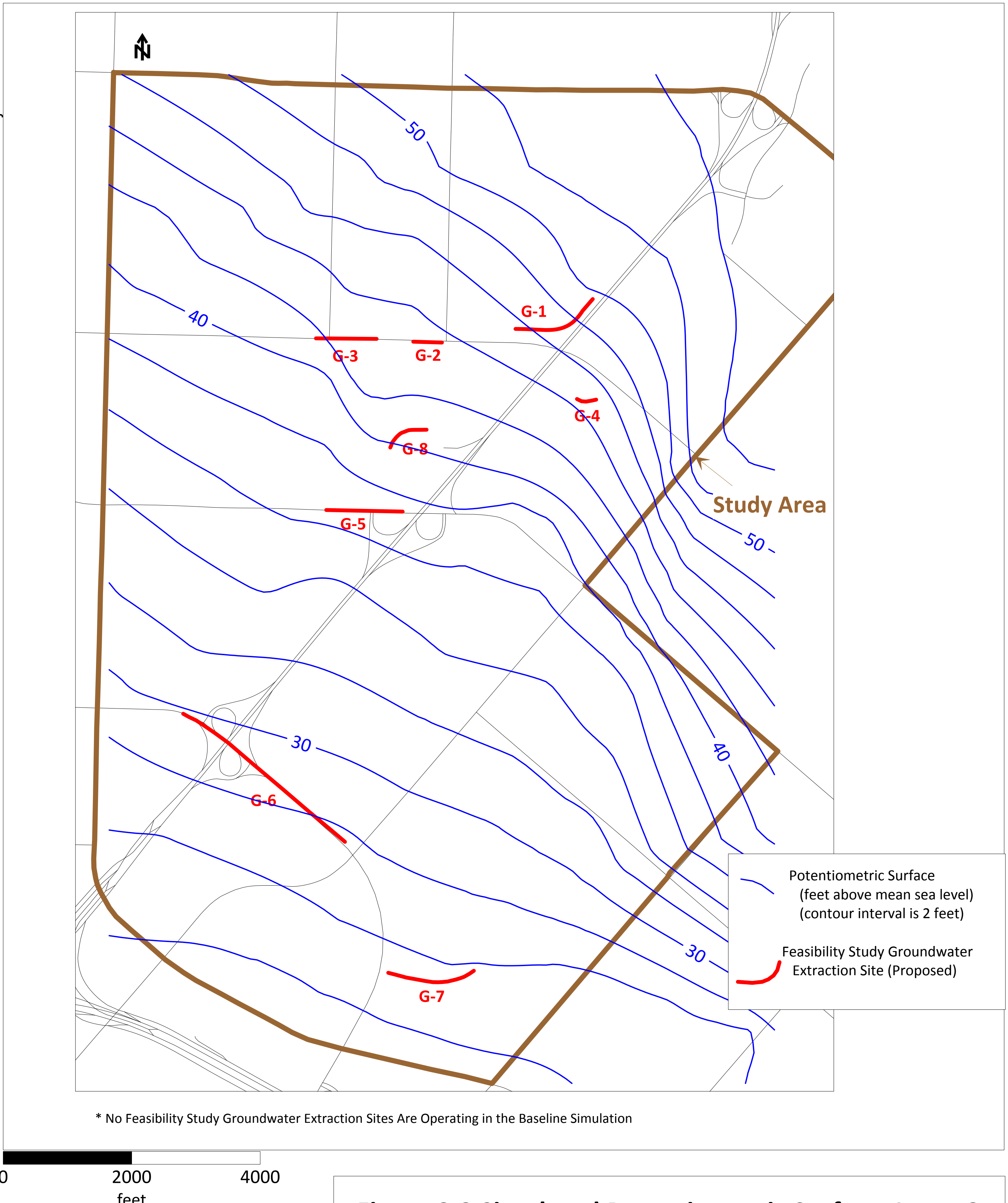
Figure 3.2 Simulated Potentiometric Surface, Layer 2 Baseline Conditions, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



* No Feasibility Study Groundwater Extraction Sites Are Operating in the Baseline Simulation

SBGPP_SourceSiteLocations.srf (06/11/21)

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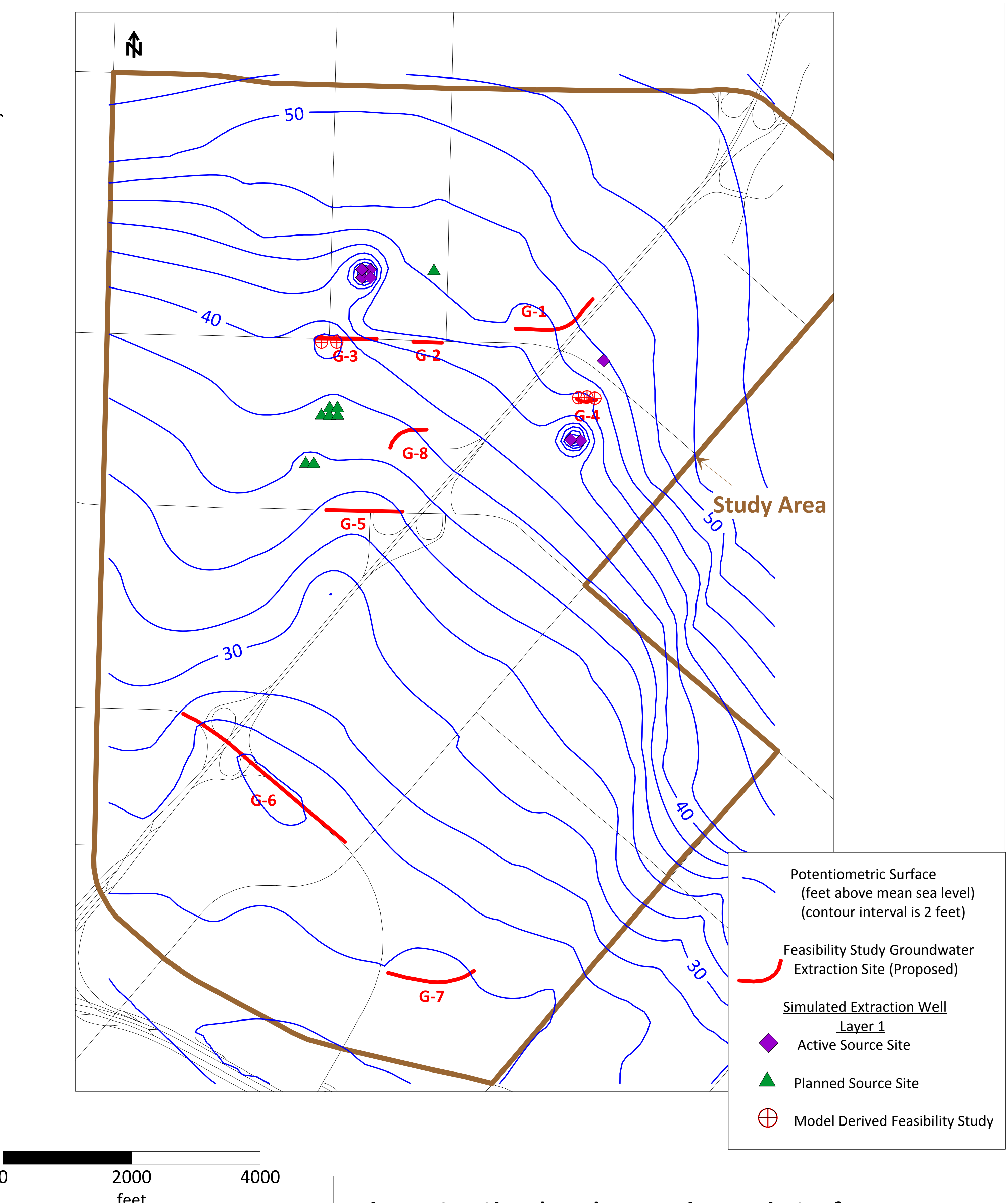
Figure 3.3 Simulated Potentiometric Surface, Layer 3 Baseline Conditions, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Plan

Project No. 151099



SBGPP_SourceSiteLocations.srf (06/11/21)

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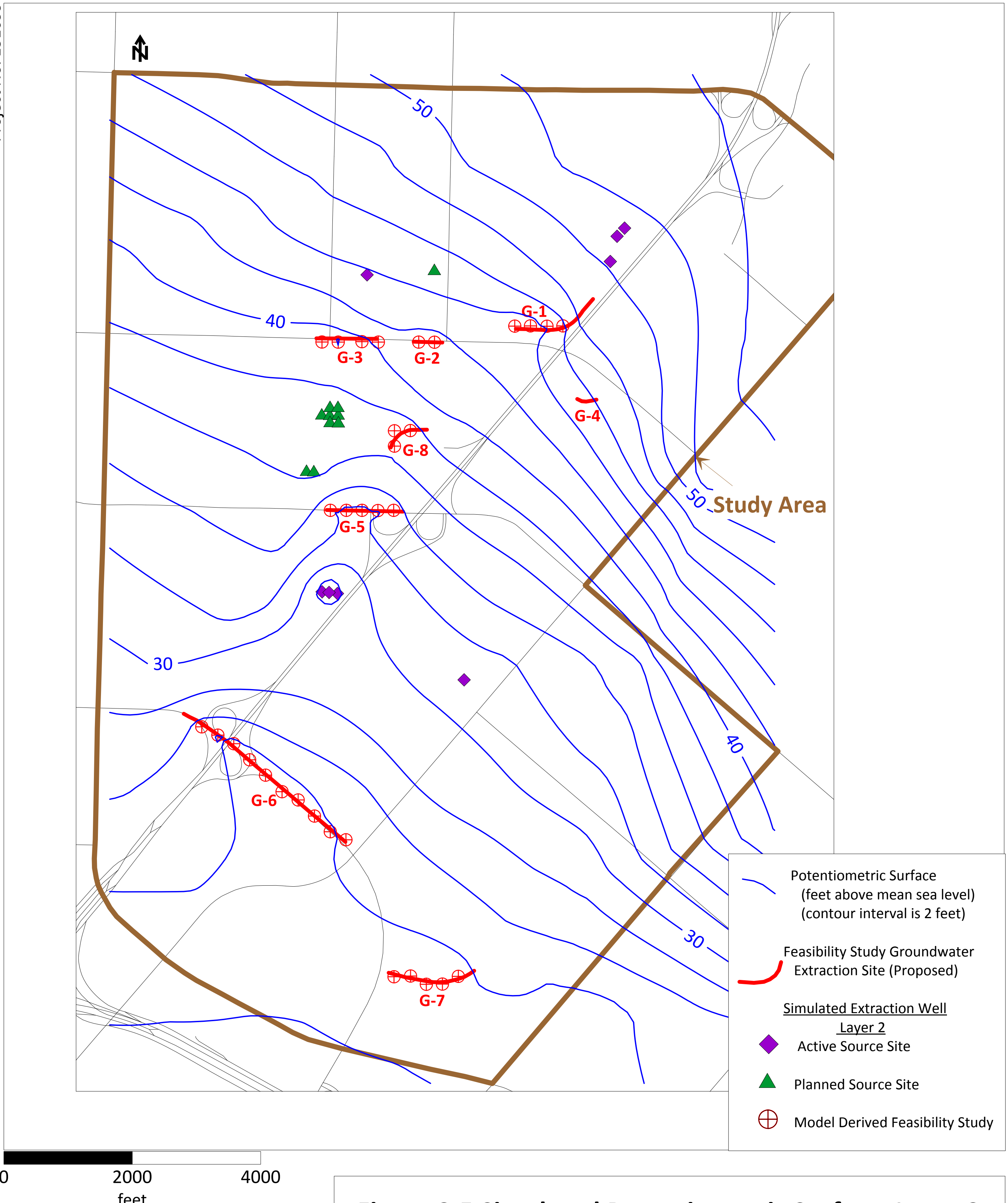
Figure 3.4 Simulated Potentiometric Surface, Layer 1
Feasibility Study Extraction Sites, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project



SBGPP_SourceSiteLocations.srf (06/11/21)

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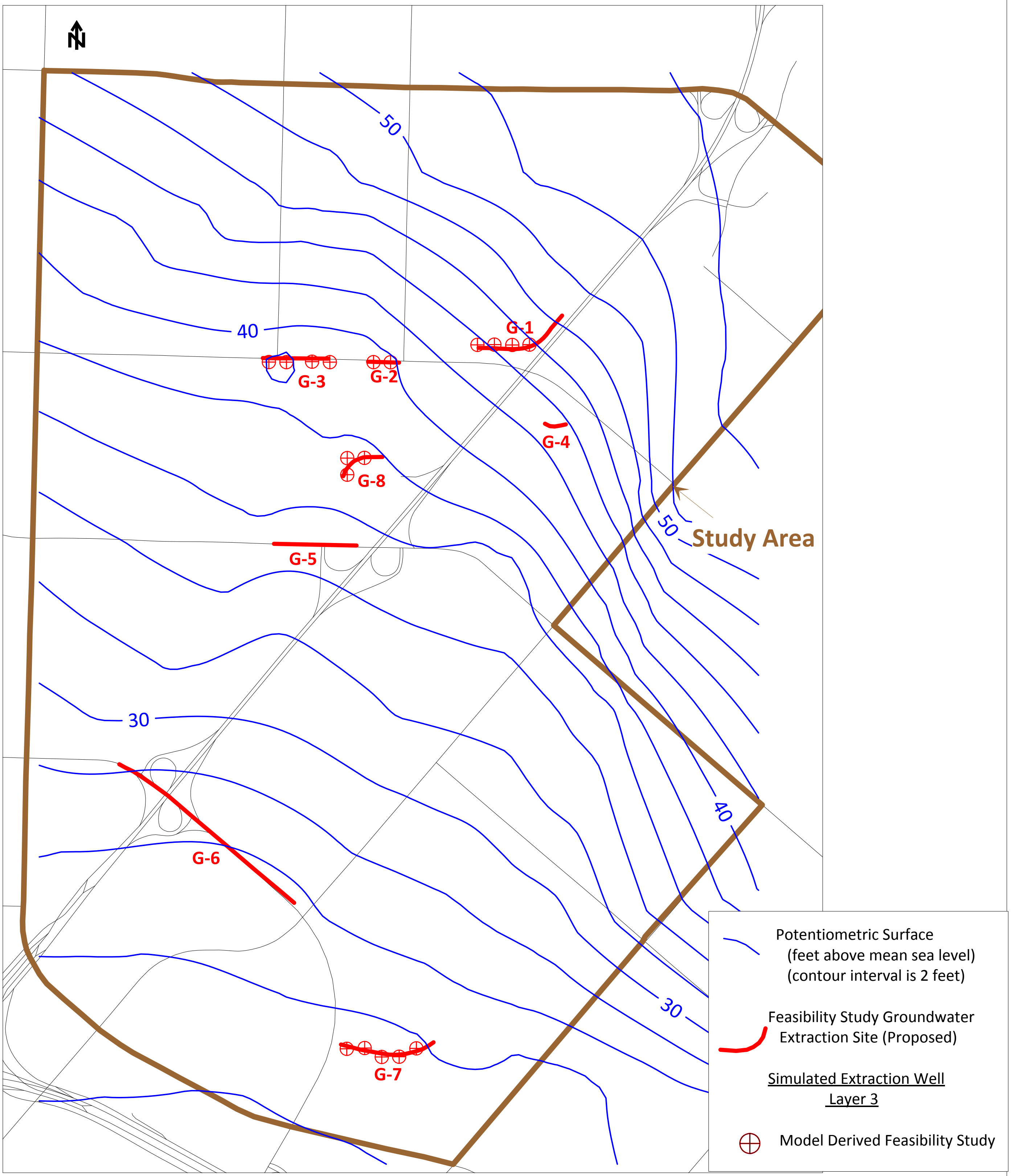
Figure 3.5 Simulated Potentiometric Surface, Layer 2 Feasibility Study Extraction Sites, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



* No Active or Planned Source Site Extraction Wells are Simulated in Layer 3

SBGPP_SourceSiteLocations.srf (06/11/21)

0 2000 4000
feet

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Figure 3.6 Simulated Potentiometric Surface, Layer 3 Feasibility Study Extraction Sites, SBGPP Model

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South Basin Groundwater Protection Project

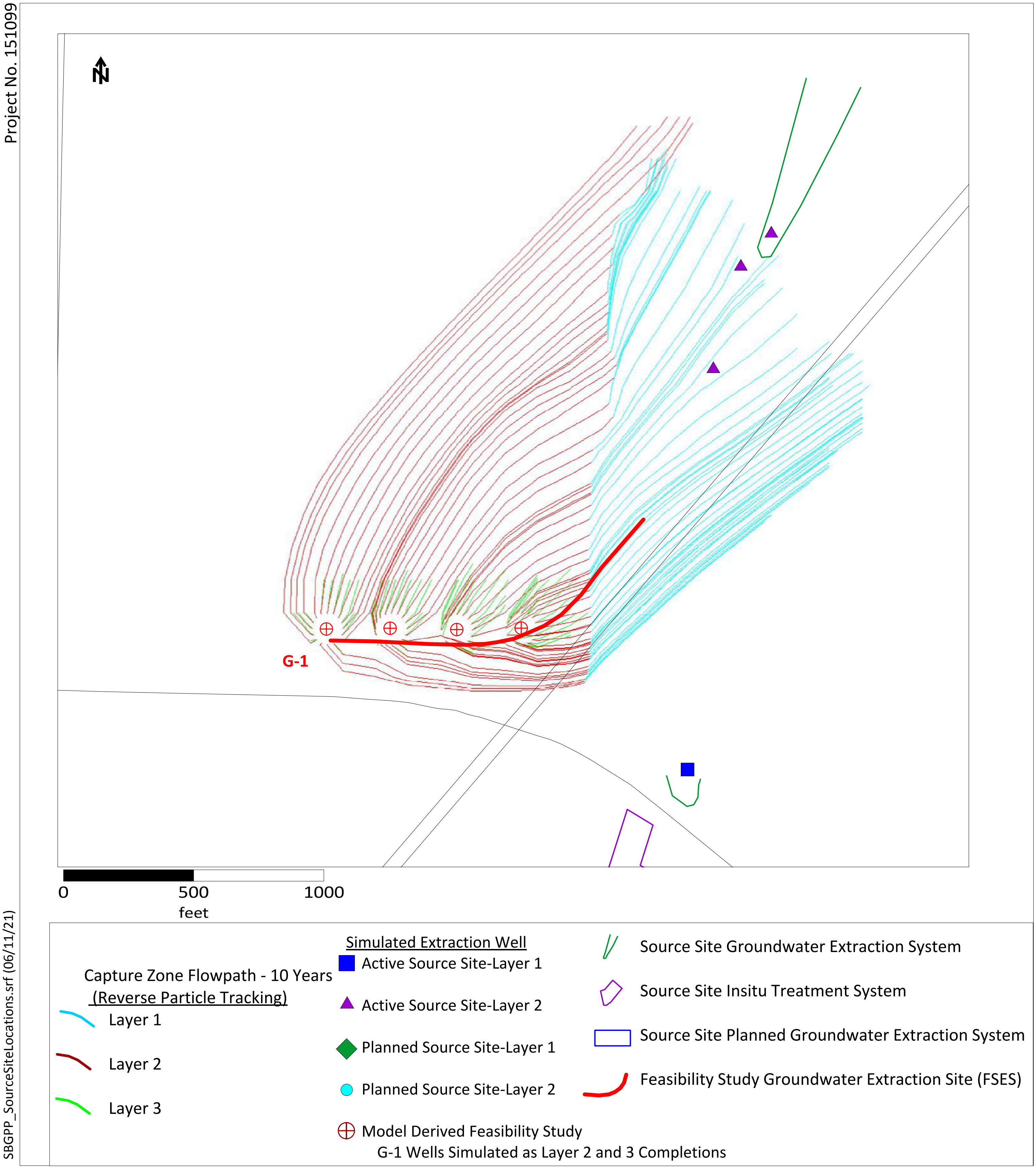

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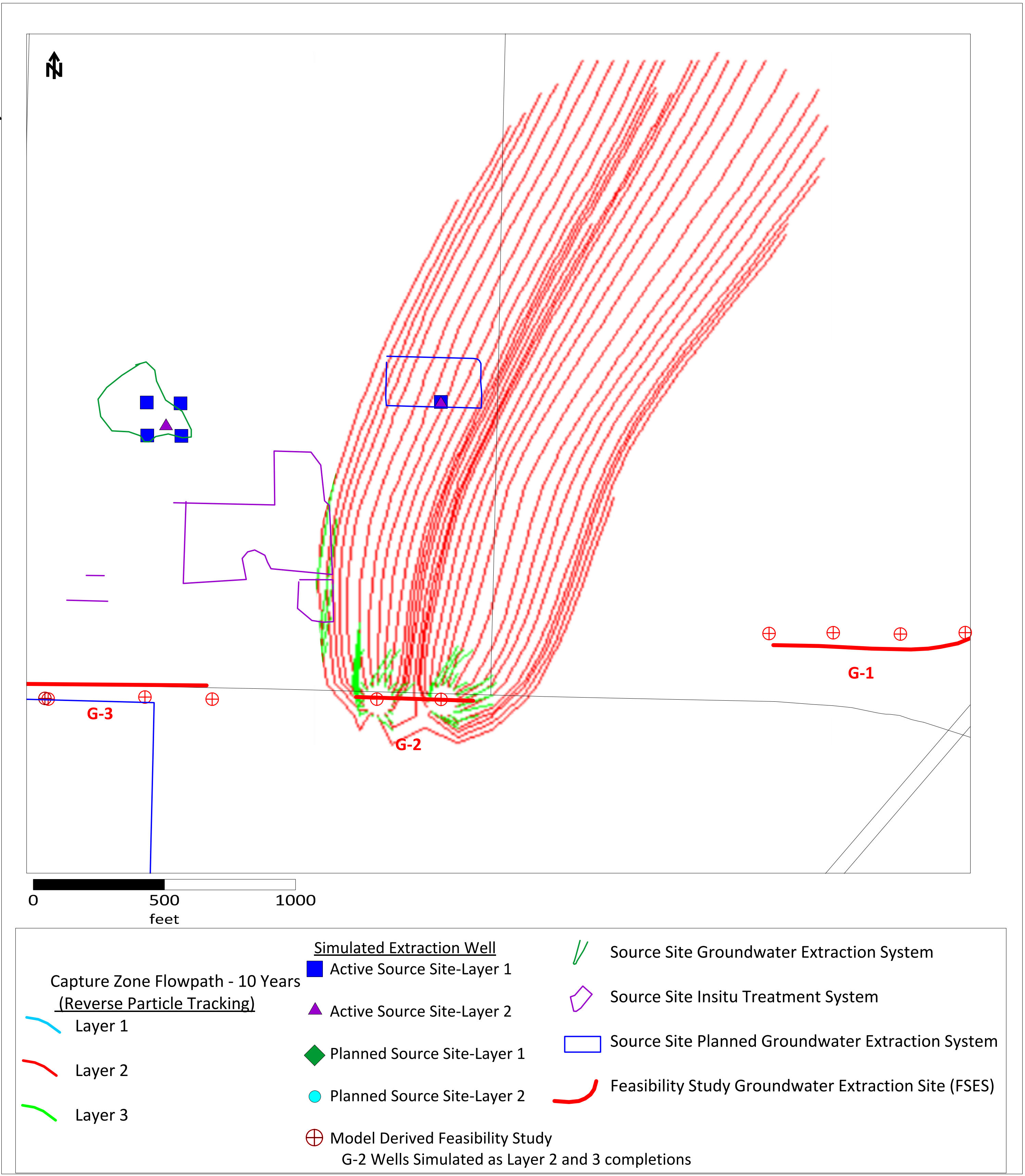
Figure 3.7 Capture Zone Analysis Feasibility Study Extraction Site G-1, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

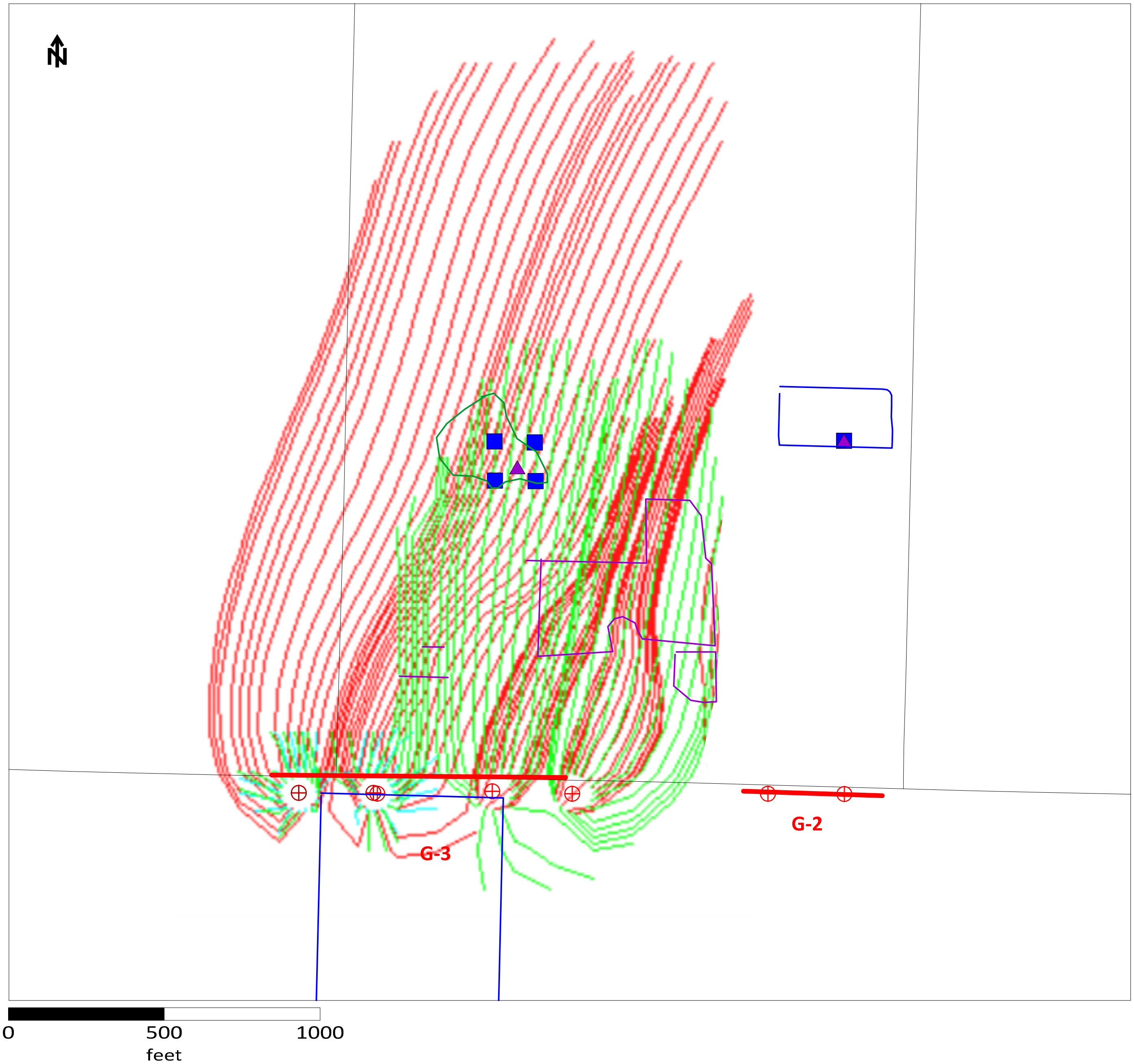


SBGPP_SourceSiteLocations.srf (06/11/21)

Engineering Analytics, Inc.

Figure 3.8 Capture Zone Analysis
Feasibility Study Extraction Site G-2, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project



Capture Zone Flowpath - 10 Years
(Reverse Particle Tracking)
Layer 1
Layer 2
Layer 3

Simulated Extraction Well
Active Source Site-Layer 1
Active Source Site-Layer 2
Planned Source Site-Layer 1
Planned Source Site-Layer 2
Model Derived Feasibility Study
Two G-3 Wells Simulated as Layer 1 Completions, Four G-3 Wells as Layer 2 and 3 completions

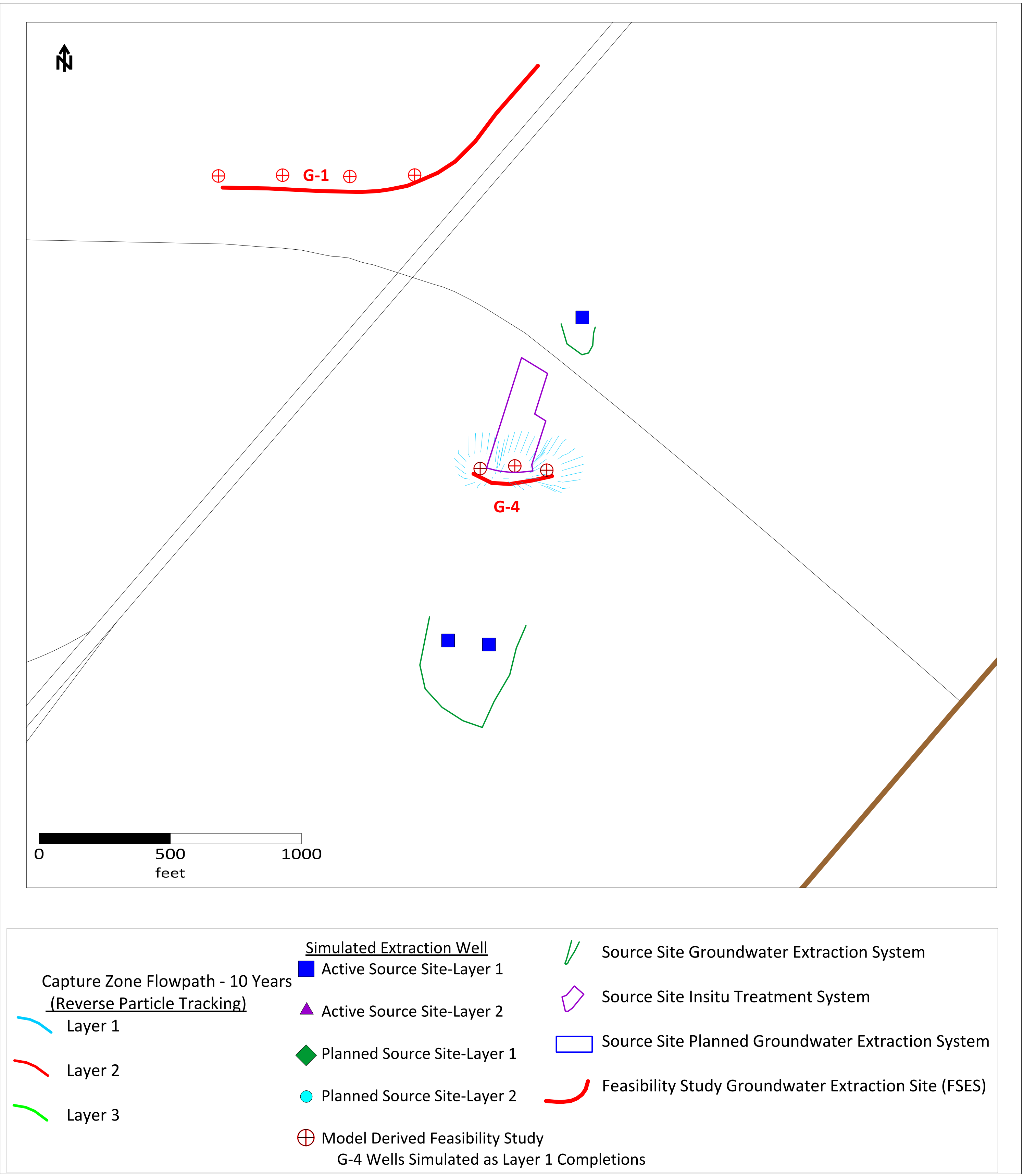
Source Site Groundwater Extraction System
Source Site Insitu Treatment System
Source Site Planned Groundwater Extraction System
Feasibility Study Groundwater Extraction Site (FSES)

Engineering Analytics, Inc.

Figure 3.9 Capture Zone Analysis
Feasibility Study Extraction Site G-3, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099

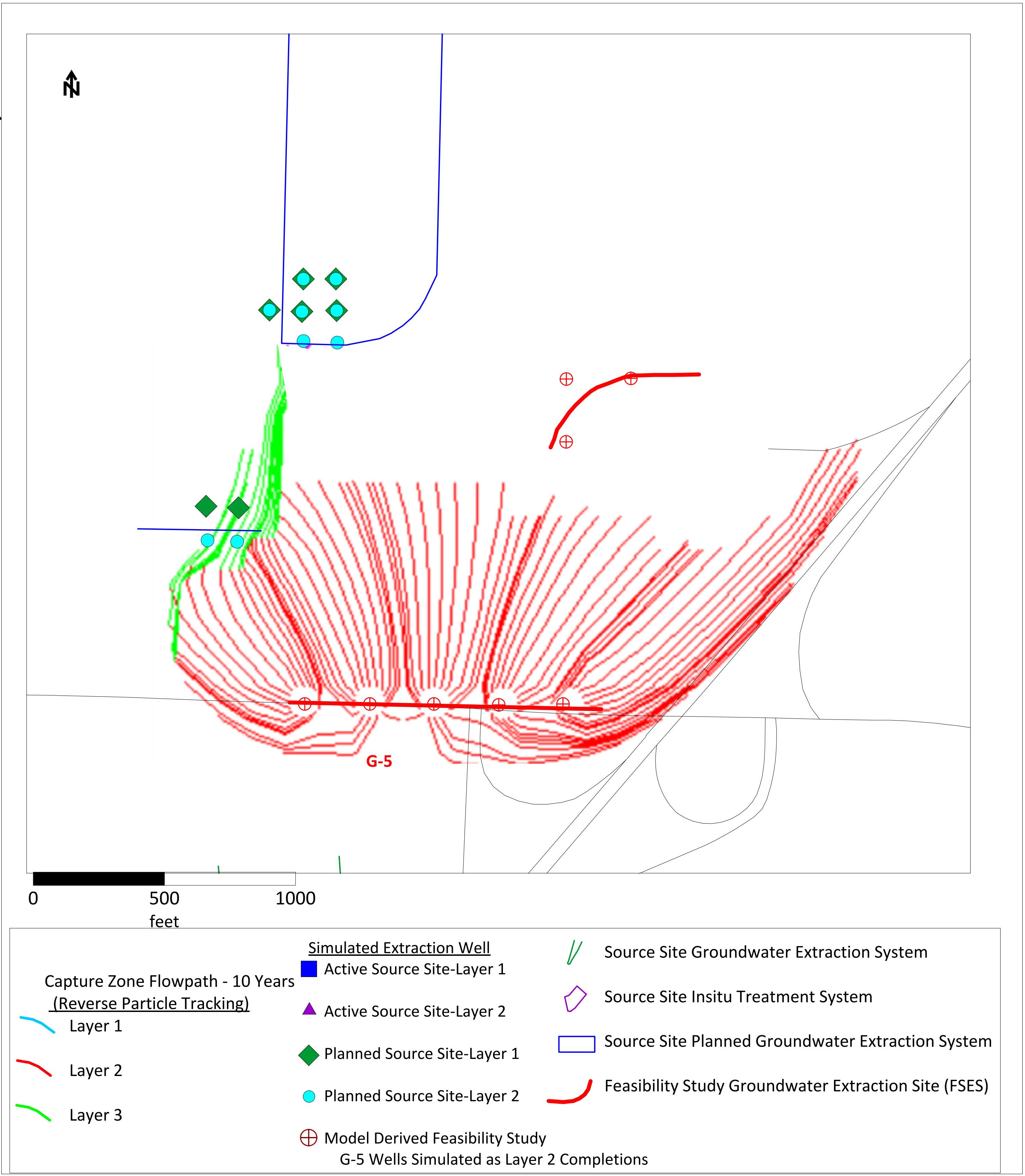


SBGPP_SourceSiteLocations.srf (06/11/21)

Engineering Analytics, Inc.

Figure 3.10 Capture Zone Analysis
Feasibility Study Extraction Site G-4, SBGPP Model

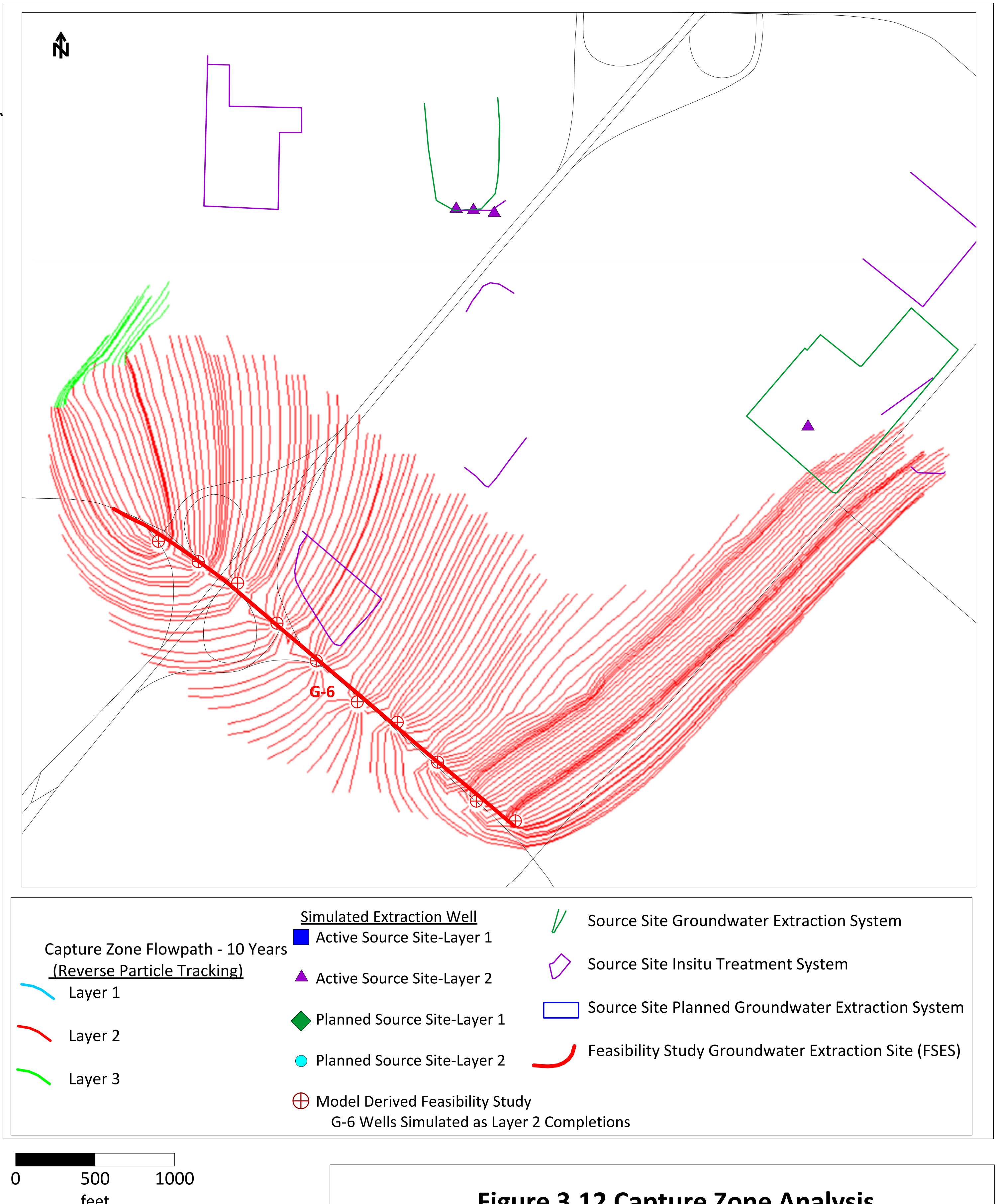
ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project



Engineering Analytics, Inc.

Figure 3.11 Capture Zone Analysis
Feasibility Study Extraction Site G-5, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project



Project No. 151099

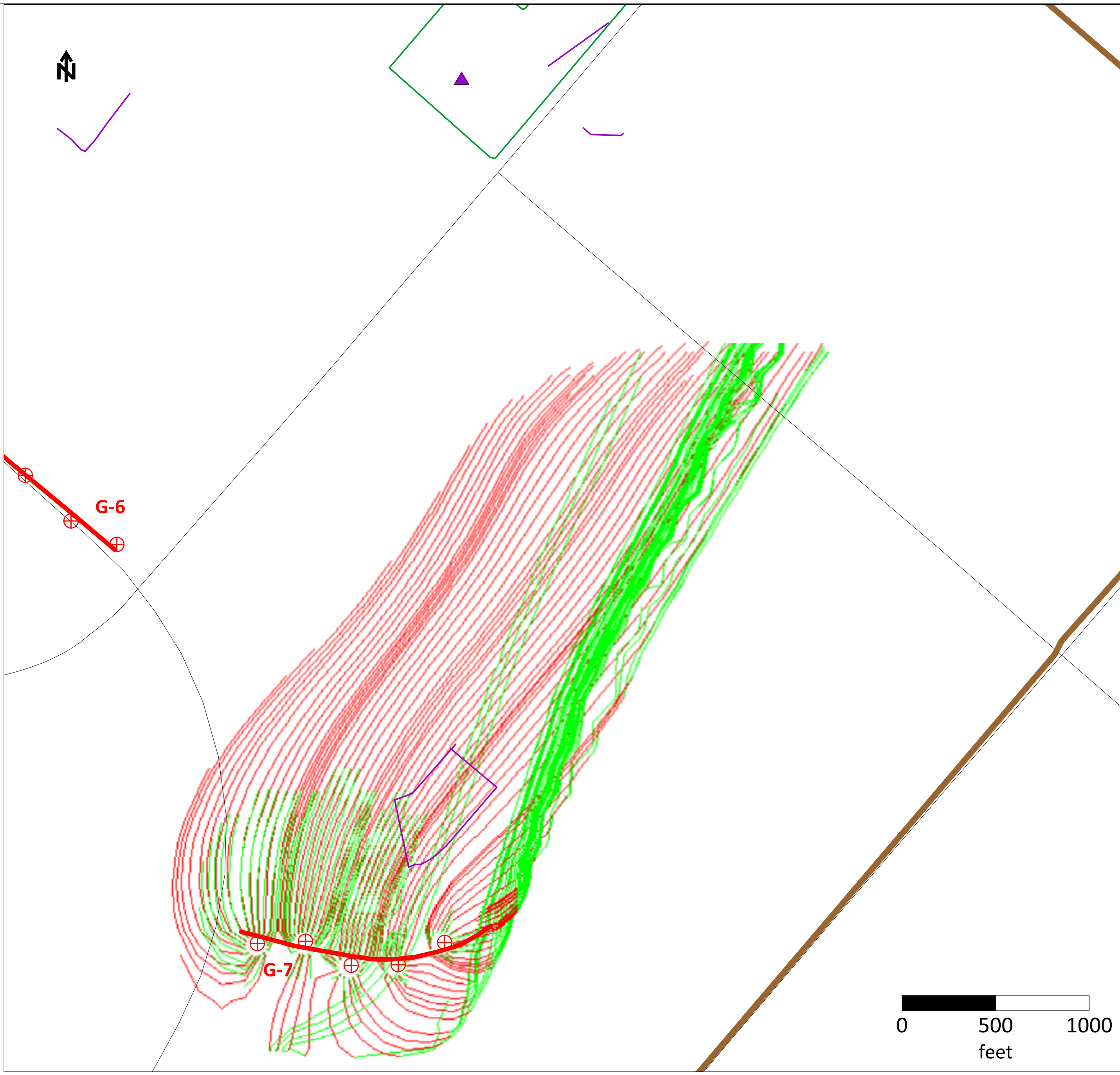
SBGPP_SourceSiteLocations.srf (06/11/21)

Engineering Analytics, Inc.

Figure 3.12 Capture Zone Analysis
Feasibility Study Extraction Site G-6, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



Capture Zone Flowpath - 10 Years
(Reverse Particle Tracking)
Layer 1
Layer 2
Layer 3

Simulated Extraction Well
Active Source Site-Layer 1
Active Source Site-Layer 2
Planned Source Site-Layer 1
Planned Source Site-Layer 2
Model Derived Feasibility Study
G-7 Wells Simulated as Layer 2 and 3 Completions

Source Site Groundwater Extraction System
Source Site Insitu Treatment System
Source Site Planned Groundwater Extraction System
Feasibility Study Groundwater Extraction Site (FSES)

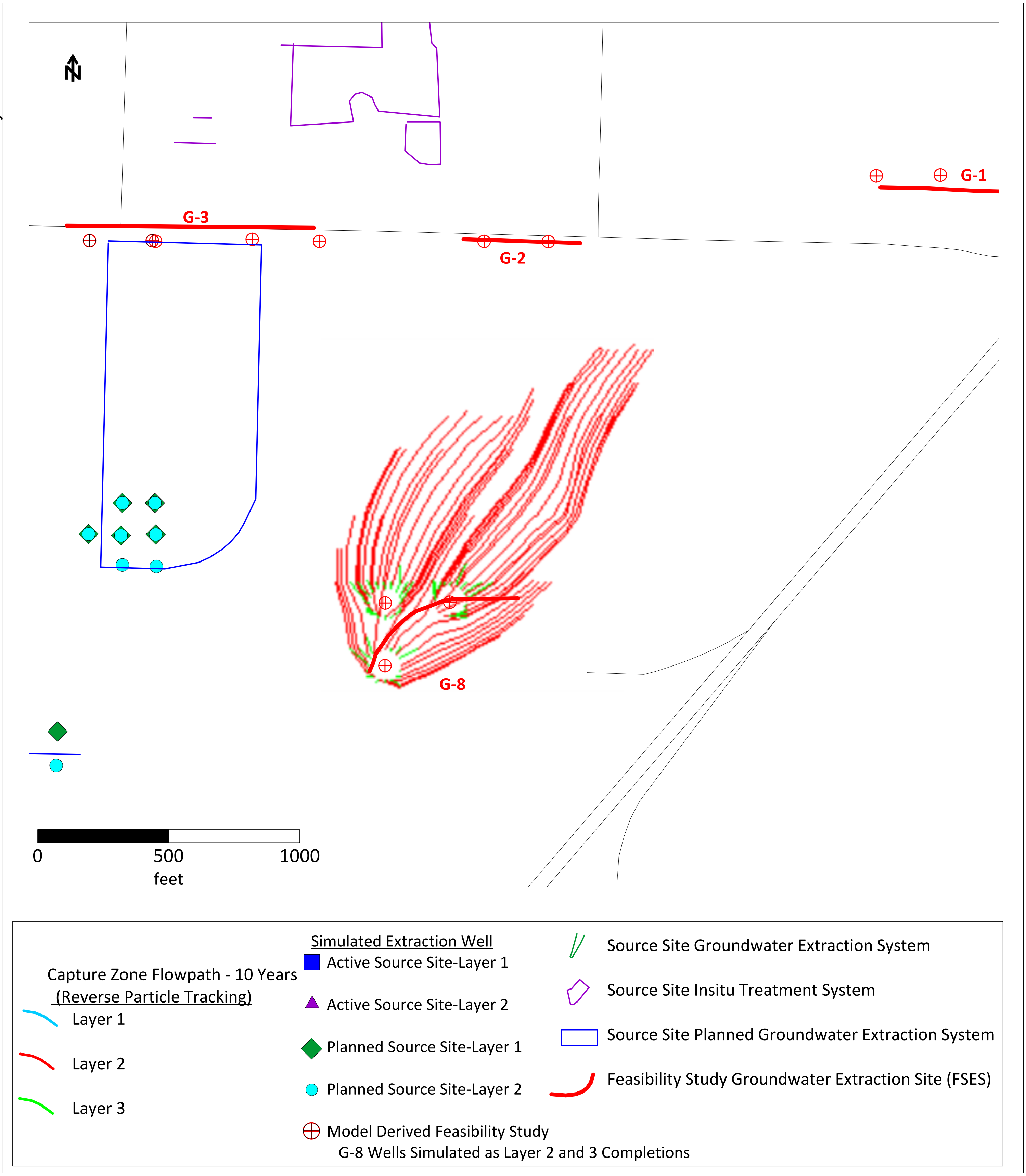
SBGPP_SourceSiteLocations.srf (06/11/21)

Engineering Analytics, Inc.

Figure 3.13 Capture Zone Analysis
Feasibility Study Extraction Site G-7, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



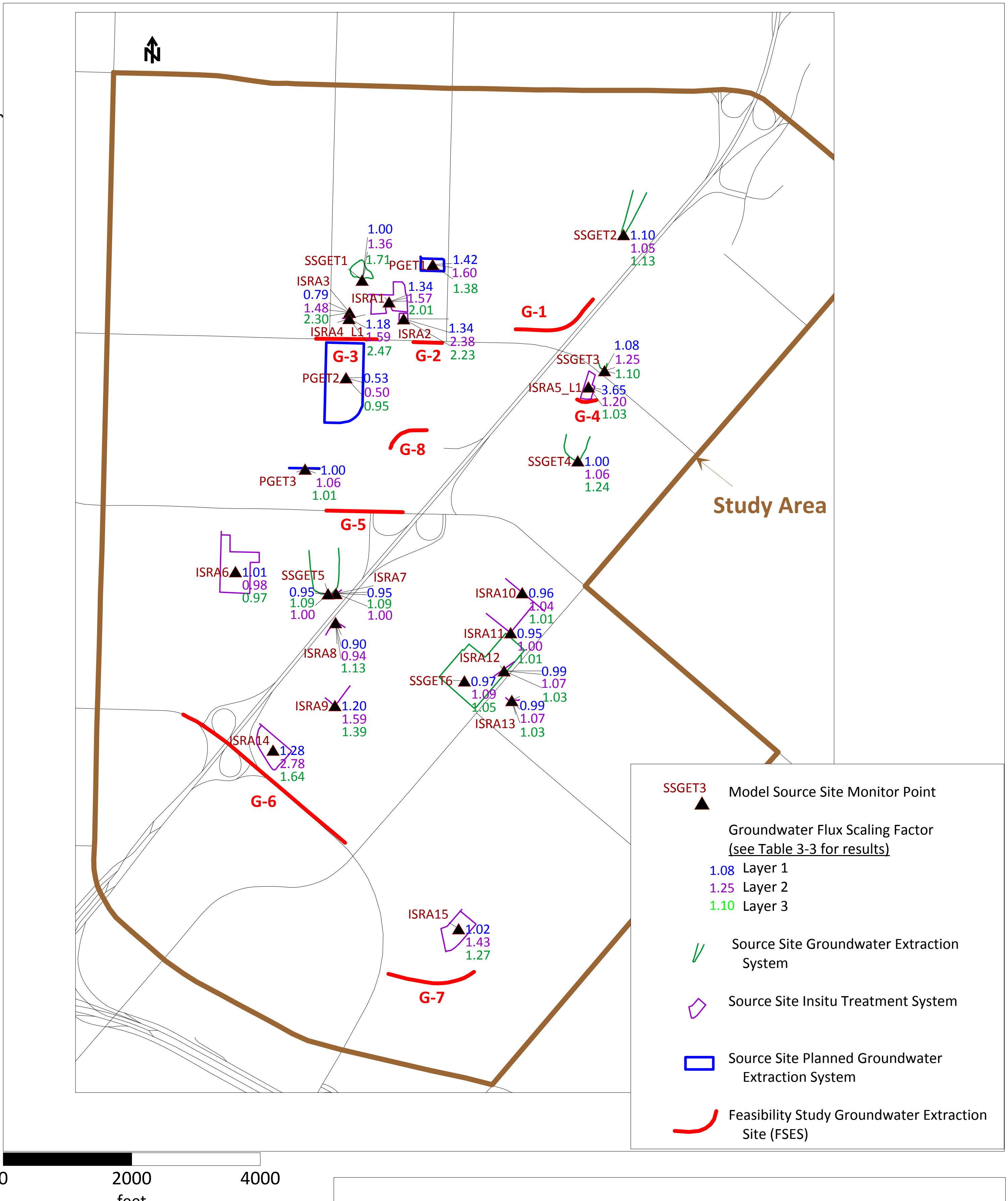
SBGPP_SourceSiteLocations.srf (06/11/21)

Engineering Analytics, Inc.

Figure 3.14 Capture Zone Analysis
Feasibility Study Extraction Site G-8, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



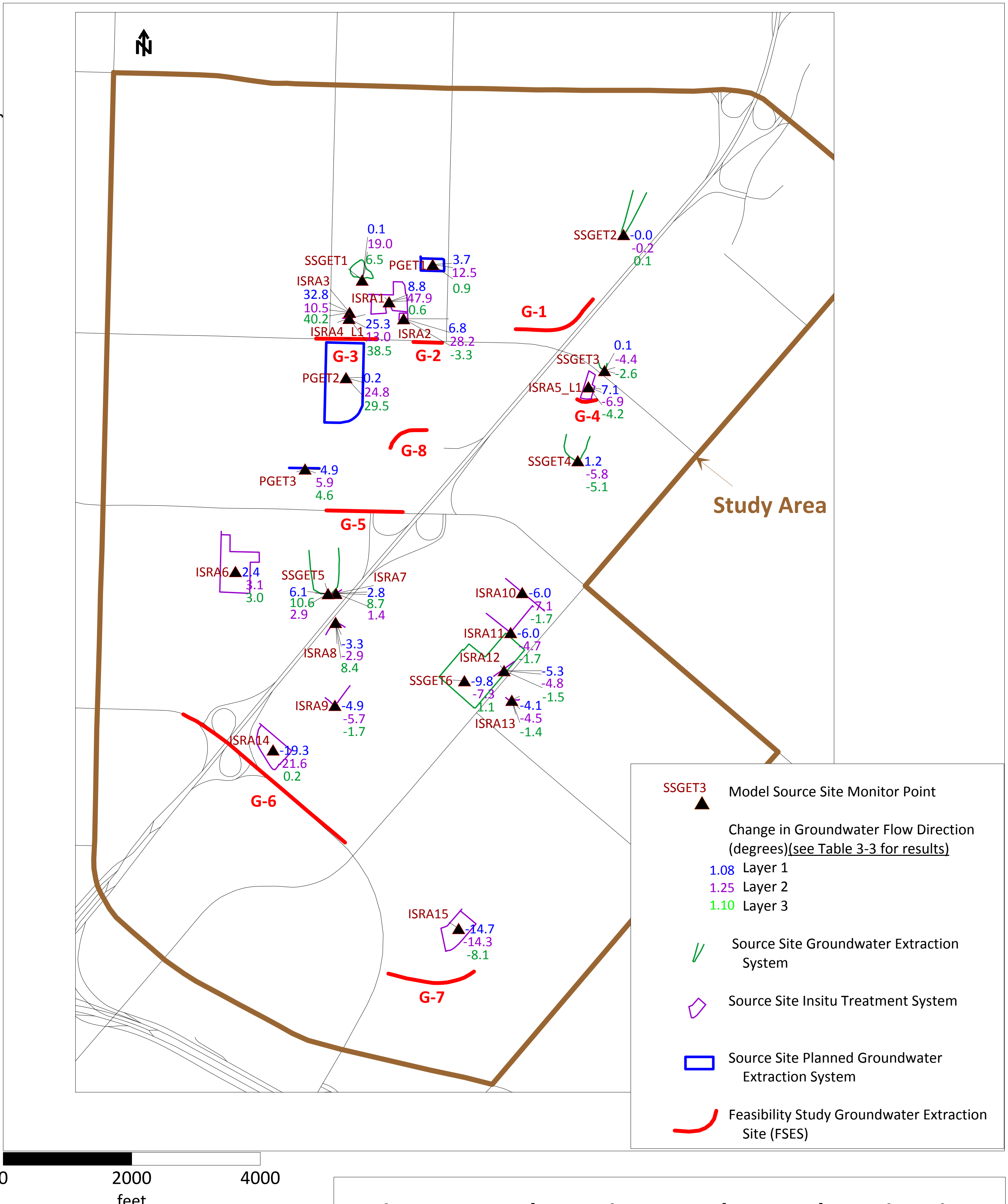
SBGPP_SourceSiteLocations.srf (06/11/21)

Engineering Analytics, Inc.

Figure 3.15 Groundwater Flux Scaling Factor at Source Sites - SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



SBGPP_SourceSiteLocations.srf (06/11/21)

Engineering Analytics, Inc.

Figure 3.16 Change in Groundwater Flow Direction at Source Sites - SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Engineering Analytics, Inc.

Figure 3.17 Simulated Net Change in Potentiometric Surface From Reinjection of Extracted Groundwater Into Layer 4, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099

SBGPP_SourceSiteLocations.srf (06/11/21)

Engineering Analytics, Inc.

Figure 3.18 Simulated Net Change in Potentiometric Surface From Reinjection of Extracted Groundwater Into Layer 4, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Plan

Project No. 151099

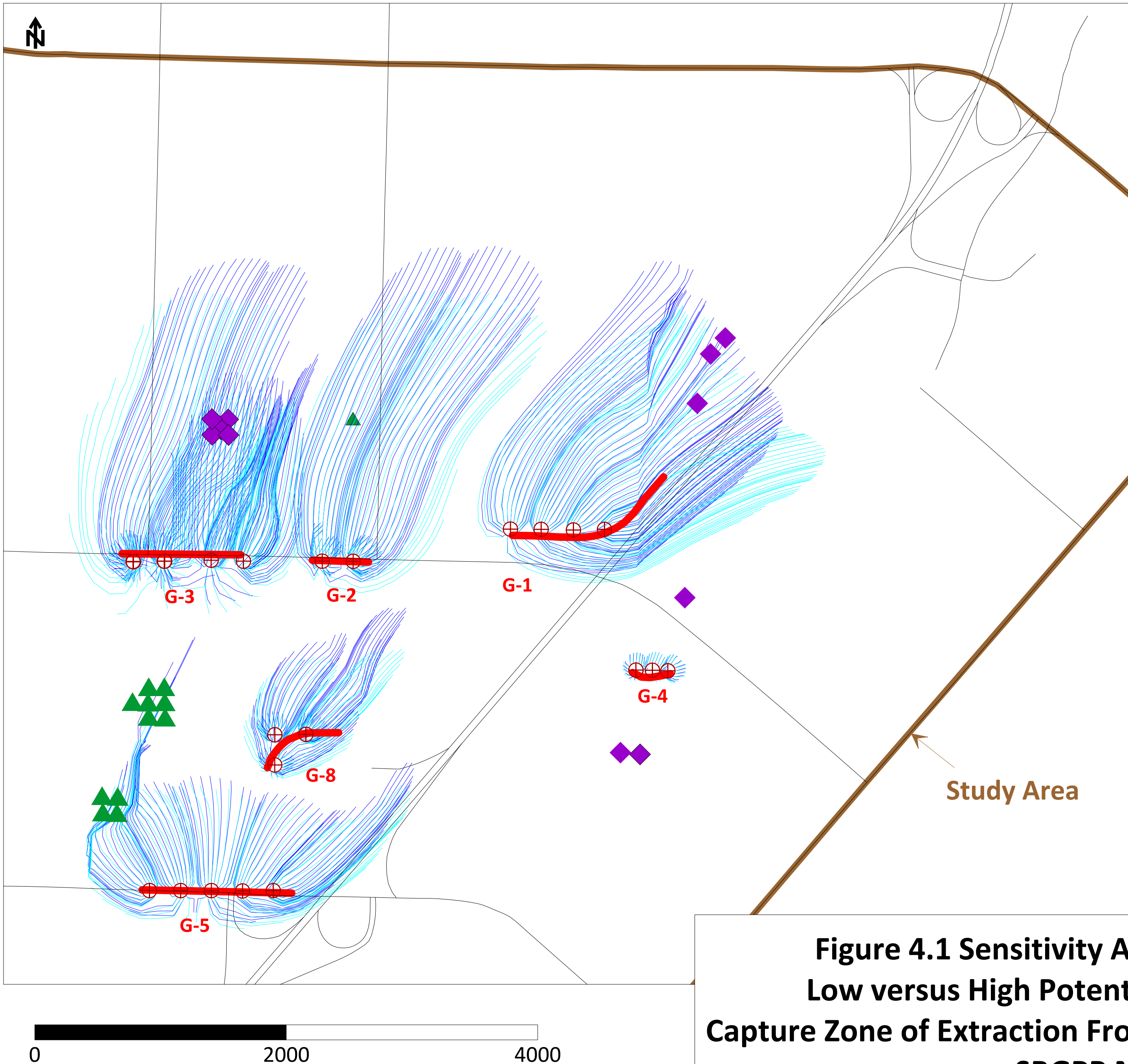
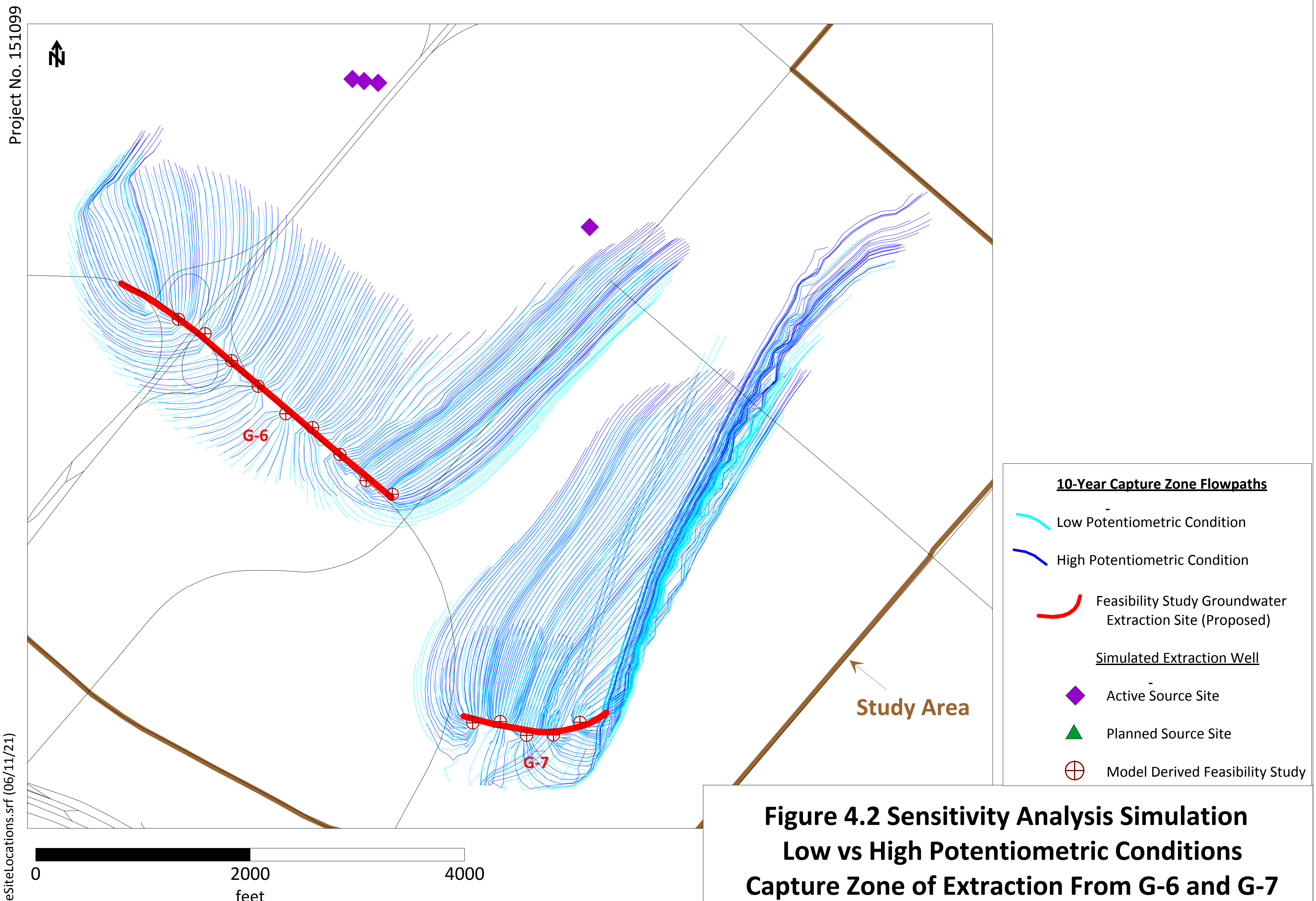


Figure 4.1 Sensitivity Analysis Simulation
Low versus High Potentiometric Conditions
Capture Zone of Extraction From G-1 through G-5 and G-8
SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Engineering Analytics, Inc.

SBGPP_SourceSiteLocations.srf (06/11/21)

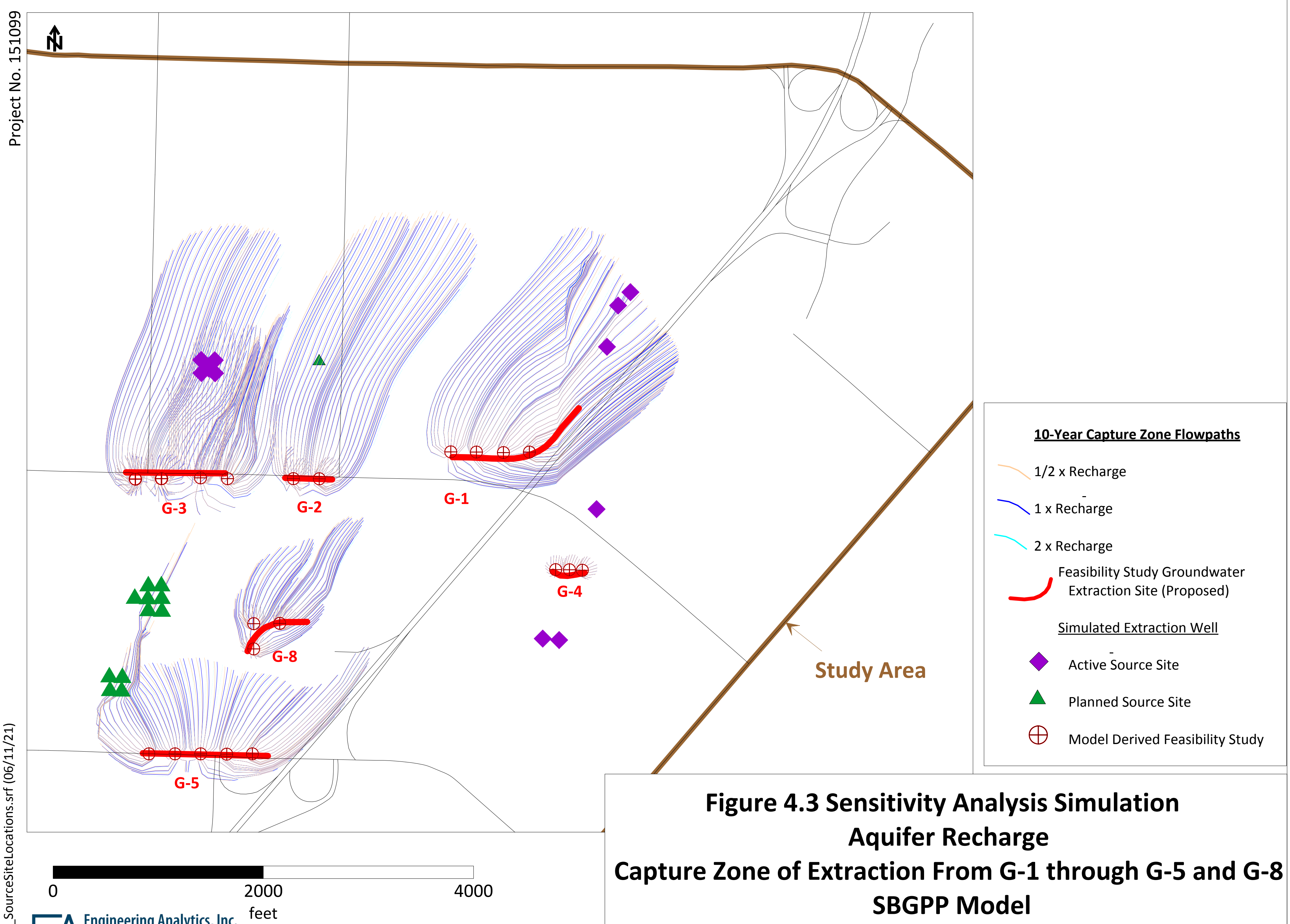


SBGPP_SourceSiteLocations.srf (06/11/21)

Engineering Analytics, Inc.

Figure 4.2 Sensitivity Analysis Simulation
Low vs High Potentiometric Conditions
Capture Zone of Extraction From G-6 and G-7
SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project



Engineering Analytics, Inc.

Figure 4.3 Sensitivity Analysis Simulation
Aquifer Recharge
Capture Zone of Extraction From G-1 through G-5 and G-8
SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

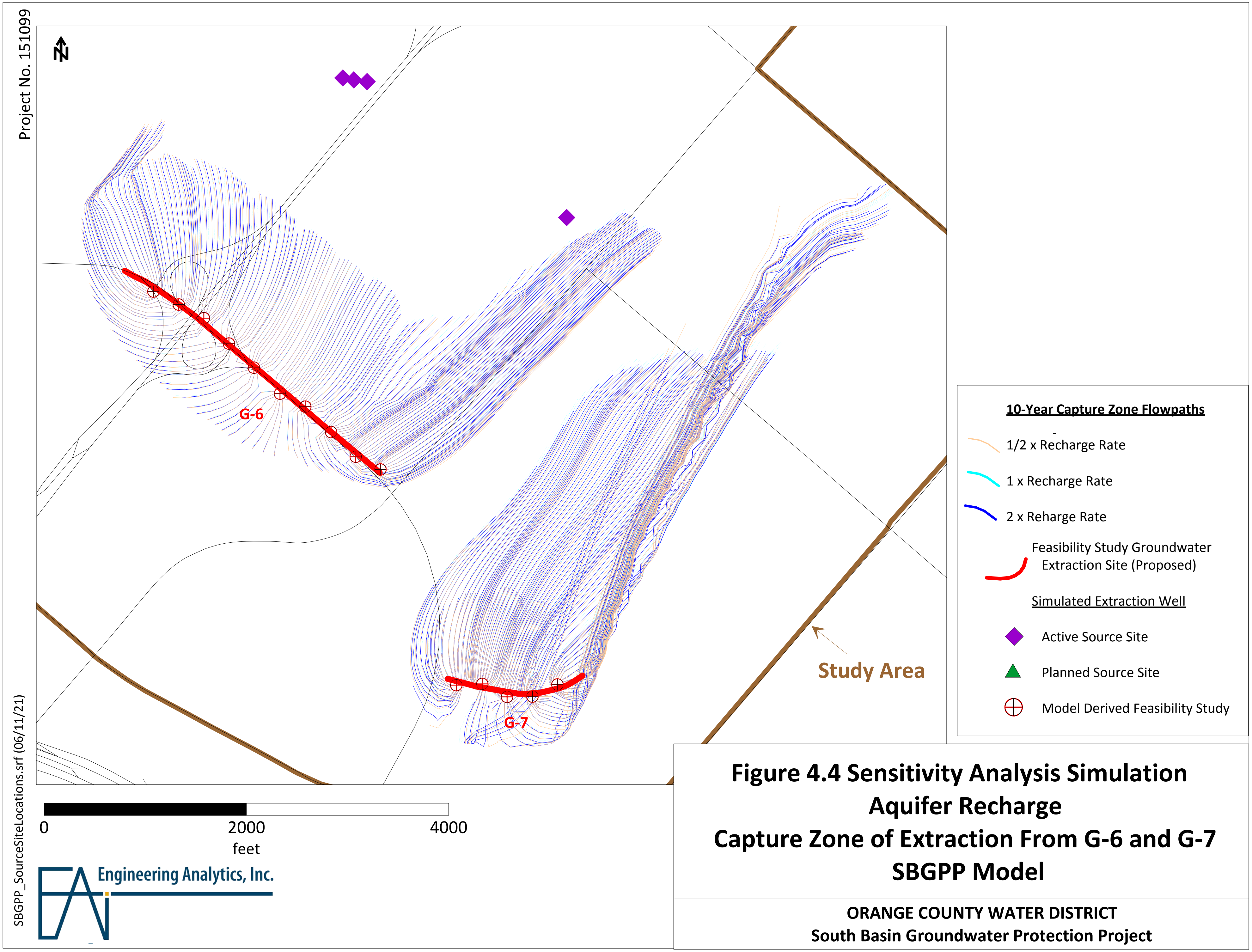
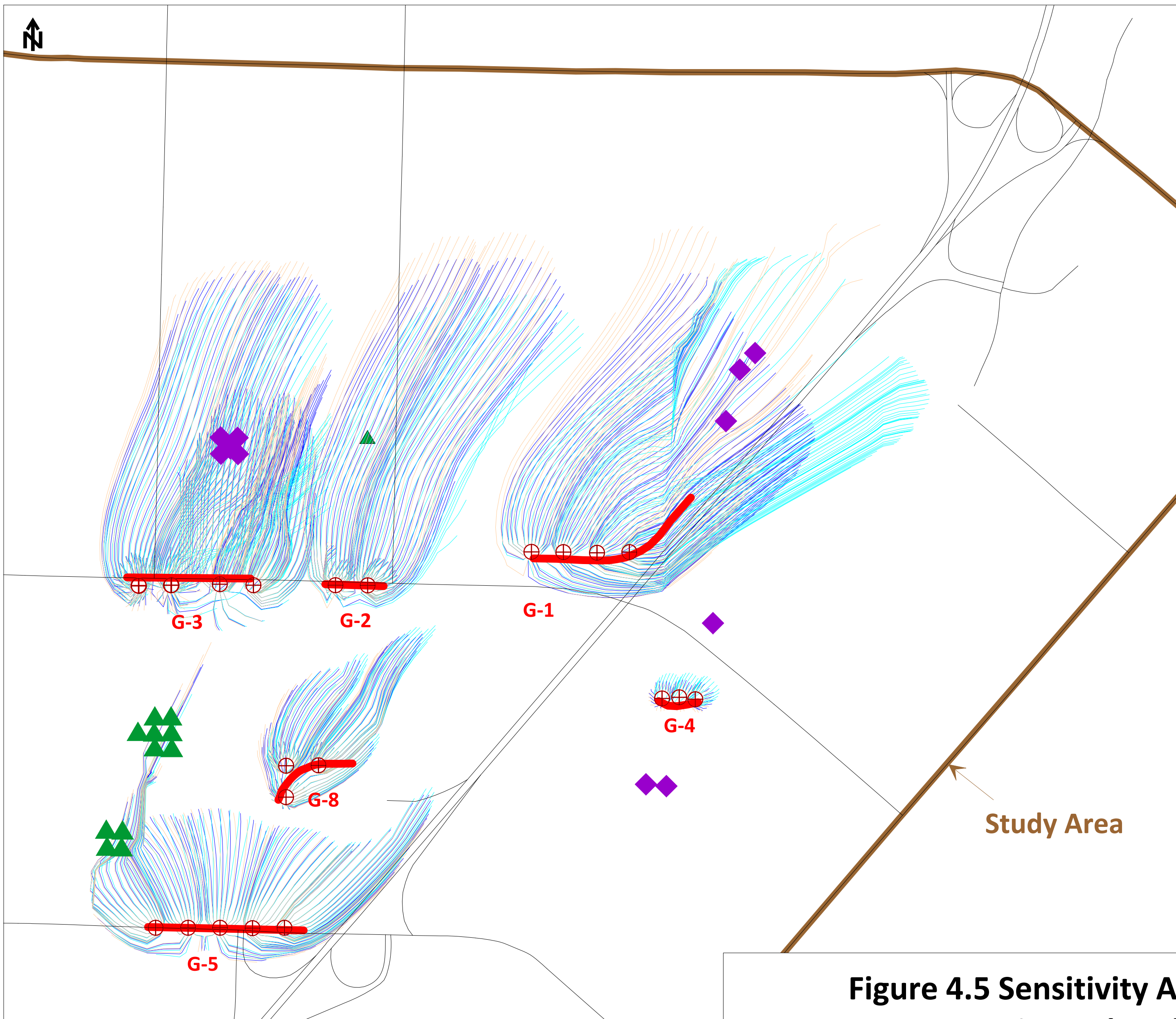
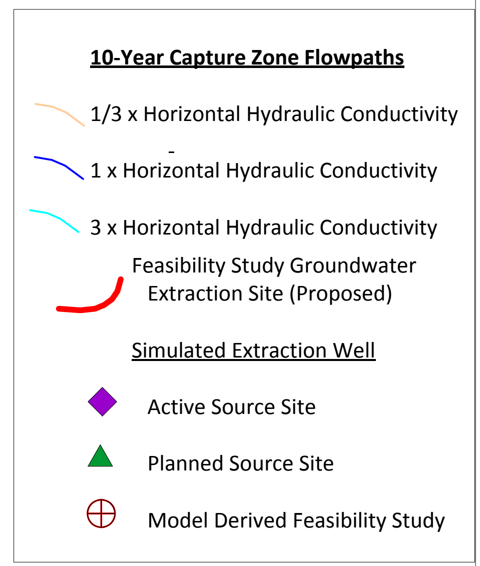


Figure 4.4 Sensitivity Analysis Simulation Aquifer Recharge Capture Zone of Extraction From G-6 and G-7 SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099





0 2000 4000
feet

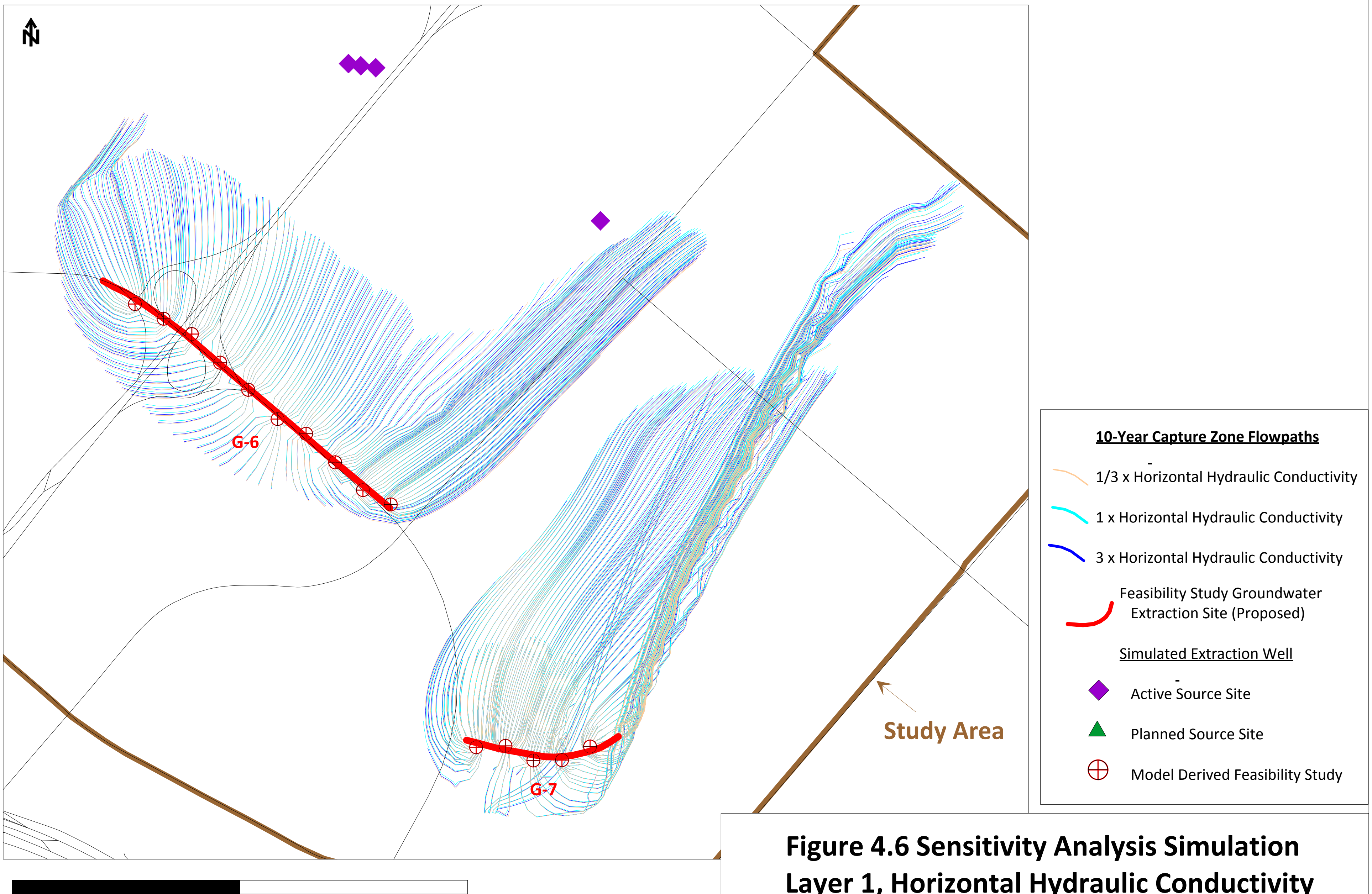
Engineering Analytics, Inc.

SBGPP_SourceSiteLocations.srf (06/11/21)

Figure 4.5 Sensitivity Analysis Simulation
Layer 1 Horizontal Hydraulic Conductivity
Capture Zone of Extraction From G-1 through G-5 and G-8
SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



Engineering Analytics, Inc.

SBGPP_SourceSiteLocations.srf (06/11/21)

Figure 4.6 Sensitivity Analysis Simulation Layer 1, Horizontal Hydraulic Conductivity Capture Zone of Extraction From G-6 and G-7 SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

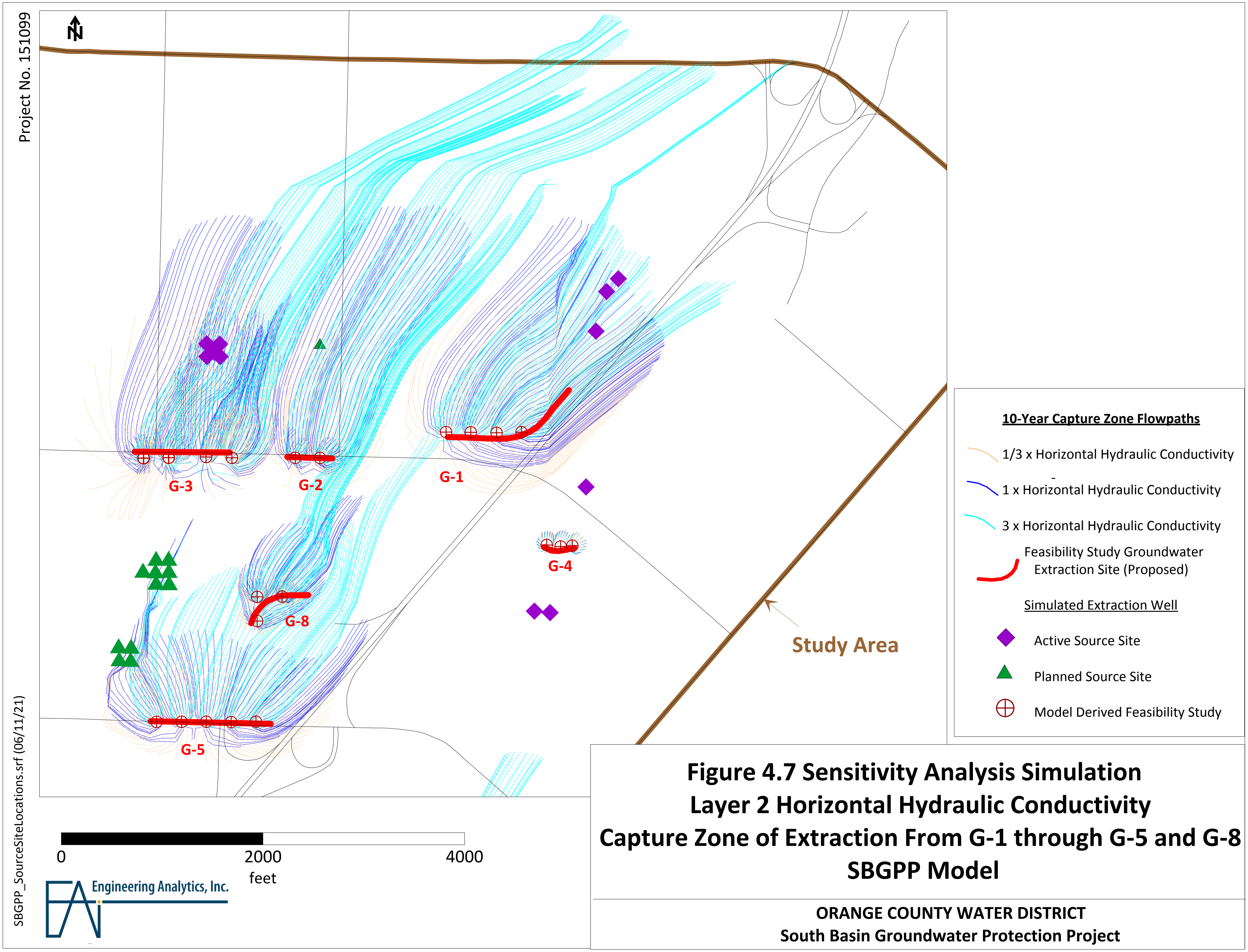


Figure 4.7 Sensitivity Analysis Simulation
Layer 2 Horizontal Hydraulic Conductivity
Capture Zone of Extraction From G-1 through G-5 and G-8
SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

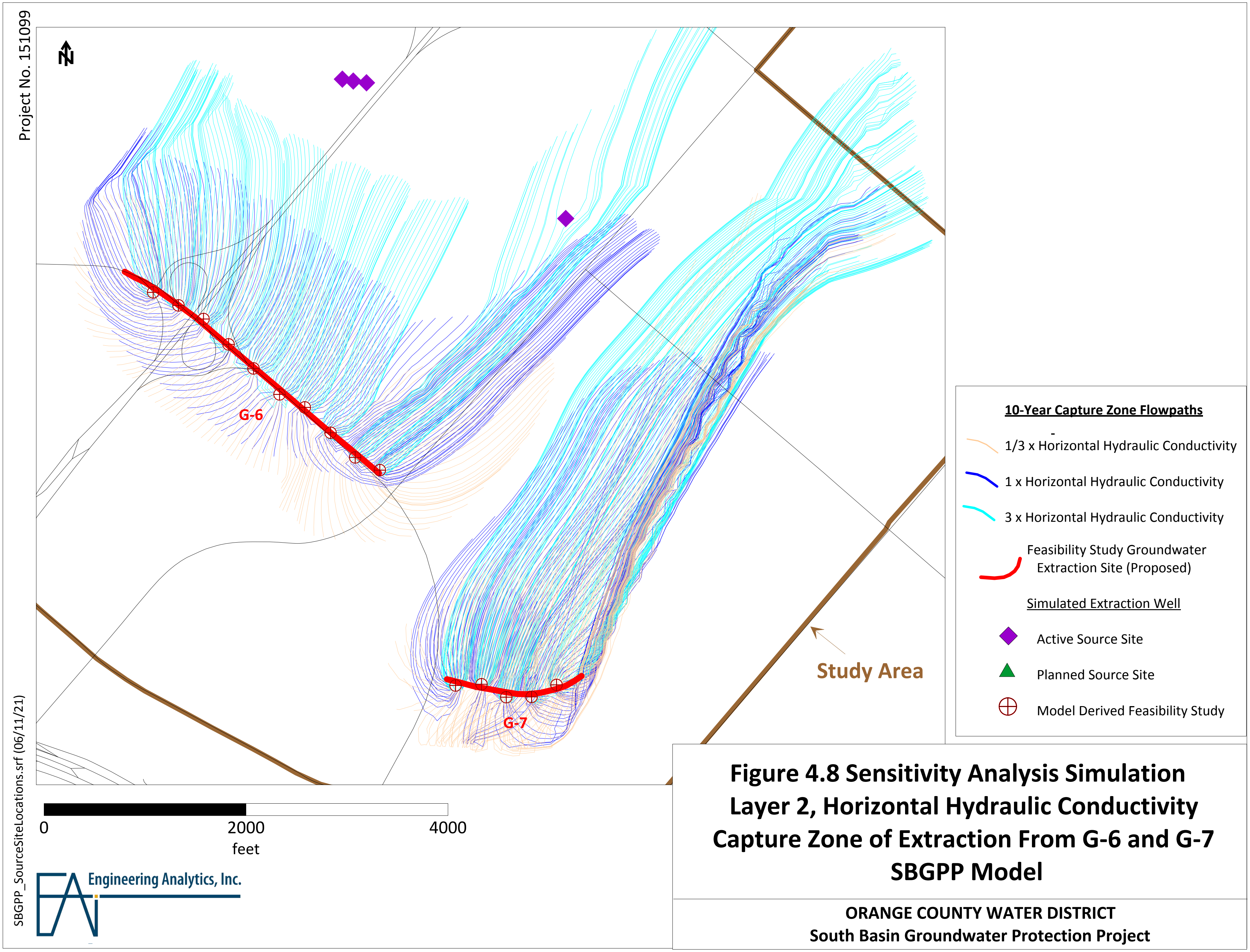
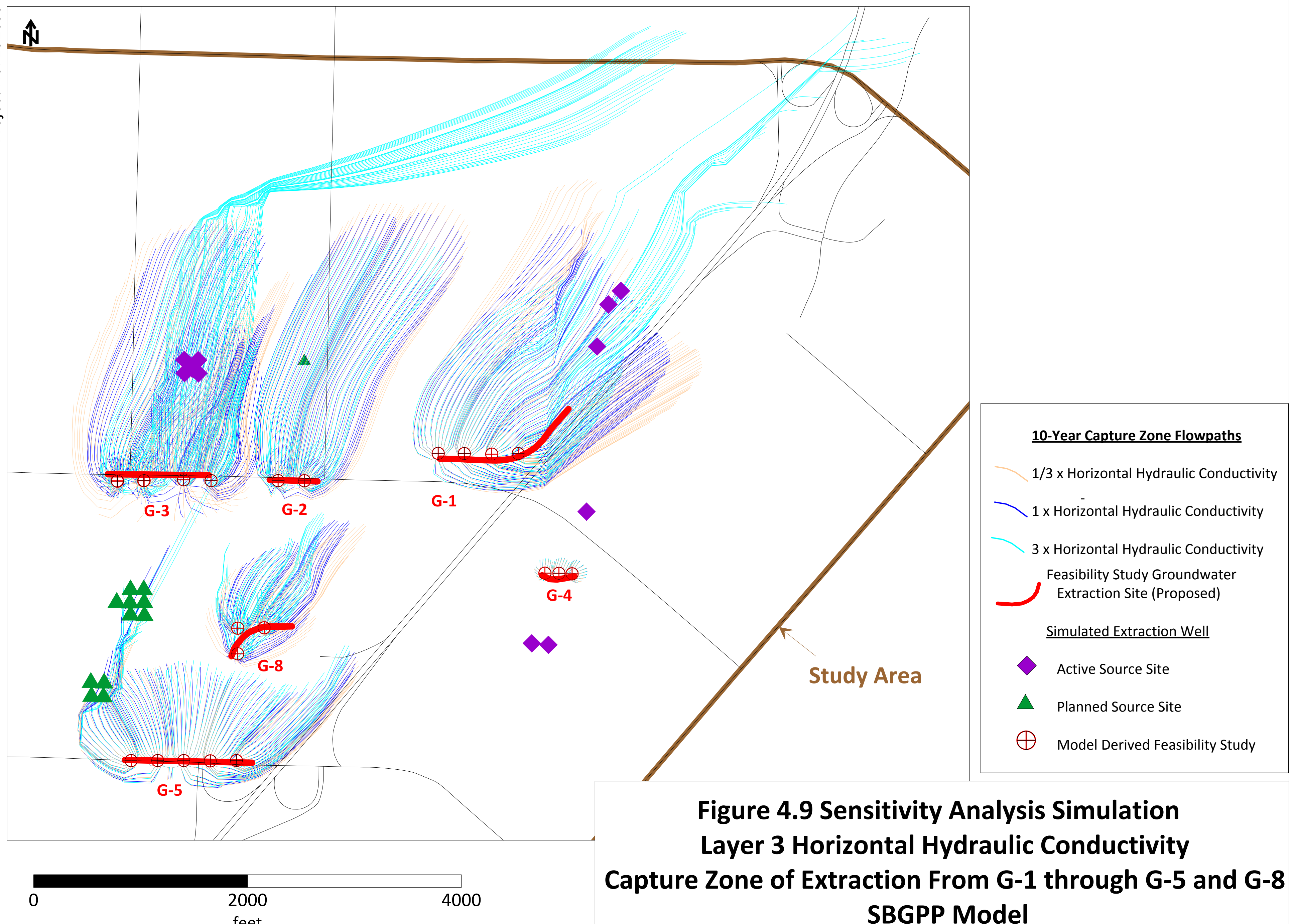


Figure 4.8 Sensitivity Analysis Simulation Layer 2, Horizontal Hydraulic Conductivity Capture Zone of Extraction From G-6 and G-7 SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



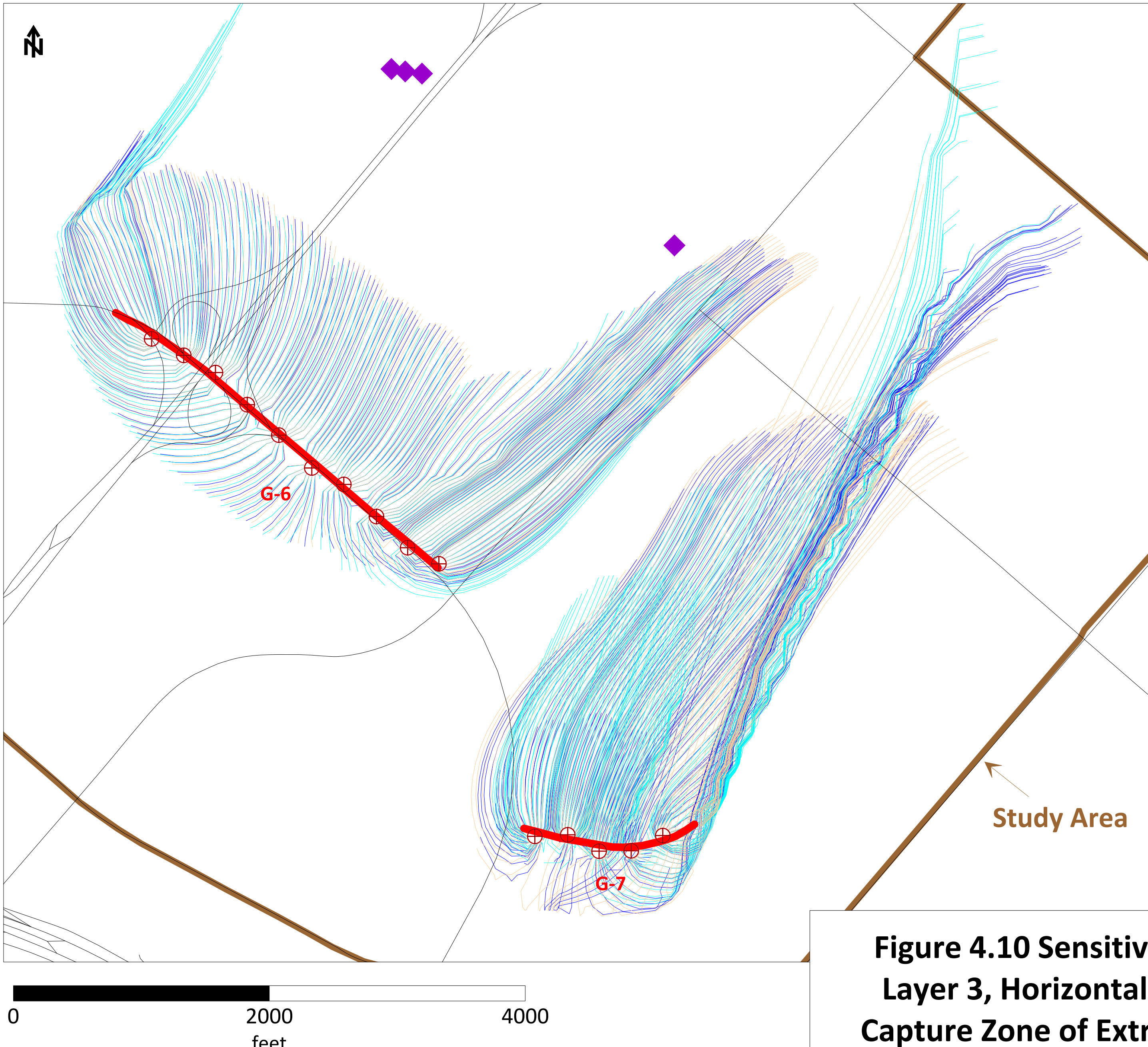
Engineering Analytics, Inc.

SBGPP_SourceSiteLocations.srf (06/11/21)

Figure 4.9 Sensitivity Analysis Simulation
Layer 3 Horizontal Hydraulic Conductivity
Capture Zone of Extraction From G-1 through G-5 and G-8
SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



10-Year Capture Zone Flowpaths

- 1/3 x Horizontal Hydraulic Conductivity
- 1 x Horizontal Hydraulic Conductivity
- 3 x Horizontal Hydraulic Conductivity
- Feasibility Study Groundwater Extraction Site (Proposed)

Simulated Extraction Well

- Active Source Site
- Planned Source Site
- Model Derived Feasibility Study

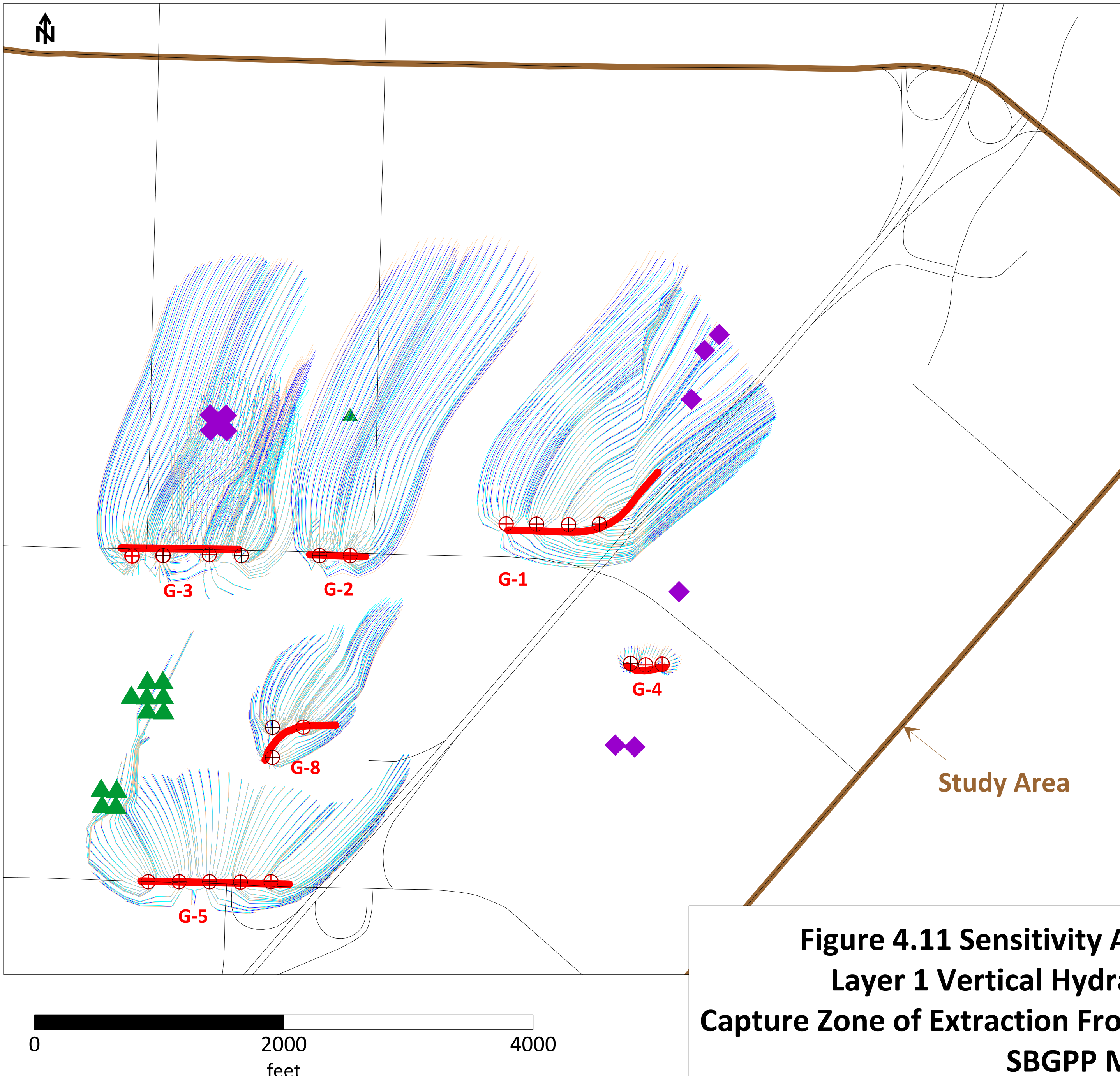
Figure 4.10 Sensitivity Analysis Simulation Layer 3, Horizontal Hydraulic Conductivity Capture Zone of Extraction From G-6 and G-7 SBGPP Model

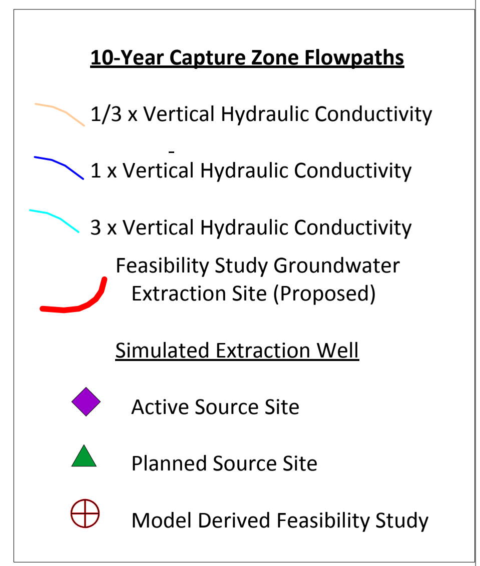
ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Engineering Analytics, Inc.

SBGPP_SourceSiteLocations.srf (06/11/21)

Project No. 151099





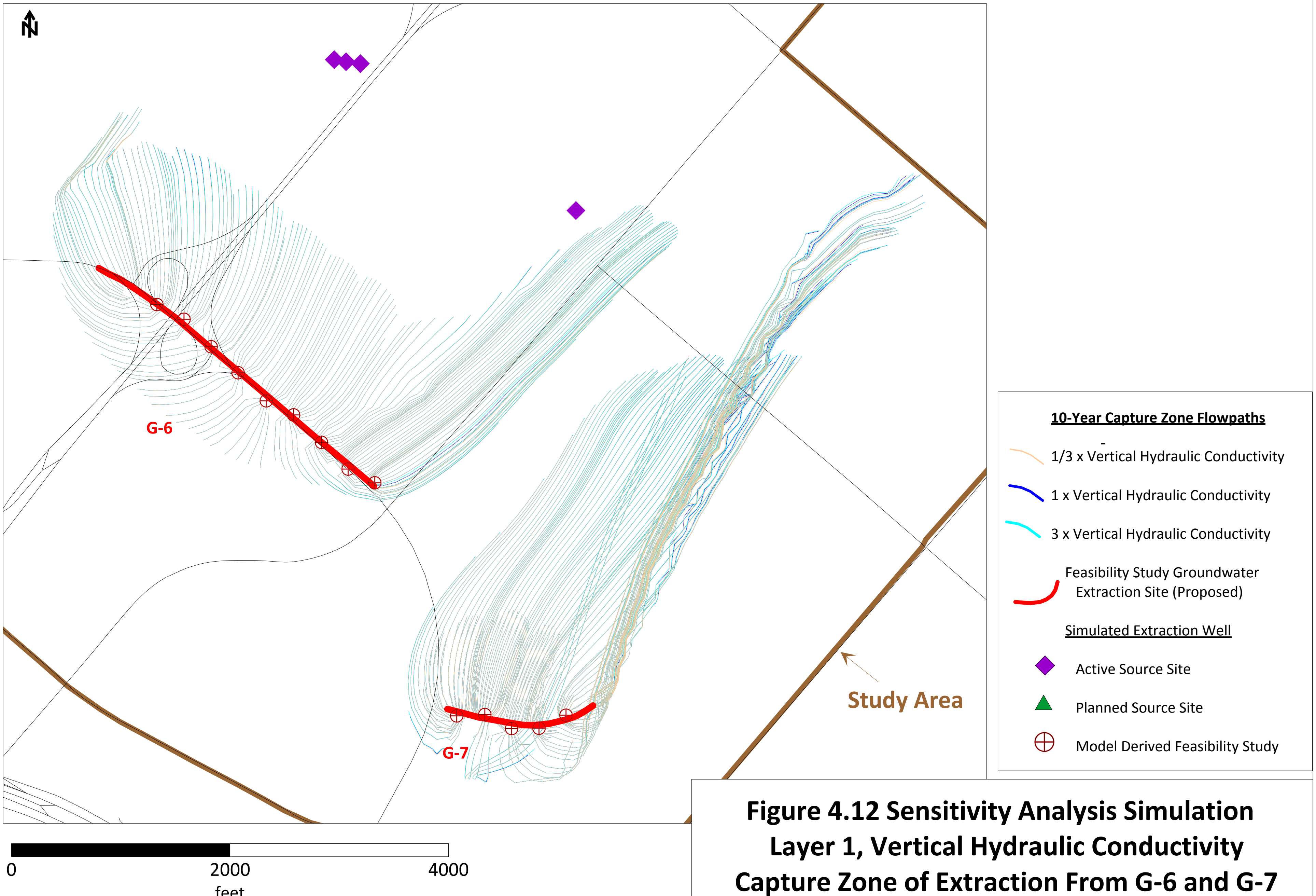
SBGPP_SourceSiteLocations.srf (06/11/21)

Engineering Analytics, Inc.

Figure 4.11 Sensitivity Analysis Simulation
Layer 1 Vertical Hydraulic Conductivity
Capture Zone of Extraction From G-1 through G-5 and G-8
SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



Engineering Analytics, Inc.

SBGPP_SourceSiteLocations.srf (06/11/21)

Figure 4.12 Sensitivity Analysis Simulation Layer 1, Vertical Hydraulic Conductivity Capture Zone of Extraction From G-6 and G-7 SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

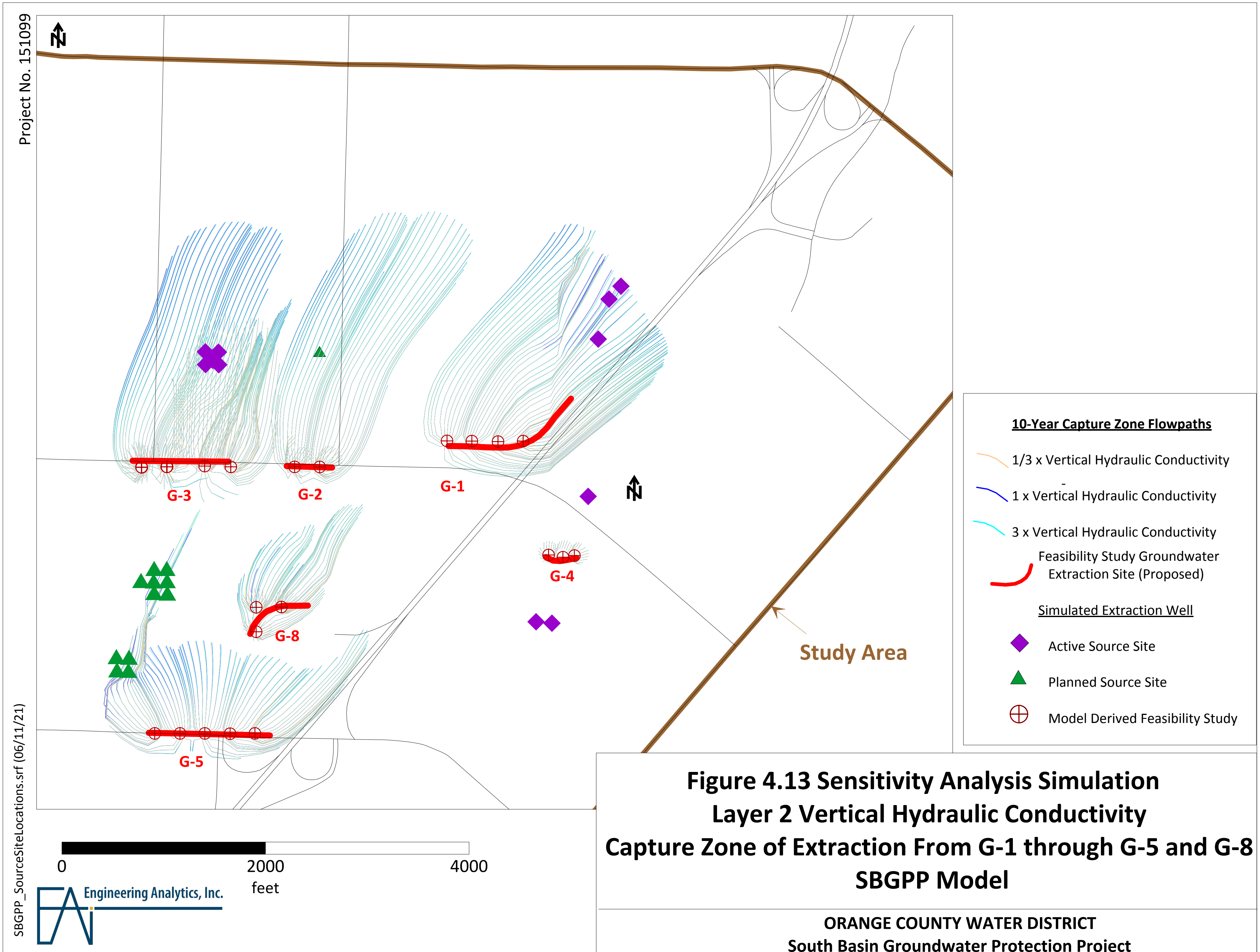
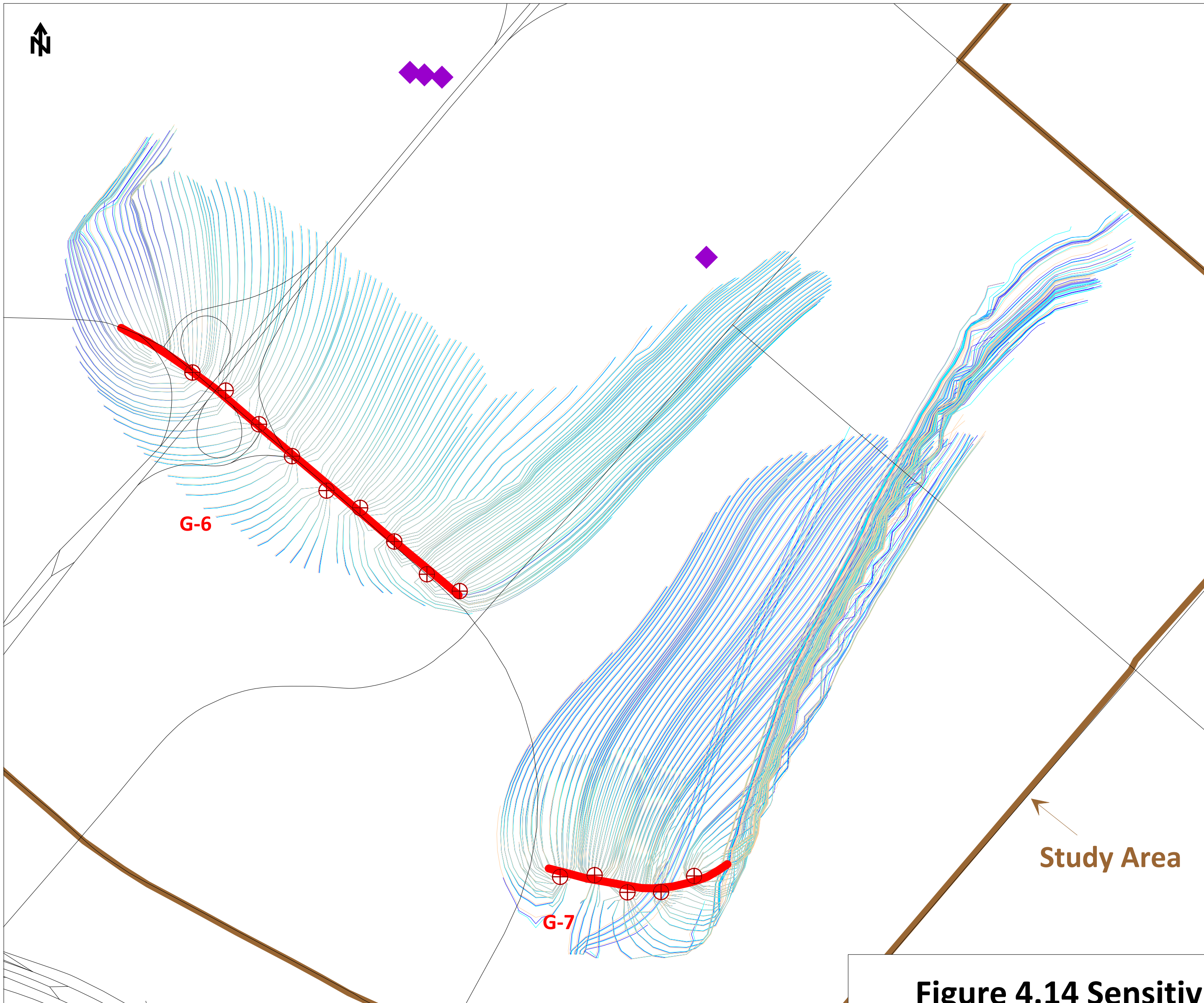


Figure 4.13 Sensitivity Analysis Simulation
Layer 2 Vertical Hydraulic Conductivity
Capture Zone of Extraction From G-1 through G-5 and G-8
SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



10-Year Capture Zone Flowpaths

- 1/3 x Vertical Hydraulic Conductivity
- 1 x Vertical Hydraulic Conductivity
- 3 x Vertical Hydraulic Conductivity
- Feasibility Study Groundwater Extraction Site (Proposed)

Simulated Extraction Well

- Active Source Site
- Planned Source Site
- Model Derived Feasibility Study

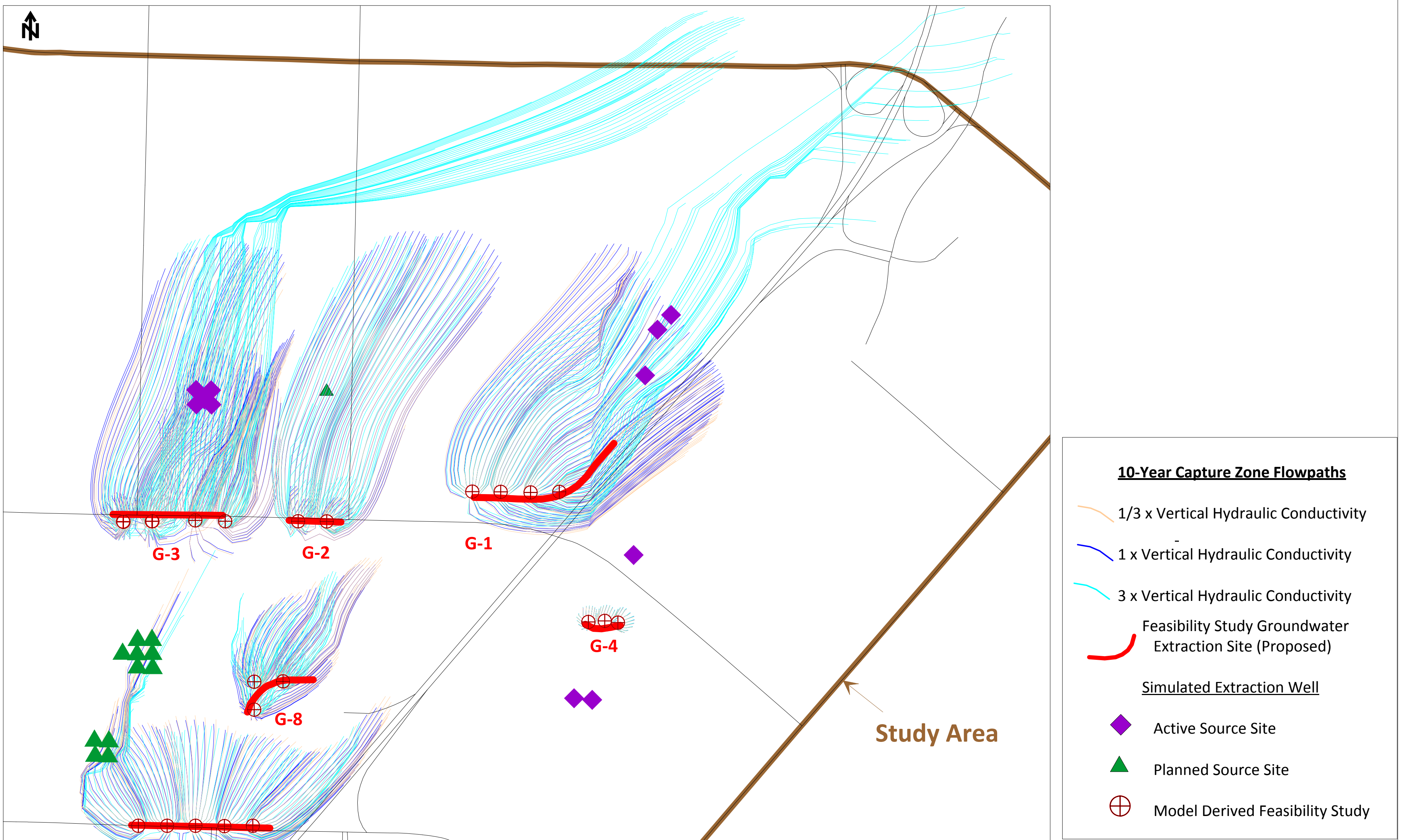
0 2000 4000
feet

Engineering Analytics, Inc.

SBGPP_SourceSiteLocations.srf (06/11/21)

Figure 4.14 Sensitivity Analysis Simulation Layer 2, Vertical Hydraulic Conductivity Capture Zone of Extraction From G-6 and G-7 SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project



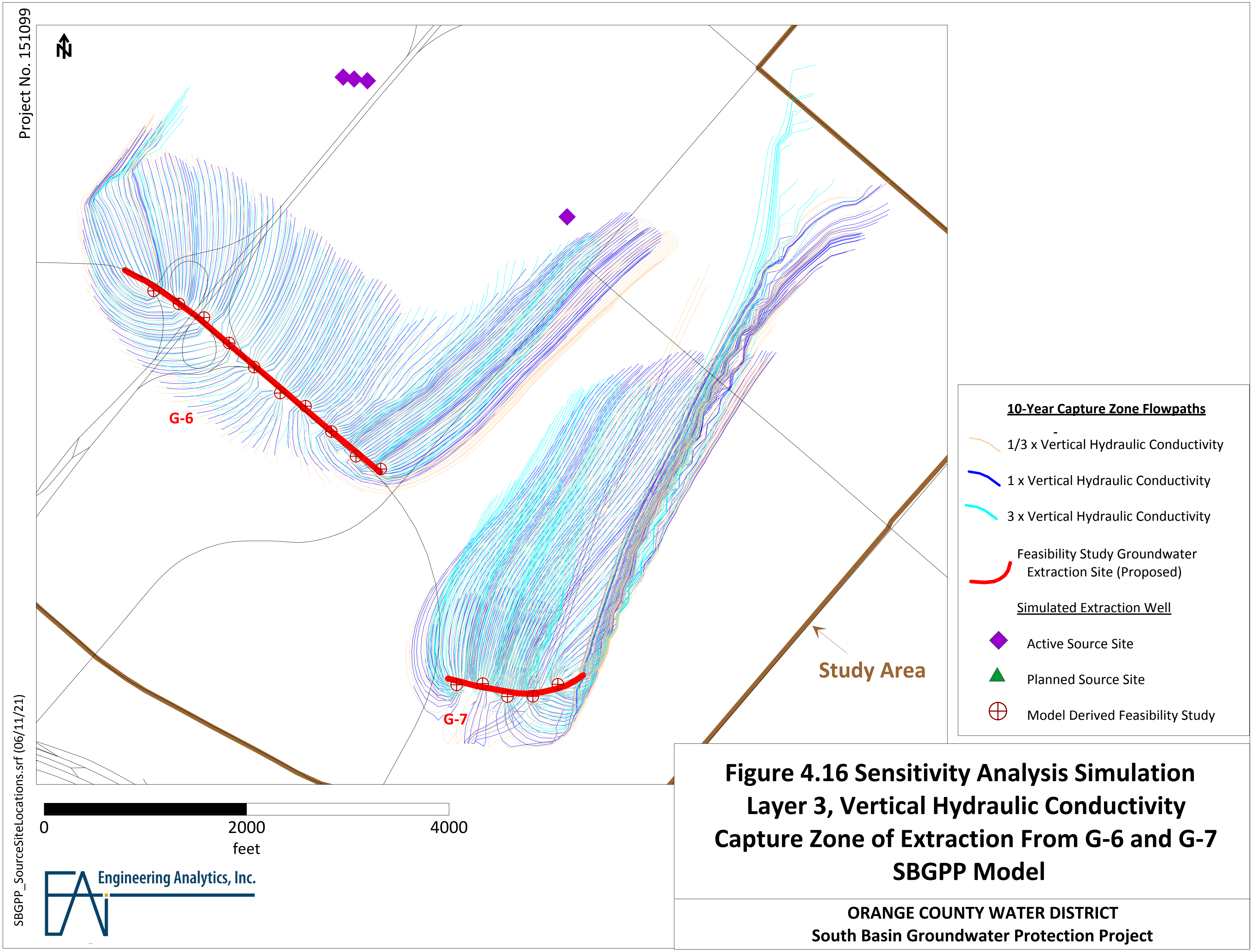
Project No. 151099

SBGPP_SourceSiteLocations.srf (06/11/21)

Engineering Analytics, Inc.

Figure 4.15 Sensitivity Analysis Simulation
Layer 3 Vertical Hydraulic Conductivity
Capture Zone of Extraction From G-1 through G-5 and G-8
SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project



Engineering Analytics, Inc.

Figure 4.16 Sensitivity Analysis Simulation Layer 3, Vertical Hydraulic Conductivity Capture Zone of Extraction From G-6 and G-7 SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

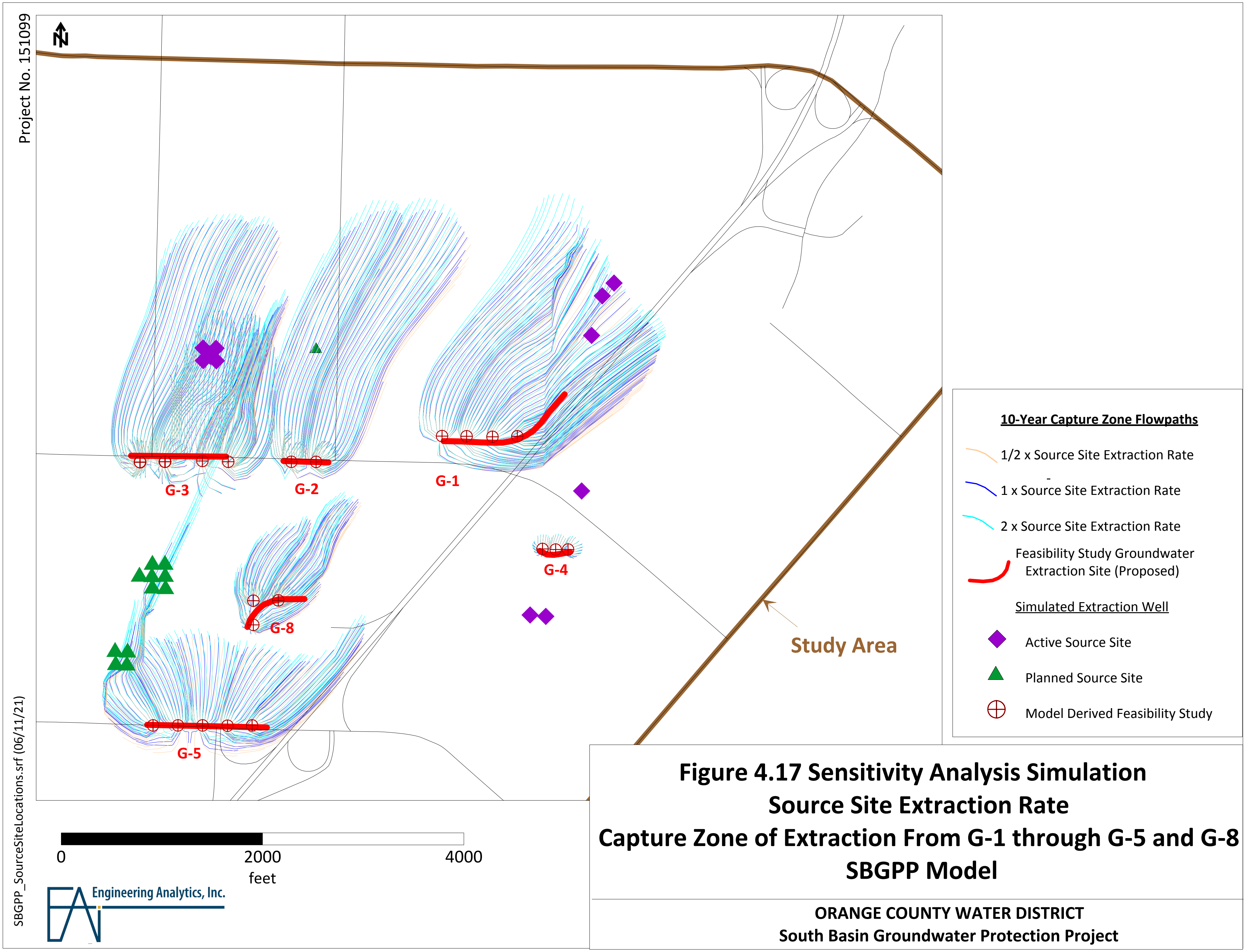
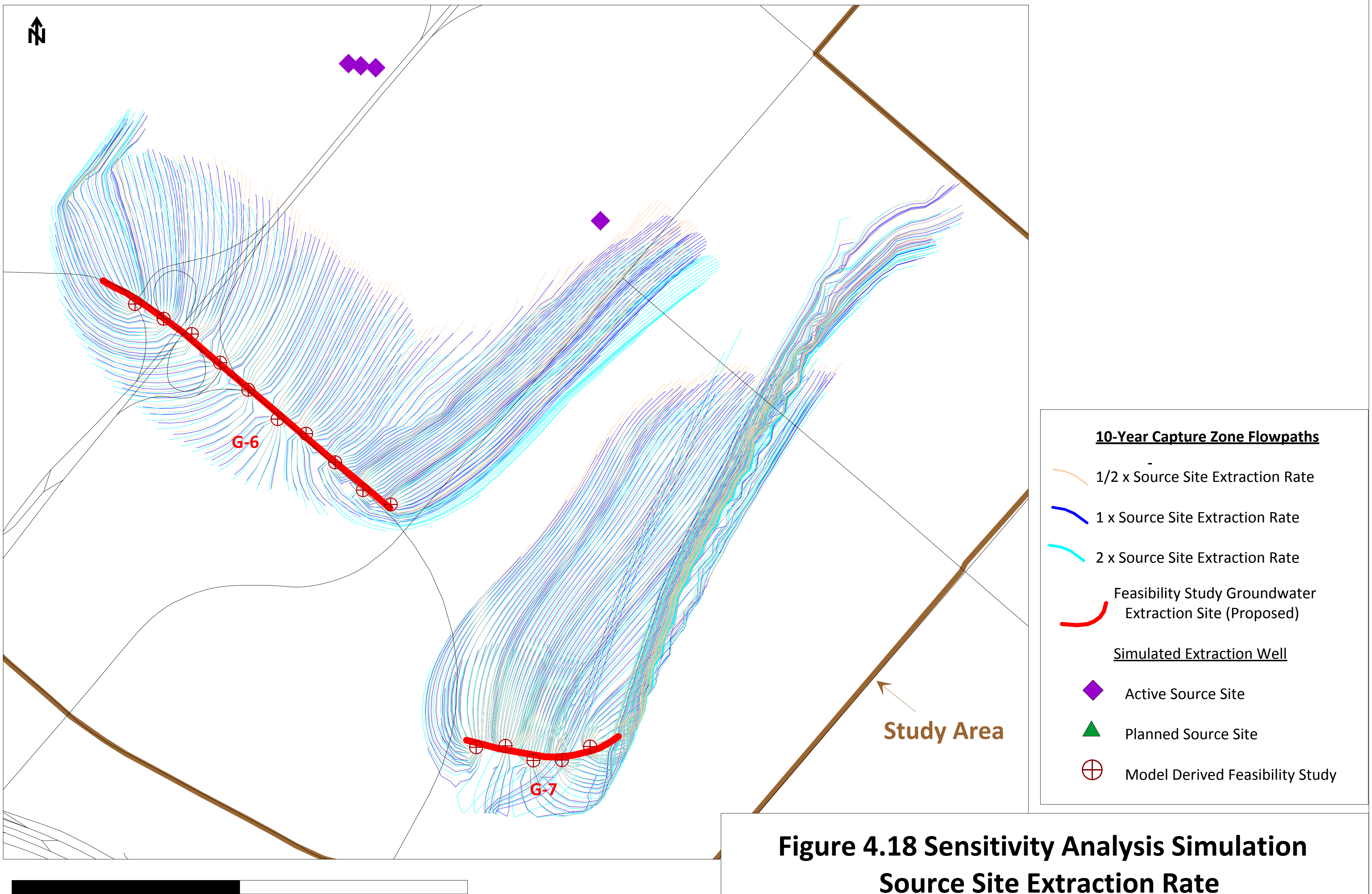


Figure 4.17 Sensitivity Analysis Simulation Source Site Extraction Rate Capture Zone of Extraction From G-1 through G-5 and G-8 SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



Engineering Analytics, Inc.

SBGPP_SourceSiteLocations.srf (06/11/21)

Figure 4.18 Sensitivity Analysis Simulation
Source Site Extraction Rate
Capture Zone of Extraction From G-6 and G-7
SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

ATTACHMENT A
MODEL INPUT AND OUTPUT FILES –
REMEDIAL SIMULATIONS
(PORTABLE EXTERNAL HARD DRIVE)

APPENDIX F
SOURCE SITE HYDROSTRATIGRAPHIC UNIT AND EXTRACTION RATE SUMMARY INFORMATION

Table F1. Summary of Allan Campbell Trust Source Site-Specific Hydrostratigraphic Units Correlated with OU2 Model/Hydrostratigraphic Layers

OU2 Layer	Site-Specific HSU[a]	HSU top feet bgs	HSU bot feet bgs	HSU top feet MSL	HSU bot feet MSL	HSU vertical depth range (feet bls)	Extraction/DPE wells	EW screen interval (feet bls)	EW flow rate (gpm)	Basis of estimate	Ongoing or planned remedial activities[a]
L1	A-Zone: interbedded silt and clay with discontinuous silty sand, clayey sand and sand lenses from near the surface to depths of approximately 50 feet bgs;	0	50			0-50	4 DPE wells				This source site may consider application of dual-phased extraction (DPE) with electrical resistance heating (ERH) in the A-Zone (Layer 1), and application of groundwater extraction to contain contaminants in the B1(50)- Zone and B1(60)-Zone (Layer 2); considering potential application of 1) heat-enhanced DPE with Electrical Resistance Heating to vadose zone capillary fringe and 2) GET in B1-Zone groundwater "...to control residual on-Site and off-Site dissolved phase impacts in the B1-Zone during and after the implementation of the HE-DPE, as necessary." FS and focused RAP in preparation
L2	B1(50)-Zone: A seven to fourteen-foot thick permeable saturated sand unit is present at variable depths between approximately 46 to 63 feet bgs, depending on location;	46	63			46-63					
L2	un-named interbedded silt and sandy clay unit, with a thickness of between two and ten feet, is present at variable depths between approximately 49 to 65 feet bgs, depending on location;	49	65			49-65					
L2/L3	B1(60)-Zone: A three to eighteen-foot thick permeable saturated sand unit is present at variable depths between 58 to 76 feet bgs, depending on location.	58	76			58-76					

Notes:
a = From BEC Addendum Conceptual Site Model and Remedial Completion Decision Analysis Report, October 23, 2020
bls = below land surface
bot = bottom
DPE = Dual-phase extraction
EW = Extraction well
gpm = gallons per minute
HSU = Site-specific hydrostratigraphic unit
MSL = Mean sea level

Table F2. Summary of Astech Source Site-Specific Hydrostratigraphic Units Correlated with OU2 Model/Hydrostratigraphic Layers

OU2 Layer	Site-Specific HSU[a]	HSU top feet bgs	HSU bot feet bgs	HSU top feet MSL	HSU bot feet MSL	HSU vertical depth range (feet bls)	Extraction/ DPE wells	EW screen interval (feet bls)	EW flow rate (gpm)[b]	Basis of estimate[a]	Ongoing or planned remedial activities[a]
L1	A Zone: The uppermost water-bearing zone at the Site has been designated as the A-zone and extends from approximately 10 to 30 feet below ground level (bgl). The A-zone is a heterogeneous mixture of silt, clay and silty sand.	10	25			10-25	EX-1, EX-2 and extraction trench	EX-1: 10-25; EX-2: 29.5-44.5	total system flow rate: 1-6.5 gpm	Average extraction rate July 2, 2020 through December 31, 2020 (2 EWs and trench extraction) was 3.5 gpm	Groundwater extractio and treatment using EWs and a shallow extraction trench
L2	B Zone: A Zone is separated from the sands of the underlying B-zone (approximately 35 to 45 feet bgl) beneath portions of the Site by a layer of silty clay.	35	45			35-45					

Notes:
a = From Worley Semi-Annual Groundwater Monitoring Report and Site Remediation Status Report, July through December 2020. 03-15-21
bls = Below land surface
bot = bottom
DPE = Dual-phase extraction
EW = Extraction well
gpm = Gallons per minute
HSU = Site-specific hydrostratigraphic unit
MSL = Mean sea level

Table F3. Summary of Baxter Healhcare Source Site-Specific Hydrostratigraphic Units Correlated with OU2 Model/Hydrostratigraphic Layers

OU2 Layer	Site-Specific HSU[a]	HSU top feet bgs	HSU bot feet bgs	HSU top feet MSL	HSU bot feet MSL	HSU vertical depth range (feet bls)	Extraction/ DPE wells	EW screen interval (feet bls)	EW flow rate (gpm)	Basis of Estimate	Ongoing or planned remedial activities[b,c]
L1	shallow semi-confining zone that occurs between the ground surface and approximately 20 feet bgs consists predominantly of interbedded low permeability clay and silt.	0	20			0-20					This source site has implemented ISCO using persulfate in the “underlying sand-dominated zone…” (Layer 2) (Arcadis, 2015) and is planning the perform additional ISCO using activated persulfate into the intervals 28 to 38 feet bgs (Layer 1) and 40 to 50 feet bgs (Layer 2) on-property (BBJ Group, 2020; RWQCB, 2020b).
L2/L3	an underlying sand-dominated zone that occurs from approximately 20 feet bgs to the deepest zone investigated to date (i.e., approximately 75 feet bgs) consists predominantly of more permeable clayey and silty sand and well-sorted and/or gravelly sand.	20	70			20-70					

Notes:

a = From Arcadis Updated Conceptual Site Model and Groundwater Remedial Action Plan, February 9, 2015

b = BBJ Group, 2020. Report of Waste Discharge and Standard Form 200, Baxter Healthcare Corporation. February 28, 2020.

c = California Regional Water Quality Control Board (RWQCB), 2020b. Discharge Authorization and Monitoring & Reporting Program No. R8-2018-0092-0017 for Implementation of a Pilot-Scale In-Situ Chemical Oxidation Study at baxter Healthcare Corporation, I.V., Systems Division; 17511 Armstrong Avenue, Irvine, California (Global Id# SL188053851; PCA# 1880500). July 16, 2020.

bls = below land surface

bot = bottom

DPE = Dual-phase extraction

EW = Extraction well

gpm = gallons per minute

HSU = Site-specific hydrostratigraphic unit

MSL = Mean sea level

Table F4. Summary of Bell Industries Source Site-Specific Hydrostratigraphic Units Correlated with OU2 Model/Hydrostratigraphic Layers

OU2 Layer	Site-Specific HSU[a]	HSU top feet bgs	HSU bot feet bgs	HSU top feet MSL	HSU bot feet MSL	HSU vertical depth range (feet bls)	Extraction/ DPE wells	EW screen interval (feet bls)	EW flow rate (gpm)	Basis of estimate	Ongoing or planned remedial activities[a,b]
L1	Local Shallow Zone: with the exception of a one to three-foot thick sand/silty sand layer at 30 to 32 feet bgs, the local shallow zone primarily consists of soils ranging from sandy silt to clayey silt.	20	40			20-40		MW-23: 25-40	4.1	Operating extraction wells[b]	This source site is implementing off-property groundwater extraction and treatment using groundwater extraction wells (Atlas Environmental Engineering, Inc., 2021). Groundwater is extracted from the Local Shallow Zone (Layer 1), the Local Intermediate Zone (Layer 2), and the Local Deep Zone (Layer 2/3).
L2	Local Intermediate Zone primarily consists of sand and silty sand, with the exception of a two to five-foot thick finer-grained sequence, consisting of interbedded sand, silt, and clay, present from approximately 52 to 56 feet bgs	45	65			45-65		GWX-6: 57.5-67.5	8.7		
L2/L3	Local Deep Zone: a fine-grained sequence of interbedded silt, clay, and sand was encountered from approximately 70 to 90 feet bgs. In the vicinity of well cluster MW-25, the fine-grained sequence was not encountered, indicating that the intermediate zone and deep zone may merge to the south.	70	100			70-100		MW-25C: 68-83	8.6		

Notes:
a = From URS Revised Remedial Action Plan 02-04-2008
b = Atlas Environmental Engineering, Inc., 2021. Former Bell Industries, Inc., 1831 Ritchey Street, Santa Ana, California, Semi-Annual Status Report, 4th Quarter 2020, SARWQCB Case #SLT8r1104088. March 30, 2021.
bls = Below land surface
bot = bottom
DPE = dual-phase extraction
EW = Extraction well
gpm = Gallons per minute
HSU = Site-specific hydrostratigraphic unit
MSL = Mean sea level

Table F5. Summary of Cherry Aerospace/Textron Source Site-Specific Hydrostratigraphic Units Correlated with OU2 Model/Hydrostratigraphic Layers

OU2 Layer	Site-Specific HSU[a]	HSU top feet bgs	HSU bot feet bgs	HSU top feet MSL	HSU bot feet MSL	HSU vertical depth range (feet bls)	Extraction/DPE wells	EW screen interval (feet bls)	EW flow rate (gpm)	Basis of estimate	Ongoing or planned remedial activities[a]
L1	Shallow (Upper) Zone	0	35			0-35	1 existing Shallow Upper Zone & 2 planned Shallow Upper Zone; 8 sand A (2 off-site); and 4 Sand B (off-site) Ews	0-35	Anticpated 0.5 gpm/well for Shallow Upper Zone EWs and 1-2 gpm/well anticipated for Sand A and Sand B EWs	modeling planned extraction wells[b]	This source site is implementing and plans on expanding groundwater extraction and treatment using DPE wells and groundwater extraction wells (CDM Smith, 2020). Groundwater is to be extracted from the Shallow (Upper) Zone (Layer 1), from Sand A (Layer 2) and from Sand B (Layers 2 and 3).
L2	First Sand Aquifer (Sand A)	35	55			35-55		35-55	0.25 - 8	constant rate and step aquifer testing	
L2/L3	Second Sand Aquifer (Sand B)	55	70			55-70		55-70	5 - 20		

Notes:

a = From CDM Smith Interim Remedial Measures Work Plan 04-30-2015
b = From CDM Smith Interim Measure Design Implementation Workplan 10-16-2020
bls = Below land surface
bot = bottom
DPE = Dual-phase extraction
EW = Extraction well
gpm = Gallons per minute
HSU = Site-specific hydrostratigraphic unit
MSL = Mean sea level

Table F6. Summary of Diceon Source Site-Specific Hydrostratigraphic Units Correlated with OU2 Model/Hydrostratigraphic Layers

OU2 Layer	Site-Specific HSU[a]	HSU top feet bgs	HSU bot feet bgs	HSU top feet MSL	HSU bot feet MSL	HSU vertical depth range (feet bls)	Extraction/ DPE wells	EW screen interval (feet bls)	EW flow rate (gpm)	Basis of estimate	Ongoing or planned remedial activities[b]
L1	A-Zone sandy silts/silty clays in unsaturated clays/silts	3	21								This source site reportedly is planning to implement in-situ chemical reduction (ISCR) using S-MicroZVI, a sulfidated zero valent iron (ZVI), into the lower portion of HSU A-Zone (Layer 1), B-Zone (Layer 2) and the upper portion of the C- Zone (Layer 2/3) using direct-push injection methods along an on-property alignment in the southern-central portion of and off-property alignment immediately south of the former Diceon property (see Figure 16 from Black Rock Geosciences, 2021).
	B-Zone silty fine sand w silt and clay layers	31	45								
L2	C-Zone fine to medium sands	48	>60								

Notes:

a = From Black Rock Geosciences Supplemental Off-Site Groundwater Investigaton October 2015
b = Black Rock Geosciences, 2021. Draft Interim Remedial Action Plan, Former Diceon Electronics, Inc., Facility. Revised March 2021.
bls = Below land surface
bot = bottom
DPE = Dual-phase extraction
EW = Extraction well
gpm = Gallons per minute
HSU = Site-specific hydrostratigraphic unit
MSL = Mean sea level

Table F7. Summary of Embee Source Site-Specific Hydrostratigraphic Units Correlated with OU2 Model/Hydrostratigraphic Layers

OU2 Layer	Site-Specific HSU[a]	HSU top feet bgs	HSU bot feet bgs	HSU top feet MSL	HSU bot feet MSL	HSU vertical depth range (feet bls)	Extraction /DPE wells	EW screen interval (feet bls)	EW flow rate (gpm)	Basis of estimate	Ongoing or planned remedial activities[b]
L1	A-Zone silts and clays with sandy interbeds that increase in frequency toward the base of the zone. The sandy interbeds appear to be laterally discontinuous.	10	48								This source site is implementing in-situ remediation by injecting/recirculating emulsified vegetable oil, sodium lactate, bicarbonate, surfactant, microbial nutrients, and calcium polysulfide into the A-Zone (Layer 1) and the C-Zone (Layer 2) (Stantec, 2020).
L2	C-Zone generally has thicker and more laterally continuous sandy beds (compared w/ A-Zone)	40	70								

Notes:
a = Stantec Q4 2019 Status & 2019 Annual Report 03-02-20
b = Stantec, 2020. Second Quarter 2020 Waste Discharge Requirements Monitoring Report, Embee Processing, LLC, 2136 South Hathaway, Santa Ana, California. July 27, 2020.
bls = Below land surface
bot = bottom
DPE = Dual-phase extraction
EW = Extraction well
gpm = Gallons per minute
HSU = Site-specific hydrostratigraphic unit
MSL = Mean sea level

Table F8. Summary of Gallade Source Site-Specific Hydrostratigraphic Units Correlated with OU2 Model/Hydrostratigraphic Layers

OU2 Layer	Site-Specific HSU[a]	HSU top feet bgs	HSU bot feet bgs	HSU top feet MSL	HSU bot feet MSL	HSU vertical depth range (feet bls)	Extraction/ DPE wells	EW screen interval (feet bls)	EW flow rate (gpm)	Basis of estimate[b]	Ongoing or planned remedial activities[a,b]
L1	Shallow Zone primarily consists of silts and clays with minor amounts of silty sand at depths near 40 ft bgs.	0	40			0-40	MW-2, MW-3, E-6, E-6R; 16 DPE wells	15-35; 5-30		0.82 gpm total extraction average; MW-3@0.005 gpm (perched groundwater); E-6R@1-1.6 gpm; 1.4-2.4 gpm total system average 2018 through June 2019[a]	This source site is implementing groundwater extraction and treatment using DPE and groundwater extraction wells (Integral, 2020). Groundwater is extracted from Shallow Zone Groundwater (Layer 1) and from Deep A Zone Groundwater (Layer 2).
L2	Deep A Zone primarily consists of sand with varying amounts of silt and clay.	40	60			40-60	MW-24	45-55		MW-24: 0.6-1[b]	
	Deep B Zone primarily consists of silts and clays, with a uniform, fine to medium grained sand layer from 70 to 75 ft	60	80			60-80				none	

Notes:

a = From Integral Q1/Q2 2019 Semiannual GW Monitirng and Remediation Report 02-07-2020
b = From CDM Integral Evaluation of the Capture Zone of Gallade Chemical, Inc.'s Remediation System 09-12-2013
bls = Below land surface
bot = bottom
DPE = Dual-phase extraction
EW = Extraction well
gpm = Gallons per minute
HSU = Site-specific hydrostratigraphic unit
MSL = Mean sea level

Table F9. Summary of GE Source Site-Specific Hydrostratigraphic Units Correlated with OU2 Model/Hydrostratigraphic Layers

OU2 Layer	Site-Specific HSU[a]	HSU top feet bgs	HSU bot feet bgs	HSU top feet MSL	HSU bot feet MSL	HSU vertical depth range (feet bls)	Extraction/ DPE wells	EW screen interval (feet bls)	EW flow rate (gpm)	Basis of estimate	Ongoing or planned remedial activities[b,c,d, e, f]
L1	First Water-Bearing Zone: predominantly low-permeability clayey sediments with some interbedded silty layers.	0	26-36			0-36	ACDEX1 through ACDEX5; EX1 through EX6, EX3R, CEI6, and CEJ6	15-30; 20-30	0.14 to 1 for ACDEX wells	b	This source site has implemented and continues to implement on-property in-situ bioremediation using emulsified vegetable oil (EVO) and acetic acid-amended water and groundwater extraction and treatment using groundwater extraction wells in the First Water-Bearing Zone (Layer 1); and off-property in-situ bioremediation using perchlorate along biobarriers installed along Deere Avenue (First Water Bearing Zone) and Alton Parkway (Second Water-Bearing Zone (Amec, 2014; Amec Foster Wheeler, 2016; Wood, 2020 and 2021).
L2	slightly coarser fine- to very fine-grained sandy materials	42	58			42-58					

Notes:

a = From AMEC Updated Remedial Investigation Report 07-30-2010
b = From AMEC Performance Progress Report for Interim Remedial Measure. Novenber 27, 2013
c = Amec, 2014. Second Performance Progress Report for Interim Remedial Measure, Adjacent Property at 2321 South Pullman Street (ACD, LLC Property), Former LNP Site. July 16, 2014.
d = Amec Foster Wheeler, 2016. Second Addendum to the 2015 Off-Site Remedial Action Plan, Former LNP Site. 1831 East Carnegie Avenue, Santa Ana, California. April 1, 2016.
e = Wood, 2020. Summary of Second Quarter 2020 Groundwater Monitoring Activities, Former LNP Site. July 15, 2020.
f = Wood, 2021. Summary of Second Quarter 2021 Groundwater Monitoring Activities, Former LNP Site. July 14, 2021.
bls = Below land surface
bot = bottom
DPE = Dual-phase extraction
EW = Extraction well
gpm = Gallons per minute
HSU = Site-specific hydrostratigraphic unit
MSL = Mean sea level

Table F10. Summary of ITT Cannon Source Site-Specific Hydrostratigraphic Units Correlated with OU2 Model/Hydrostratigraphic Layers

OU2 Layer	Site-Specific HSU[a]	HSU top feet bgs	HSU bot feet bgs	HSU top feet MSL	HSU bot feet MSL	HSU vertical depth range (feet bls)	Extraction wells	EW screen interval (feet bls)	EW flow rate (gpm)	Basis of estimate[a]	Ongoing or planned remedial activities[b, c]
L1	Shallow Unit - relatively low-permeability clays and silts from grade to approximately 25 ft bgs.	0	25			0-25					
L2	Intermediate Unit - relatively higher permeability sands from approximately 25 to 65 ft bgs, separated by an approximately 5- to 10-foot-thick lens of lower permeability silt and clay from approximately 40 to 50 ft bgs. The upper portion of the Intermediate Unit is referred to as Sand A, and the lower portion is referred to as Sand B.	25	65			25-65	RW-1, RW-2 & RW-3	RW-1: 32-62; RW-2: 30-60; RW-3: 30-60	RW-1: 8 gpm; RW-2: 5 gpm; RW-3: 32 gpm	Operating extraction wells[a]	This source site is implementing near off-property groundwater extraction and treatment using groundwater extraction wells (Arcadis, 2020). Groundwater is extracted from the Intermediate Unit, which is further subdivided into Sand A (Layer 2) and Sand B (Layer 2); and has implemented and reportedly plans to implement additional far off-property ISB (Arcadis, 2020; RWQCB, 2021).
L3	Deep Unit - relatively low-permeability clays and silts from approximately 65 to at least 85 ft bgs.	65	85			65-85					

Notes:

a = From Semiannual Groundwater Monitoring Report, First and Second Quarters 2020 08-13-2020
b = Arcadis, 2020. Semiannual Groundwater Monitoring Report, Third and Fourth Quarters 2019, ITT LLC Dyer Road Property, 666 East Dyer Road, Santa Ana, California. March 27, 2020.
c = 25, 2021.
bls = Below land surface
bot = bottom
EW = Extraction well
gpm = Gallons per minute
HSU = Site-specific hydrostratigraphic unit
MSL = Mean sea level

Table F11. Summary of Ricoh Source Site-Specific Hydrostratigraphic Units Correlated with OU2 Model/Hydrostratigraphic Layers

OU2 Layer	Site-Specific HSU[a]	HSU top feet bgs	HSU bot feet bgs	HSU top feet MSL	HSU bot feet MSL	HSU vertical depth range (feet bls)	Extraction/ DPE wells	EW screen interval (feet bls)	In-situ injection (ISCO) flow rate (gpm)[b]	Basis of estimate	Ongoing or planned remedial activities[a,c]
L1/L2	Upper Zone is from approximately 10 to 50 ft bgs. Groundwater in this zone is semiconfined ("leaky") to confined. Fine-grained soils from ground surface to 20-25 ft bgs act as a confining layer, while permeable sands below 25 ft bgs act as the principal groundwater zone.	0	50						ranged from approximately 1.8 to 8.8 gpm: pressures approximately 20 to 80 psi	documented ISCO in-situ injections	This source site has implemented ISCO using potassium permanganate (Wayne Perry, Inc., 2010) and reportedly planned to implement enhanced ISB pilot testing using lactate (Wayne Perry, Inc., 2019). The previous and planned injections were/will be into the Upper Zone (Layer 1 and Layer 2) and into the Lower Zone (Layer 3) on-property.
L3	Lower Zone below 50 ft bgs and is currently accessed by one well screened from 57 to 62 ft bgs (Well RMW-10).	57	62								

Notes:

a = From Wayne Perry from WORKPLAN FOR IN SITU BIOREMEDATION PILOT STUDY 10-05-2018
b = From Wayne Perry Remedial Action Report, December 28, 2010
c = Wayne Perry, Inc., 2019. Application/Report of Waste Discharge Permit for In-Situ Bioremediation Pilot Test, Former Ricoh Electronics Facility 17482 Pullman Avenue Irvine, California. March 15, 2019.
bls = Below land surface
bot = bottom
DPE = Dual-phase extraction
EW = Extraction well
gpm = Gallons per minute
HSU = Site-specific hydrostratigraphic unit
MSL = Mean sea level

Table F12. Summary of Soco West/Holchem Source Site-Specific Hydrostratigraphic Units Correlated with OU2 Model/Hydrostratigraphic Layers

OU2 Layer	Site-Specific HSU[a]	HSU top feet bgs	HSU bot feet bgs	HSU top feet MSL	HSU bot feet MSL	HSU vertical depth range (feet bls)	Extraction/ DPE wells	EW screen interval (feet bls)	EW flow rate (gpm)	Basis of estimate	Ongoing or planned remedial activities[a]
L1	HSU 1 – Sandy silts and silty/clayey silts located approximately 65 to 55 feet above mean sea level (ft amsl), corresponding to depths of 0 to 10 feet below ground surface (ft bgs). This unit is not present south of East Warner Drive;	0	10	65	55						
	HSU 2 – Low permeability silts and clays with sandy silt lenses located approximately 55 to 15 ft amsl, corresponding to depths of 10 to 50 ft bgs;	10	50	55	15						
L2	HSU 3 – High permeability sands, silts, and clays located approximately 15 to -10 ft amsl, corresponding to depths of 50 to 70 ft bgs. HSU 3 is the primary downgradient transport pathway for solutes, and groundwater flow in HSU 3 is generally due south;	50	70	15	-10						This source site reportedly is planning to implement enhanced in-situ bioremediation (EISB) into HSU 3 (Layer 2) using injection wells and a permeable reactive barrier (PRB) (Geosyntec Consultants, 2015).
L3	HSU 4 – Low permeability silts and clays located approximately 0 to -50 ft amsl, corresponding to depths of approximately 70 to 120 ft bgs. HSU 4 "appears to be acting as a competent aquitard" (ARCADIS, 2009); and	70	120	0	-50						
L4	HSU 5 – High permeability sand and gravelly sand located approximately -50 to ≥ -72 ft amsl.	120	>142	-50	>-72						

Notes:

a = From Geosyntec FS & RAP 07-14-2015
bls = Below land surface
bot = bottom
EW = Extraction well
gpm = Gallons per minute
HSU = Site-specific hydrostratigraphic unit
MSL = Mean sea level

Table F13. Summary of Steelcase Source Site-Specific Hydrostratigraphic Units Correlated with OU2 Model/Hydrostratigraphic Layers

OU2 Layer	Site-Specific HSU[a]	HSU top feet bgs	HSU bot feet bgs	HSU top feet MSL	HSU bot feet MSL	HSU vertical depth range (feet bls)	Extraction wells	EW screen interval (feet bls)	EW flow rate (gpm)	Basis of estimate	Ongoing or planned remedial activities[a]
	Zone A a series of thin sand to silty-sand interconnected lenses with a thickness ranging from approximately 0.5 and 7.5 feet. These lenses were observed between 6 and 25 feet bgs.	0	25	65	55	0-25					This source site has implemented and continues to implement groundwater extraction and treatment using groundwater extraction wells in Zone B (Layer 1) on the source site property (ERM, 2020).
L1	Unnamed layer between Zone A and Zone B: primarily silt and clay in the southern and northern areas, respectively. This less permeable intervening aquitard contains isolated thin, laterally restricted, silty-sand to sandy-silt lenses, generally 2 to 3 feet thick. The most laterally extensive, more permeable lenses (showing an increase in sand content) have been termed the B-minus zone. The B-minus zone was observed in 12 of the 21 cone penetration testing (CPT) and boring locations drilled prior to 2012, varying in thickness from 0 to 6.0 feet (average of 1.7 feet) and occurring primarily between 35 and 39 feet bgs. The B-minus zone is not laterally continuous or sufficiently permeable to warrant focus as a separate permeable zone. Where present and reasonably connected with Zone B, the B-minus zone is considered a vertical extension of Zone B.primarily silt and clay in the southern and northern areas, respectively. This less permeable intervening aquitard contains isolated thin, laterally restricted, silty-sand to sandy-silt lenses, generally 2 to 3 feet thick. The most laterally extensive, more permeable lenses (showing an increase in sand content) have been termed the B-minus zone. The B-minus zone was observed in 12 of the 21 cone penetration testing (CPT) and boring locations drilled prior to 2012, varying in thickness from 0 to 6.0 feet (average of 1.7 feet) and occurring primarily between 35 and 39 feet bgs. The B-minus zone is not laterally continuous or sufficiently permeable to warrant focus as a separate permeable zone. Where present and reasonably connected with Zone B, the B-minus zone is considered a vertical extension of Zone B.	25	39	55	15	25-39					
L1	Zone B is comprised of sand to silty-sand to clayey-sand layers with a thickness ranging from approximately 3 to 15 feet in the southern portion of the site. The top of this zone lies 33 to 40 feet bgs and the bottom of the zone lies 45 to 48 feet bgs. In the northern portion of the site, Zone B appears to possibly thicken. The top of Zone B in the area also lies approximately 48 feet bgs; the bottom of the zone extends beyond the maximum depth explored.	~40	~60			40-60	MW-22B & MW-23B	MW-22B: 45-55; MW-23B: 38-53	MW-22B: 4.0; MW-23B: 8.5	Operating extraction wells[a]	
L1/L2	Unnamed layer between Zone B and Zone C primarily silt and clay layer below Zone B and above the next significant permeable groundwater zone (Zone C) has an observed thickness ranging from approximately 14.8 to 25.2 feet (average thickness of 19.2 feet).	~50	~70			50-70					

Table F13. Summary of Steelcase Source Site-Specific Hydrostratigraphic Units Correlated with OU2 Model/Hydrostratigraphic Layers

OU2 Layer	Site-Specific HSU[a]	HSU top feet bgs	HSU bot feet bgs	HSU top feet MSL	HSU bot feet MSL	HSU vertical depth range (feet bls)	Extraction wells	EW screen interval (feet bls)	EW flow rate (gpm)	Basis of estimate	Ongoing or planned remedial activities[a]
L2	Zone C is the third laterally consistent permeable groundwater zone with an observed thickness ranging from 6.3 and 8.3 feet (average thickness of 6.9 feet). The top of Zone C occurs between 68.6 to 72.5 feet bgs; the bottom of Zone C occurs between 75.5 to 79.4 feet bgs.	~70	~76			70-76					
L3	Unnamed layer between Zone C and Zone D silt and clay layer below Zone C and above the next permeable zone (Zone D) has an observed thickness ranging from approximately 10.2 to 11.8 feet (average thickness of 11.2 feet)	~75	~85			75-85					
L3	The last known laterally consistent permeable groundwater zone underlying the site is Zone D, which has an observed thickness ranging from 1.3 to 4.3 feet (average thickness of 3.0 feet). The top of Zone D occurs between 86.3 to 90.2 feet bgs; the bottom of this zone occurs between 88.6 to 94.5 feet bgs. The presence of Zone D beneath the site is based on the E2 CPT investigation (see Attachments A and B). Below Zone D to 100 feet bgs (the maximum depth of previous investigations), site geology primarily consists of silt and clay.	~88	~93			88-93					

Notes:
a = From ERM Annual Report 2019, July 2020
bls = Below land surface
EW = Extraction well
gpm = Gallons per minute
HSU = Site-specific hydrostratigraphic unit
MSL = Mean sea level

Table F14. Summary of Troy Computer Source Site-Specific Hydrostratigraphic Units Correlated with OU2 Model/Hydrostratigraphic Layers

OU2 Layer	Site-Specific HSU	HSU top feet bgs	HSU bot feet bgs	HSU top feet MSL	HSU bot feet MSL	HSU vertical depth range (feet bls)	Extraction/ DPE wells	EW screen interval (feet bls)	In-situ injection (ISCO) flow rate (gpm)[b]	Basis of estimate	Ongoing or planned remedial activities[a,b]
L1/L2											This source site has implemented EISB using HRC and 3DMe (Bryant Geoenvironmental, Inc., 2010) and reportedly is planning to perform ISCO using activated PersulfOx and ISB using 3DMe+CRS+BDI emplaced using a horizontal well targeting a treatment zone from 17 to 25 feet bgs (Layer 1) on the source site property (Regenesis, 2017).

Notes:
a = Regenesis Proposal No. CrS56989, May 23, 2017
b = Bryant Geoenvironmental, Inc. Project Status, Corrective Action Plan - Groundwater Remediation, May 10,2010
bls = Below land surface
DPE = Dual-phase extraction
EW = Extraction well
HSU = hydrostratigraphic unit
MSL = Mean sea level

APPENDIX G
SUMMARY OF DATA GAPS FOR THE SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT – ORANGE COUNTY SOUTH BASIN GROUNDWATER PROTECTION PROJECT, OPERABLE UNIT 2 (GRANT AGREEMENT NO. D1712505)

Santa Ana Regional Water Quality Control Board

November 21, 2019

Mr. David Bolin
Principal Hydrogeologist
Orange County Water District
18700 Ward Street
Fountain Valley, CA 92708
(DBolin@ocwd.com)

SUMMARY OF DATA GAPS FOR THE SUPPLEMENTAL REMEDIAL INVESTIGATION REPORT - ORANGE COUNTY SOUTH BASIN GROUNDWATER PROTECTION PROJECT, OPERABLE UNIT 2 (Grant Agreement No. D1712505)

Dear Mr. Bolin:

As previously discussed in our July 11, 2019 letter, the Supplemental Remedial Investigation Report (Report) dated April 25, 2019, did not identify if further investigation is necessary in the project area prior to the development of the Feasibility Study (FS). The Regional Board maintains that there are a number of areas where data is missing downgradient (or off-site) from sources of contamination and, at a public technical meeting to go over our comments to the Report, offered to summarize those for Hargis. Addressing these data gaps would improve the analysis of the Study Area (i.e. final Report and FS). In order for the Report and subsequent FS to be comprehensive, this data is necessary and should be evaluated. Given the ongoing litigation involving the Report and proposed remedies, this communication highlights areas where little to no investigation has occurred, by either Orange County Water District (OCWD) or Responsible Parties (RPs).

1. **Location and identification of historic production wells (i.e. municipal, domestic, industrial, agricultural, etc.):**
    a. Wells that may act as vertical conduits from the Shallow Aquifer into the Principal Aquifers remain a data gap. As previously discussed, the former production wells in the vicinity of the Study Area may continue to act as a primary mechanism for the transport of contaminants of concern (COCs) into the Principal Aquifer until they are properly assessed.

- **b.** If the identification of such wells is not feasible, the Report should include:
  - **i.** An analysis of all possible pathways into the Principal Aquifer and recommendations for future investigations that will support data-driven conclusions.
  - **ii.** Analysis of exceedances at IRWD-3, and an explanation of whether any actions by OCWD, or the RPs resulted in that well being placed back in service.
  - **iii.** Analysis of hydraulic gradients (communication) between the Shallow and Principal Aquifer throughout the project Study Area, with specific consideration near operational production wells.

2. **Bell Industries off-site**
   - **a.** Further delineation is needed vertically and laterally near MW-24 and 24C stepping out laterally to the west, and downgradient to the southwest.
   - **b.** Further delineation is needed vertically and laterally to the northwest and upgradient of the property near E St Andrew Place. There may be upgradient contributions from unidentified potentially responsible parties (PRPs).
   - **c.** Further delineation is needed vertically and laterally south of Bell Industries and adjacent to the 55 Freeway near CPT-15, 114, 17, and 111. Since 2012, no data has been collected, therefore, the extent of the comingled COC plume may have migrated beyond the contour boundary and may be impacting Sites south of the 55 Freeway.
3. **Engineering Plating off-site**
   - **a.** Further delineation is needed downgradient of the Site both vertically and laterally. There are potential future impacts to operational production well SA-26/1 and destroyed well W-14831. The influence of SA-26/1 operation (i.e. vertical downward gradient and lateral capture zone) and its influence on contaminant migration remains a data gap.
4. **Steelcase off-site**
   - **a.** Further delineation is needed north of the Site, located adjacent to 55 Freeway between Bell Avenue and Valencia Avenue. The upgradient and on-site monitoring well MW-29B (50-60 ft below ground surface [bgs]) has detectible concentrations of 1,1-Dichloroethylene (1,1-DCE) and 1,4-dioxane which may indicate plume comingling from upgradient sources.
5. **Holchem and Circuit One off-site**
   - **a.** Further delineation is needed vertically and laterally near CPT-100, 206, 104, and 180. This area is bounded to the west by Holchem/Embee Plating, to the south by E Warner Avenue, to the east by Circuit One, and to the north by Barlen Enterprises. There has been comingling of the plume in this area; however, no data has been obtained since 2012 to substantiate how the plume boundaries are currently defined for all COCs.
6. **Gallade Chemical off-site**
   - **a.** Further delineation is needed vertically and laterally to the north of the Site, upgradient of CPT-91 and E-7. Concentrations of Tetrachloroethylene (PCE) have been detected in well E-7 from 5-20 ft

bgs, which may indicate an upgradient source. In addition, no data has been collected from 0-31 ft bgs near CPT-91.

7. **Area Bounded by S. Grand Avenue, E. Warner Avenue and the 55 Freeway.**
    a. Since 2012, no data has been collected in the area near CPT-115, 116B, and 117, therefore, this area needs further delineation vertically and laterally. The upgradient contributions have not been fully defined for target COCs, especially for Trichloroethylene (TCE), 1,1-DCE and 1,4-dioxane. Therefore, the depicted plume boundaries may have merged and/or migrated vertically and laterally since its initial assessment.
8. **Cherry Aerospace off-site**
    a. CPT data has been collected in 2012 and 2015; however, no data has been collected since. Further delineation is needed both vertically and laterally for the following locations:
        i. West of Cherry Aerospace and north of SAM-4.
        ii. Southwest of Cherry Aerospace, west of IRWD-3.
    b. There are potential future impacts to operational production well IRWD-3 through abandoned/destroyed/inactive production wells (i.e. municipal, domestic, industrial, agricultural etc.). The influence of IRWD-3 operation is causing vertical downward gradient according to monitoring well SAM-4. Therefore, these production wells may be a continued migration pathway and remain a data gap.
9. **ITT Cannon off-site**
    a. Further delineation is needed vertically and laterally between SAM-5 and SAM-6, and near CPT-123, 124, and 190. Nearby monitoring wells MW-45B (44.3-59.3 ft bgs) and MW-17A/B (5-25 and 30-35 ft bgs) do not fully capture the shallow contamination from approximately 0-60 ft bgs and to a lesser extent do not capture the leading edge of the COCs plume from approximately 60 ft bgs-basal sand as depicted in the figures.
10. **Dyer Business Park off-site**
    a. Since 2012, no data has been collected southwest of Dyer Business Park and north of SAM-7, therefore, the extent of the comingled COC plume may have migrated beyond the contour boundary since the time the groundwater grab samples were obtained.
    b. In addition, data gaps exist in the vicinity of SAM-7. TCE concentrations in SAM-7A (39.5-49.5 ft bgs) have fluctuated from approximately 32.1 ug/l to 49 ug/L. No data exists from 0-39.5 ft bgs and step-out borings in all directions have not delineated nor identified an upgradient source/potential downgradient impacts.
11. **Intersection of 55 Freeway and East Dyer Road**
    a. Further delineation is needed vertically and laterally in the vicinity of SAM-6, CPT-168, CPT-171, and west of 7-MW-5.
        i. Approximatively 0-60 ft bgs:
            1. The eastern extent of the TCE and PCE plumes near CPT-171 have not been defined.
            2. The leading edge of the 1,1-DCE and 1,4-dioxane plume near CPT-168 has not been delineated. There is the potential for the 1,1-DCE and 1,4-dioxane plumes emanating

from the general areas of Holchem, Universal Circuits/Bell Industries and Steelcase to have comingled since the collection of water quality samples in 2012.

   - **ii.** Approximately 60 ft bgs-basal sand:
     1. The leading edge of the 1,1-DCE and 1,4-dioxane plume near CPT-168 has not been delineated. There is the potential for the 1,1-DCE and 1,4-dioxane plumes emanating from the general areas of Holchem, Universal Circuits/Bell Industries and Steelcase to have comingled since the collection of water quality samples in 2012.

12. Northeast of the intersection of Redhill Avenue and Deere Avenue

- **a.** Further delineation is needed vertically and laterally for all COCs to the northeast of SAM-11 and south of Barranca Pkwy. In addition, SAM-11A (47.5-52.5 ft bgs) does not provide water quality data from 0-47.5 ft bgs and remains a data gap.

13. West of the intersection of Redhill Avenue and Alton Parkway

- **a.** Further delineation is needed vertically and laterally for all COCs in between CPT-141 and CPT-186. This data gap is also related to item 11, above.

14. South of the intersection of Redhill Avenue and Gillette Avenue

- **a.** The eastern edge of the plume between Gillette Avenue and Armstrong Avenue (near SAM-10 and north of Baxter Healthcare) has not been delineated for all COCs. The Former Standard Screw Products Site (1712 Langley Avenue, Irvine, CA 92714) will provide some groundwater monitoring data; however, further delineation is necessary and this area remains a data gap.
- **b.** In addition, no data exists from 0-36.5 ft bgs in the vicinity of SAM-10A (36.5-46.5 ft bgs) and step-out borings have not delineated potential downgradient impacts. CPT-170 (18-22 and 27-31 ft bgs) had detectable concentrations of all COCs within this shallow zone.

15. South of the 55 Freeway and MacArthur Blvd

- **a.** The southern edge of the plume has not been fully delineated vertically and laterally and presents a data gap. Since 2012, no data has been collected south of the intersection of MacArthur and the 55 Freeway, therefore, the extent of the comingled COC plume may have migrated beyond the contour boundary since the time the groundwater grab samples were obtained. Data gaps exist at the leading edge of the plume near CPT-147, 148, 160, 159, and 157.
- **b.** In addition, SAM-8A is screened from 33-43 ft bgs and does not address shallow contamination from 0-33 ft bgs.

16. Baxter Healthcare and Edwards Lifesciences off-site

- **a.** Further delineation of the leading edge of the plume is needed vertically and laterally located to the west of MacArthur Blvd, bounded by Redhill Avenue and Main Street, and in the general vicinity of CPT-174.
- **b.** Further delineation of the plume is needed vertically and laterally to the east of MacArthur Blvd, bounded by Redhill Avenue and Main Street, and in the general vicinity of CPT-156, 175, 176, and 184. The leading edge of

the plume has not been delineated for all COCs. In addition, SAM-9A (37.5-42.5 ft bgs) does not address shallow contamination from 0-37.5 ft bgs. The sites at the southern edge of the project Study Area include Olen Properties (2031 Main Street, Irvine, CA 92714) and Deft Chemical Coating, Inc. (17451 Von Karman Avenue, Irvine, CA 92714) which have groundwater monitoring data that may further define the downgradient extent of the contaminants.

If you have any questions, contact Chad Nishida at (951) 782-3252 or by e-mail at: chad.nishida@waterboards.ca.gov, or you may contact Nick Amini, Chief of the Site Cleanup Program, at (951) 782-7958 or by e-mail at: nick.amini@waterboards.ca.gov.

Sincerely,

Nishida

Chad Nishida
Water Resources Control Engineer
Site Cleanup Program

cc: Bill Hunt – OCWD (whunt@ocwd.com)
Roy Herndon – OCWD (rherndon@ocwd.com)
Chris Ross – Hargis + Associates (cross@hargis.com)
Kevin Coons – Hargis + Associates (kcoons@hargis.com)
Julie Macedo – SWRCB, OE (julie.macedo@waterboards.ca.gov)
Robert Reeves – SWRCB, DFA (robert.reeves@waterboards.ca.gov)
Aparjeet Rangi – SWRCB, DFA (aparjeet.rangi@waterboards.ca.gov)

R:\RB8\Shared\Section\SCP\Site_Cleanup_Section_info\Prop 1 Applications\South Basin_2\20191106_OCWD_SBGPPdatagap_list112119_Final

APPENDIX H
03/25/21 RWQCB COMMENTS ON THE DRAFT FEASIBILITY STUDY INITIAL SCREENING EVALUATION FOR THE ORANGE COUNTY SOUTH BASIN GROUNDWATER PROTECTION PROJECT, OPERABLE UNIT 2 (GRANT AGREEMENT NO. D1712505)

CALIFORNIA
Water Boards

GAVIN NEWSOM
GOVERNOR

JARED BLUMENFELD
SECRETARY FOR
ENVIRONMENTAL PROTECTION

Santa Ana Regional Water Quality Control Board

March 25, 2021

Mr. Bill Leever
Principal Hydrogeologist
Orange County Water District
18700 Ward Street
Fountain Valley, CA 92708
(wleever@ocwd.com)

COMMENTS ON THE DRAFT FEASIBILITY STUDY INITIAL SCREENING EVALUATION FOR THE ORANGE COUNTY SOUTH BASIN GROUNDWATER PROTECTION PROJECT, OPERABLE UNIT 2 (GRANT AGREEMENT NO. D1712505)

Dear Mr. Leever,

Santa Ana Regional Water Quality Control Board (Santa Ana Water Board) staff have completed our review of the "*Feasibility Study Initial Screening Evaluation*" (FSISE) for the South Basin Groundwater Protection Project Operable Unit 2 (OU2) submitted on February 3, 2021, by your consultant Engineering Analytics, Inc. (EA). The document was submitted for our technical review as part of the reporting requirements listed in the Proposition 1 Grant Agreement (No. D1712505) for the Remedial Investigation and Feasibility Study (RI/FS) between the Orange County Water District (OCWD) and State Water Resources Control Board (State Water Board) Division of Financial Assistance (DFA). This letter provides Santa Ana Water Board staff comments on the FSISE.

Comments:

1. General – The authors of the report, statement of qualifications and signature(s) and seal(s) of the registered professional(s) responsible for the work should be included in the final document, to be consistent with section C-26 of the Grant Agreement.

2. General – Attachment 1 in our letter titled "*Comments on Revised Draft Supplemental Remedial Investigation Report…,"* dated February 3, 2020, depicts the off-property areas that we had excluded from analysis of the Feasibility Study (FS). Portions of remedial alternatives 3 through 6 include application of in-situ chemical oxidation (ISCO) or extraction well containment within this exclusion area and should be removed.

3. Section 1.0 Introduction – *"Operable Unit 1 is being addressed by others separately and …"* Please revise to read: "Operable Unit 1 is being addressed by responsible parties for the source sites under the oversight of the State of California and …"

4. Section 1.2 Remedy Status – The text states, "*Five-year remedy reviews would be performed to track the progress and effectiveness of the interim remedy. The five-year*

remedy reviews also would evaluate the progress and effectiveness of the source site remedial efforts as they pertain to preventing off-property migration of Chemicals of Concern (COCs)." It should be noted that if a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, such action should be reviewed no less often than every five years after the initiation of the selected remedial action. Given the complexity of the South Basin comingled plume and the various potentially responsible parties (PRPs) that are or will be implementing on-site and off-site assessment/remediation, it is prudent to frequently monitor the remedial action. This is to ensure that human health and the environment are being protected by the remedial action, and that changes are implemented expeditiously as needed.

5. Section 1.3.1 Geologic and Hydrogeologic Framework – The referenced upper, middle, and lower portion of the Shallow Aquifer system and the attributed depth intervals have not been discussed in the FSISE. The investigation reports for many of the source sites within the Orange County South Basin have included the terms "A and B" (or 1st and 2nd) water-bearing zones. In the absence of any definition or explanation, the correlation between the upper, middle, and lower portions of the Shallow Aquifer with A/B zones at sources sites under our oversight remains unclear.
    a. There are also inconsistencies in naming of the stratigraphic layers as presented in the FSISE and the Remedial Investigation (RI) Report (i.e. Layers 1-4 versus upper, middle, lower Shallow Aquifer). We recommend that you provide full definitions and explanations in the text and plume figures, so as to be consistent with the terminology in the RI Report. Depending on the location within the Study Area, the depth of each hydrostratigraphic unit (HSU) may vary significantly. Therefore, the detailed analysis of alternatives in the FS can greatly benefit from updated figures with location-specific plume contours and location-specific HSU labels that can be correlated with nearby source sites that are also being investigated.

6. Section 1.3.5.2 Active Water Supply Wells – The table that lists the eight active water supply wells within the Study Area has a caption that is not referenced within the table. Please identify the corresponding cathodic protection well with a superscript.

7. Section 1.7.1 Potential Human Health Risk – The text states, *"The remaining* [contaminants of potential concern] *COPCs were not retained as COCs, based on the following criteria: Did not appear to be related to sites (for example, dioxins, per- and polyfluoroalkyl substances [PFAS], and fluoride)."* Eight or more facilities within the South Basin study area were listed in the State Water Board Order WQ 2019-0045-DWQ for the determination of the presence of PFAS at chrome plating facilities. Pending additional site-specific data, the presence of PFAS may become more evident and may be of potential concern to the proposed remedial alternatives.

8. Section 1.7.2 Potential Human Health Risk – Please explain why Freon-113, which has been detected in groundwater at concentrations above its maximum contaminant level (MCL) for drinking water in at least one source site within the Study Area, has not been listed as a groundwater COC for further evaluation.

9. Section 2.0 Remedial Action Objectives – *"In order to be compatible with remediation at source sites, the* [interim remedial measures] *IRMs would be implemented to avoid substantially negatively affecting groundwater quality … at or near the source sites with*

ongoing or planned remedial actions." Please note that it is our staff's position that any substantial effect on groundwater quality or flow near the source sites could potentially complicate the ongoing or planned execution of remedial actions by the responsible parties.

10. Section 2 Remedial Action Objectives (RAOs) –
    a. (RAOs-1 and 2), the terms "decreasing" as well as "to the extent practicable" and "to the extent practical" have been used for the lateral and vertical extent of COC impacts to lower concentration areas and the Principal Aquifer: "*1. Protect groundwater resources from further degradation by decreasing lateral and vertical migration of high concentration COCs into zones with lower concentrations of COCs within OU2, to the extent practicable; 2. Protect groundwater resources by decreasing potential for vertical migration of high concentration COCs from the upper/middle portions of the Shallow Aquifer System to the Principal Aquifer System through Legacy Water Supply Wells, to the extent practical."* We ask that the term "preventing" in the RAOs be used with "to the extent practicable/practical."
    b. RAO-5: The text states: "*Minimize discharge of COC exceeding ecological risk-based concentration from the Shallow Aquifer System to surface water channels*." It is unclear how this objective is achievable using Alternative 5 (i.e. application of ISCO).
    c. We understand that OCWD is planning to implement an in-situ remediation barrier along the Armstrong Channel in the area south of the Baxter Healthcare and Edwards Lifesciences sites (Figure 2-4). Since the bottom of the channel is unpaved and its elevation is below the water table, please explain how this remedy could be implemented effectively. In addition, please explain how the release of ISCO reagent into the channel will be avoided.
    d. RAO-6: "*Prevent unacceptable human exposure to groundwater contaminated by COCs*." The wording should be revised to "Prevent human exposure to contaminated groundwater with COC concentrations exceeding drinking water MCLs or any other applicable regulatory levels."

11. Section 4.1 General Response Actions – Monitored natural attenuation (MNA) has been listed under "In-situ Treatment Cleanup Actions." Please be advised that we do not consider natural attenuation a "cleanup action," because it is a passive remedy. MNA is more fitting under the "Monitoring" category in this section and throughout the FSISE.

12. Section 4.2 Identification of Remedial Technologies and Process Options – Treated Water Discharge or End Use Options have been listed under "Remedial Technology" within the table under this section. "End use options" for treated water are not considered remedial technologies for cleanup of contaminated groundwater.

13. Section 5.1 Effectiveness – In the screening of remedial technologies, the short- and long-term effectiveness and reduction achieved should include discussion regarding toxicity, mobility and volume for all technologies that were considered. The short-term effectiveness refers to the construction and implementation period, and the long-term effectiveness refers to the period after the remedial action is completed.

14. Section 5.4.4.1 Groundwater Extraction – The document refers to two publications by the United States Environmental Protection Agency, and states that pump and treat

(P&T) *"'is a common method for cleaning up groundwater and other aqueous media contaminated with dissolved chemicals, including industrial solvents, metals, and fuel oil."* P&T technologies must often operate for an extended period of time (decades) to meet aquifer cleanup goals, and in many cases may fail to achieve those goals. Limitations and concerns with this technology are evident when an assessment of remaining contaminant concentrations indicates an asymptotic curve, or when concentrations rebound after system shutdown. The residual mass of volatile organic compounds (VOCs) in groundwater tends to adsorb to organic materials in less permeable soils, and may later migrate back into the groundwater via back-diffusion, thus acting as a long-term source of contamination.

15. Section 5.4.5.1.3 Membrane Processes – The text states, *"the rejected concentrate/brine solution is typically 85-95% of the influent flow for nanofiltration and 80-90% of the influent flow for* [reverse osmosis] *RO and would require discharge to a* [publicly owned treatment works] *POTW."* The ratio of permeate flow (product water) to feed flow is often referred to as a percent recovery. Rejected water can range from 20% to 50% of the feedwater, and is dependent on the number of stages in which the membranes are configured and the feed pressure. Please verify that the text is accurately defining the rejected concentrate/brine solution, recovery and their respective percentages.

16. Section 5.4.6.1 Injection – *"State Water Resources Control Board Resolution 92-49 prohibits degradation of groundwater used for potable uses."* The correct citation for the State Water Resources Control Board's Anti-Degradation Policy is Resolution 68-16.

17. Section 5.4.7.1 Monitored Natural Attenuation –
    a. *"If applied at appropriate locations, with an adequate monitoring network and analytical schedule, MNA is effective…"* Please explain the proposed method for selecting appropriate locations for MNA. The occurrence and continued success of natural attenuation is interdependent on the geophysical and geochemical characteristics of the subsurface, as well as the physical and chemical characteristics of the contaminant(s) that are present. As such, the concept of "applying MNA at appropriate locations" appears to be misguided.
    b. *"However, as a stand-alone remedial action, MNA would require a substantial number of monitor wells and …"* Please replace 'remedial action' with 'process option.'

18. Section 5.4.7.3 Chemical Processes – The text states that the *"potential challenges associated with ISCO in OU2 include an inability to reduce COC concentrations before they cross flow from the Shallow Aquifer System into the Principal Aquifer System through Legacy Water Supply Wells in part because the locations of these wells are not precisely known and the remedy duration."* The challenge in having limited knowledge of the locations of legacy water supply wells pertains to any type of remedial action within the South Basin. The ISCO remedy can typically be utilized for COC mass destruction, thereby preventing further degradation of groundwater quality by decreasing the migration of high concentrations of COCs into zones with lower concentrations of COCs, especially in areas of the plume that are derived from multiple sources (comingled). We recommend either removing the statement quoted above, or applying it to all general response actions, with the exception of the "no action" alternative.

19. Section 5.5 Retained Remedial Technologies and Process Options – *"The Institutional Controls, Monitoring, and Sealing Legacy Water Supply Wells process options are not considered stand-alone remedial alternatives."* We recommend adding MNA to this list.

20. Section 6.2.3 Alternative 3 – *"Groundwater would be extracted in higher concentration areas to: decrease lateral …; and begin to treat and reduce the concentrations of COCs in groundwater."* We recommend replacing 'concentrations' with 'mass' in the quoted sentence. The same sentence is repeated under the descriptions of Alternatives 5 and 6, and should also be revised.

21. Section 6.2.5 Alternative 5 Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using In-Situ Chemical Oxidation – The text proposes a Pre-Design Investigation (e.g. target contaminants, lithology, hydrogeology, and other site-specific conditions) if the selected alternative is ISCO (Persulfate activation). The Pre-Design Investigation should not be limited to Alternative 5 and it should be applied to other alternatives that also involve containment and MNA.

    a. It would be prudent to conduct additional investigations with respect to data gaps, lithology, hydrogeology and site-specific conditions (e.g. geochemical data, bench scale testing, pilot studies, etc.), in order to optimize the design of OCWD's interim remedy. Improper design may result in remedy ineffectiveness (i.e. limited reduction in COC concentrations and extended cleanup timeframe), the inability to scale treatment of the IRM to a full scale remedy, and/or interference with current source site remedies or proposed future remedies (i.e. generating unfavorable byproducts, causing unwanted plume migration, altering groundwater geochemical conditions, dewatering monitoring wells). Periodic post-implementation monitoring will aid in confirming the remedy's effectiveness and performance.
    b. The text states, *"Persulfate activation is required to convert the persulfate into the highly reactive persulfate radical, …"* For further clarification, please insert 'anion' after the second 'persulfate' in the quoted sentence.

22. Section 6.2.6 Alternative 6 – *"As conceptually illustrated on Figure 2-5, … and accessible locations within a selected high concentration area with OU2, …"* It seems that 'in' is missing between 'with' and 'OU2.'

23. Figure 1-5 – The monitoring well locations for the Former Standard Screw Products facility should be shown in the figure, and should be consistent with the information presented in Figure 5-1 in the RI Report.

24. Figure 1-14 – The extent of perchlorate impacts originating from the former LNP site within the upper portion of the shallow aquifer system as depicted for concentration ranges of 6 to 60 μg/L is not consistent with our records for perchlorate impacts originating from the referenced site in the A and B water-bearing zones (also refer to comment 5, above).

25. Figures 1-18 through 1-23 – The figures depict cis-1,2-dichloroethene (cis-1,2-DCE) and hexavalent chromium detections throughout the study area. Please address the following:
    a. Provide plume contours for cis-1,2-DCE and hexavalent chromium.

b. The figure legend and icons should be revised to be consistent with Figures 1-6 through 1-15 as presented in the RI Report.
c. The vertical depth intervals should be revised to be consistent with other related figures (i.e. Upper and Middle portions of the shallow aquifer versus Layers 1-4).

26. Figure 2-4 and Figure 2-5 – The figures include implementation of “Alternative 5- ISCO” and “Alternative 6- groundwater extraction and treatment combined with ISCO” immediately downgradient of the Embee Plating facility. The Santa Ana Water Board has authorized discharges of amendment at the Embee site, in accordance with the General Waste Discharge Requirements for In Situ Groundwater Remediation (Order No. R8-2018-0089), since 2016. Groundwater treatment has been ongoing at the site, using bioremediation and in-situ chemical reduction for treatment of VOCs, perchlorate, and hexavalent chromium. It appears that implementation of Alternative 5, downgradient of Embee Plating, may not be compatible with the efforts of the responsible party (RP) to create oxygen-reducing conditions in the subsurface, and thereby remediate the hexavalent chromium contamination attributable to the Embee facility. Application of extraction activities per Alternative 6 may potentially impact groundwater flow around the Embee site. This effect should be evaluated to ensure that capture zones of the extraction wells and implementation of ISCO will not have negative effects on in-situ remediation efforts that are based on reducing geochemical conditions. Specifically, remediation of the hexavalent chromium plume that originated from the referenced site may negatively be impacted by implementation of ISCO.

27. Figure 2-4 – Please remove the proposed application area next to the ITT Cannon’s planned in-situ remediation area. We have already discussed the expansion of the planned remedy with the RP to include areas further to the south.

28. Appendix A Applicable or Relevant and Appropriate Requirements (ARARs) – Santa Ana Water Board staff have provided comments to the ARARs in a letter dated July 25, 2018. Please ensure these comments are addressed.

We appreciate the opportunity to review this deliverable. If you have any questions, please contact me at (951) 782-7958, or by email at nick.amini@waterboards.ca.gov.

Sincerely,

Afshin Nick Amini Digitally signed by Afshin Nick Amini
Date: 2021.03.25 10:01:47 -07'00'

A. Nick Amini, Ph.D., P.E.
Chief, Site Cleanup Section

cc: Roy Herndon – OCWD (rherndon@ocwd.com)
Chris Ross – Engineering Analytics (CRoss@enganalytics.com)
Ken Puentes – Engineering Analytics (KPuentes@enganalytics.com)
Julie Macedo – SWRCB, OE (julie.macedo@waterboards.ca.gov)
Robert Reeves – SWRCB, DFA (robert.reeves@waterboards.ca.gov)
Meghan Tosney– SWRCB, DFA (meghan.tosney@waterboards.ca.gov)
Aparjeet Rangi – SWRCB, DFA (aparjeet.rangi@waterboards.ca.gov)

Yolanda Garza – DTSC (yolanda.garza@dtsc.ca.gov)
Emad Yemut – DTSC (emad.yemut@dtsc.ca.gov)

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APPENDIX I
03/29/21 STATE WATER BOARD DFA COMMENTS ON THE DRAFT FEASIBILITY STUDY INITIAL SCREENING EVALUATION

From:	Rangi, Aparjeet@Waterboards
To:	Leever, Bill; Amini, Nick@Waterboards; Sturdivant, Ann@Waterboards; Chris Ross; Law, Jessica@Waterboards; Ken Puentes; Tosney, Meghan@Waterboards; Behrooz, Mehrnoosh@Waterboards; Nishida, Chad@Waterboards; Reeves, Robert@Waterboards; Herndon, Roy
Subject:	RE: Draft Feasibility Study Initial Screening Evaluation (FSISE)
Date:	Monday, March 29, 2021 2:09:49 PM
Attachments:	image003.png

Good Afternoon Bill,

Thank you for submitting the Feasibility Study Initial Screening Evaluation (FSISE) Report on February 11, 2021 for the Orange County Water District (OCWD) – South Basin (SB) Remedial Investigation/Feasibility Study (RI/FS) Proposition 1 Grant Agreement (D1712505) project.

Staff from the State Water Board Division of Financial Assistance (DFA) has the following comments on the FSISE Report. Additionally, the Santa Ana Regional Water Quality Control Board (Regional Water Board) provided comments on the FSISE Report. Comments provided by the DFA and the Regional Water Board should be addressed in revisions to the FSISE Report. Alternatively, these comments could be addressed in the Feasibility Study Report, which is due June 30, 2021.

Comments:

1. **Specific Recommended Remedial Action Objectives (RAO), Page 12–** The RAOs do not include proposed groundwater cleanup goals, the area that would be addressed by the groundwater cleanup activities and, estimated timeframe for achieving the groundwater cleanup goals. The RAOs should be updated to include groundwater cleanup goals, the area addressed by groundwater cleanup activities and estimated timeframes for achieving the proposed groundwater cleanup goals.

2. **Geologic and Hydrogeologic Framework, Page 20:** The description of hydrogeologic zones in the Project area appears to be inconsistent with the description provided in the Supplemental Remedial Investigation Report (Supplemental RI Report), dated July 1, 2020. The description of the Shallow Aquifer System, which ranges from near land surface to a depth of approximately 162 ft below ground surface (bgs), was divided into the four layers (Layer 1 through 4). No explanation or justification was provided in the FSISE Report describing why this change was made. Furthermore, inconsistencies between the Supplemental RI and FSISE Report raises concern that contaminant plume maps provided for the Shallow Aquifer System may not be consistent with the contaminant distribution and data gaps described in the RI Report (i.e. extent of groundwater contamination and data gaps) and the development and evaluation of feasible remedial alternatives provided in the FSISE Report. The interpretation of the Shallow Aquifer System layer provided in the FSISE Report should be revised to be consistent with the hydrogeologic interpretation provided in the Supplemental RI Report, or the FSISE Report should be updated to justify these changes. In addition, if changes to the hydrogeologic interpretation are made, the FSISE Report should include updated groundwater plume maps that incorporate changes to the Shallow Aquifer System layer.

Thanks
Aparjeet

Aparjeet Rangi, P.E.
Water Resource Control Engineer
State Water Resources Control Board

Division of Financial Assistance
Aparjeet.Rangi@Waterboards.ca.gov
Ph: (916) 319-8255

From: Leever, Bill <wleever@ocwd.com>
Sent: Thursday, February 11, 2021 3:51 PM
To: Amini, Nick@Waterboards <Nick.Amini@waterboards.ca.gov>; Sturdivant, Ann@Waterboards <Ann.Sturdivant@waterboards.ca.gov>; Chris Ross <CRoss@enganalytics.com>; Law, Jessica@Waterboards <Jessica.Law@Waterboards.ca.gov>; KPuentes@enganalytics.com; Tosney, Meghan@Waterboards <Meghan.Tosney@waterboards.ca.gov>; Behrooz, Mehrnoosh@Waterboards <Mehrnoosh.Behrooz@Waterboards.ca.gov>; Nishida, Chad@Waterboards <Chad.Nishida@Waterboards.ca.gov>; Rangi, Aparjeet@Waterboards <Aparjeet.Rangi@Waterboards.ca.gov>; Reeves, Robert@Waterboards <Robert.Reeves@waterboards.ca.gov>; Herndon, Roy <rherndon@ocwd.com>
Subject: Draft Feasibility Study Initial Screening Evaluation (FSISE)

EXTERNAL:

All,

DFA has asked that the Draft Feasibility Study Initial Screening Evaluation (FSISE) also be submitted to the TAC via a direct email (as opposed to an attachment in the MS Teams meeting invitation that was sent on February 3, 2021). Please let me know if you have any questions.

Bill Leever
Principal Hydrogeologist

Orange County Water District
18700 Ward Street, Fountain Valley, CA 92708
tel: (714) 378-3245
fax:
email: wleever@ocwd.com

APPENDIX J
04/07/21 OCWD SOUTH BASIN TECHNICAL ADVISORY COMMITTEE MEETING MINUTES (D1712505)

MINUTES

OCWD South Basin Technical Advisory Committee Meeting (D1712505)

April 7, 2021
10:00 am – 11:50 am

MS Teams Link click here
Phone only: +1 (916) 535-3094, Phone Conference ID: 878 968 773#

Attendees:

X	Robert Reeves	DFA	Prop 1 Program Manager	Robert.Reeves@waterboards.ca.gov
X	Aparjeet Rangi	DFA	Project Manager	Aparjeet.Rangi@Waterboards.ca.gov
X	Jessica Law	RWQCB	Site Cleanup Program	Jessica.Law@Waterboards.ca.gov
X	Meghan Tosney	DFA	Chief Prop 1 GWGP	Meghan.Tosney@waterboards.ca.gov
X	Chad Nishida	RWQCB	Site Cleanup Program (Prop 1)	Chad.Nishida@Waterboards.ca.gov
X	Mehrnoosh Behrooz	RWQCB	Site Cleanup Program	Mehrnoosh.Behrooz@Waterboards.ca.gov
X	Carl Bernhardt	RWQCB	Site Cleanup Program	Carl.Bernhardt@Waterboards.ca.gov
	Kayla Kawamura	RWQCB	Site Cleanup Program	Kayla.Kawamura@Waterboards.ca.gov
X	Nick Amini	RWQCB	Chief, Site Cleanup Program	Nick.Amini@waterboards.ca.gov
	Ann Sturdivant	RWQCB	Supervising Engineering Geologist	Ann.Sturdivant@waterboards.ca.gov
X	Bill Leever	OCWD	Project Manager	wleever@ocwd.com
X	Roy Herndon	OCWD	Chief Hydrogeologist	rherndon@ocwd.com
X	Chris Ross	EA	Project Manager	CRoss@enganalytics.com
	Ken Puentes	EA	Project Hydrogeologist	KPuentes@enganalytics.com
X	Errol Lawrence	EA	Project Hydrogeologist	ELawrence@enganalytics.com

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10:00-10:05 **Roll Call/Introduction** Bill Leever

Bill identified attendees (marked above) and reviewed the agenda.

10:05-10:15 **Groundwater Model and Overview of CSM/Model Laying** Chris Ross

Chris provided an overview (with slides) of the groundwater model layering, conductivity, and water levels observed vs. simulated. The model calibration is complete. The model TM will be part of the detailed alternatives evaluation TM. Robert Reeves asked if any information will be provided on the statistical analysis of observed vs. simulated water level data. Chris indicated that the observed vs. simulated water level analysis will be part of the model TM. Mona asked if the model included a solute transport component, and Chris responded it did not. Nick asked if the model incorporated source site remediation well extraction, and Chris responded that it does.

10:15-11:10 **TAC Comments & OCWD/EA Discussion of Initial Screening Evaluation TM** All

Bill initiated the discussion with the introduction of the TAC draft FSISE comments and the focus on General Comment 2. Nick provided an explanation of the Board's comments related to the FSISE alternatives, as follows:

Alternative 5: ISCO IRM south of the ITT: ITT has committed to investigating and remediating the contaminant plume south of its site near the draft FSISE ISCO alternative along Daimler. As such, the draft FSISE proposed ISCO alignment at this location is not needed. Roy asked how far south ITT is willing to investigate and remediate. Jessica indicated that she does not know specifically how far south ITT will remediate, but that ITT will be responsible for cleanup of contamination that the Regional Board deems their responsibility. They are currently planning two new off-site monitoring wells. They will evaluate new data and refine their remedial alternatives accordingly.

Regional Board does not have an issue with the Dyer Road or MacArthur Blvd. remedial alternative alignments.

Nick and Mona discussed concerns regarding proximity of the ISCO alternative alignment to the OCFCD's flood control channel south of Armstrong Ave., Baxter Healthcare, and Edwards Lifesciences. Concerns include, as identified in the draft FSISE comments, potential daylighting of ISCO amendments in the channel bottom and potential chemical interference with onsite efforts by Baxter. Chris asked if the concern is just with ISCO or does it also apply to groundwater extraction. Mona indicated it was primarily ISCO, but if groundwater extraction were to show significant changes in groundwater gradients that impact source site remediation, then that would be a concern. Bill asked about elevated TCE and PCE (14,000 micrograms per liter [µg/L]) concentrations in a Hydropunch sample reported by Baxter. Mona is aware of the elevated concentrations and believes they are related to disturbances in the detection limit of all analytes due to very high Freon-113 concentrations (210,000 ug/L) within the sample collected in Armstrong Avenue, close to former Edwards source area. However, Mona also indicated there may be additional investigation by DRSS near the Kaiser site located upgradient of Baxter. The Kaiser and the former BFM Energy sites may be contributing sources of VOCs and 1,4-dioxane observed at the Baxter site. OCWD and EA indicated their appreciation for receiving these comments from the RWQCB, as it identifies issues that will be addressed during the detailed remedial alternatives evaluation process.

Robert discussed his concern, as well as the Regional Board's concern, related to the hydrostratigraphic nomenclature within the SRI and draft FSISE (Upper, Middle, Lower vs. Layers 1-4). Robert and Chad indicated they prefer to see plume concentration contour maps vs. dot plot maps. After some discussion, it was determined that dot plots of the COPCs would be prepared by layer and submitted with the draft detailed remedial alternatives evaluation memo. The detailed alternatives evaluation, and ultimately the remediation implementation, will take into consideration the site specific hydro-stratigraphy, well screens and target aquifers when it comes to evaluating potential impacts to planned or existing source site remedial actions. Chad indicated that the layering system should be thoroughly explained, as mentioned in the comments. RB may request plume maps in the detailed evaluation in higher density areas where an interim remedy may likely be implemented. The TAC agreed that the detailed evaluation of remedial alternatives could move forward.

11:10-11:40	**DTSC Site updates, New RB Site updates**	Chad Nishida

Chad provided the below updates on DTSC sites based on multiple meetings he and Nick have had with DTSC.

<ins>Soco West</ins>: Nick noted that the site has some of the highest groundwater VOC concentrations in the South Basin area. Chad indicated that there is a DTSC approved remedial action plan and Remedial

Design Implementation Plan (RDIP) and listed the four remedial activities proposed (flow control gates, enhanced in-situ remediation along Maywood, perimeter slurry wall to 70 feet bgs; however, this component still needs to be optimized and approved by DTSC, and ISCR permeable reactive barrier using ZVI at the Diesel Logistics site). Implementation has been paused since DTSC/SOCO-West is not certain with the remediation strategy OCWD will be implementing. DTSC agreed that SOCO-West will not implement their remedy until legal issues are resolved. According to DTSC, they have been in talks with OCWD. Roy asked Chad if any of these remedial actions were south of Warner Ave, and he said no, not to his knowledge. With respect to the proposed remedial alternative alignments in the draft FSISE memo, DTSC is concerned about potential impacts on the proposed RDIP due to changes in groundwater velocity and its impact on residence time. There is less concern with ISCO/ZVI interferences provided that the remedies are complimentary; however, the concerns include impacts from the radius of influence and impacts from hexavalent chromium (Cr+6) detected near the alignment. OCWD responded that we appreciate this input and will make sure that the upcoming detailed remedial alternative evaluation will include the appropriate analysis and findings to address these concerns.

<u>Cherry Aerospace</u>: Groundwater is monitored semi-annually (April) to coincide with Diceon and Embee Plating. Target COCs include VOCs and 1,4-dioxane (1,1-DCA, 1,1,1-TCA) and Freon-113. They have done plating at the site. Groundwater has been impacted by on-site activities but also from upgradient sources north of Dyer Road; DTSC staff indicated that the proposed extraction well remedial alternative alignment to the north of the site on east Warner Avenue may be beneficial in addressing contamination coming onto Cherry. DTSC also commented on potential impacts (i.e. altering groundwater flow direction, velocity and production of unfavorable byproducts through injection) of proposed remedial alternatives east of the Cherry site and recommended that a 2017 report on the conceptual site model and groundwater flow modeling by Cherry's consultant (CDM) be reviewed to ensure there are no substantial negative impacts to existing or planned remedial actions by responsible parties. Additionally, the Interim Remediation Workplan Approved in 2018 includes extraction wells at depths ranging from 35-72 feet bgs with design flows ranging from 0.5-4 gpm and a total design flow of 50 gpm. This low flow rate may be easily influenced by nearby remedial action. The PRP is still working through on-site permitting and off-site access and is expected to be implemented in Q3 of 2021. Chad also mentioned that the hydrostratigraphic unit (HSU) layering system is similar to SOCO-West and is more robust than that presented by OCWD. Roy replied that OCWD and EA will review and consider the information in this report during the detailed remedial alternatives evaluation.

<u>Diesel Logistics</u>: There is an approved work plan for installation of groundwater monitoring wells to be implemented this year (2021), including subsequent monitoring. There is ongoing quarterly SVE; no groundwater remedial actions planned.

<u>Embee</u>: The in-situ biological enhancement is occurring on-site and no off-property remediation. Embee will be implementing 19 direct push injection points (Sodium lactate, emulsified vegetable oil, calcium polysulfide, sodium bicarbonate and nutrients) at four locations on-site and is focused on targeting Cr+6 which has migrated downgradient of the injection well barriers. It appears that the deeper 50-60 foot zones may be acting as the main migration pathway for contaminants (laterally continuous and high groundwater velocity). DTSC is concerned about draft FSISE memo's ISCO alignment along Warner that could convert Cr+3 to Cr+6, thus this should be evaluated in addition to its radius of influence. Cr+6 may already be present in the proposed injection area. OCWD responded that, again, this is good input which will be addressed in the detailed remedial alternatives evaluation. Being a chrome plating facility, Embee was included in the State Board order to perform PFAS groundwater testing. DTSC indicated that EP-16C detected concentrations of PFOS at 15,000 ng/L and the occurrence of PFAS compounds should be evaluated in the FS.

Diceon: Sulfidated ZVI injection is proposed on-site and immediately off-site; a new type of ZVI is proposed, so RWQCB limited injections to pilot scale along an intermediate barrier. RWQCB noted 1,4-dioxane is coming onto north side of site and suspects it is coming from Gallade; RB/DTSC are concerned that proposed ISCO remedial alternative could counter the effectiveness of the ZVI which is to reduce and dechlorinate the VOCs, just 200 feet north. DTSC is currently reviewing interim measures to remediate sources of releases and control the migration of VOCs in groundwater (37,000 ug/L of TCE [16 on-Site and 14 off-site wells]). It should be noted that increasing concentrations of TCE are observed in their southern MW-9C C-Zone wells (48-60 feet bgs). OCWD responded that we appreciate this input and will make sure that the upcoming detailed remedial alternative evaluation will include the appropriate analysis and findings.

Gallade: Remedial action plan approved by waterboard (two excavations) and according to the consultant have contained the VOC GW plume. The site is continuing with SVE, and dual phase extraction since the 1990s.

11:40-11:50 **Schedule Update, Next Steps on the FSISE TM** Bill Leever

Bill provided an update on the schedule. No changes to schedule distributed with 2/11/2021 TAC meeting minutes.

There was discussion related to how TAC comments on the draft FSISE memo will be addressed. It was agreed that TAC comments will be addressed in a stand-alone response to comments document. DFA prefers to receive the meeting minutes first when they are ready, since the discussion and recollection for everyone is fresh. Response to comments to the draft FSISE will be submitted at a later date when they are ready.

11:50 **Walk-in Items, Action Item Recap, Adjourn**

None

Action Items:

1. **Path forward on the FSISE TM?**
2. **Mona to provide map showing Embee's proposed 19 DPT onsite injection points.**
3. **Chad to provide Diesel Logistics (DTSC Site) monitoring well installation workplan.**
4. **Chad/Nick to provide their DTSC meeting notes.**

APPENDIX K
05/20/21 RESPONSE TO COMMENTS ON THE DRAFT FEASIBILITY STUDY INITIAL SCREENING EVALUATION FOR THE ORANGE COUNTY WATER DISTRICT SOUTH BASIN GROUNDWATER PROTECTION PROJECT

Technical Memorandum

To:	Bill Leever, PG, CHG	From:	Chris Ross, PG, CHG
Company:	Orange County Water District	Date:	May 20, 2021
EA No.:	151099.221		PROFESSIONAL GEOLOGIST CHRISTOPHER G.A. ROSS No. 4594 STATE OF CALIFORNIA
Re:	Response to Comments on the Draft Feasibility Study Initial Screening Evaluation for the Orange County Water District South Basin Groundwater Protection Project		

1.0 INTRODUCTION

The Draft Feasibility Study Initial Screening Evaluation (FSISE) was prepared by Engineering Analytics, Inc. (EA) on behalf of the Orange County Water District (OCWD) in support of the South Basin Groundwater Protection Project (SBGPP) Remedial Investigation/Feasibility Study (RI/FS) being conducted by OCWD to address groundwater contamination in Operable Unit 2 (OU2) in the south-central portion of the Orange County Groundwater Basin (the Basin) in Orange County, California (Study Area) (EA, 2021). OU2 is groundwater contamination in the Shallow Aquifer System off-property of numerous groundwater contamination source sites (source sites) located within the Study Area where groundwater contaminant plumes emanating from individual source sites have migrated and commingled.

The purpose of the FSISE is to evaluate and screen remedial technologies and process options that will be retained for the development of remedial alternatives to address groundwater contamination in OU2. The remedial alternatives that were identified in the FSISE will be further evaluated as part of the Draft Feasibility Study Detailed Evaluation (FSDE). OCWD is conducting the SBGPP RI/FS in cooperation with California Environmental Protection Agency, Department of Toxic Substances Control (DTSC) and the California Regional Water Quality Control Board, Santa Ana Region (Santa Ana Water Board) to develop an interim remedy for OU2 groundwater contamination.

On February 3, 2021, the FSISE was submitted to the SBGPP Technical Advisory Committee[1] (TAC) for their review as part of the reporting requirements listed in the Proposition 1 Grant Agreement (No. D1712505) for the RI/FS between OCWD and the State Water Resources Control Board (State Water Board) Division of Financial Assistance (DFA). In a letter dated March 25,

[1] The Technical Advisory Committee comprises the Santa Ana Regional Water Quality Control Board and the State Water Resources Control Board Division of Financial Assistance.

2021, the Santa Ana Water Board transmitted their comments on the FSISE to OCWD (Santa Ana Water Board, 2021). The DFA provided comments in an e-mail to OCWD dated March 29, 2021. On April 7, 2021, a meeting was convened between representatives of the Santa Ana Water Board, DFA, OCWD, and EA to discuss the Santa Ana Water Board and DFA comments on the FSISE. The following responses to Santa Ana Water Board and DFA comments incorporate information that was discussed during the April 7, 2021 meeting.

OCWD is preparing the FSDE and plans to include the sections of the FSISE in the FSDE, excepting Section 7.0 – Recommendations for Detailed Evaluation. OCWD will include revisions in red-line/strikeout format to Sections 1 to 6 of the FSDE (from the FSISE) as outlined in the below responses to Santa Ana Water Board and DFA comments. Therefore, revisions to the draft FSISE will be incorporated into the FSDE and there is no need to prepare another version of the FSISE.

2.0 RESPONSE TO SANTA ANA WATER BOARD COMMENTS

Comment 1

General – The authors of the report, statement of qualifications and signature(s) and seal(s) of the registered professional(s) responsible for the work should be included in the final document, to be consistent with section C-26 of the Grant Agreement.

EA's Response to Comment 1

The author of the report, statement of qualifications and signature and seal of the registered professional responsible for the work will be included in the Final FS which will incorporate both the FSISE and FSDE.

Comment 2

General – Attachment 1 in our letter titled *"Comments on Revised Draft Supplemental Remedial Investigation Report…,"* dated February 3, 2020, depicts the off-property areas that we had excluded from analysis of the Feasibility Study (FS). Portions of remedial alternatives 3 through 6 include application of in-situ chemical oxidation (ISCO) or extraction well containment within this exclusion area (Santa Ana Water Board Exclusion Area) and should be removed.

EA's Response to Comment 2

There are two areas identified in the FSISE related to ISCO and one area related to groundwater containment as a potential interim remedy that exist within the Santa Ana Water Board Exclusion Area. The area located south of the southern-most ITT Cannon in-situ injection wellfield along McGaw Avenue and Daimler Street (Area 1) was related to ISCO (Alternative 5, Figure 2-4 from the FSISE). The area located near Armstrong Channel, south of the Baxter Health Care (Area 2) source site is related to both ISCO and groundwater containment (Alternatives 3 to 6, Figures 2-2 to 2-5 from the FSISE). The Santa Ana Water Board indicated that ITT Cannon will be responsible for applying additional groundwater remedial action in Area 1 above. The potential ISCO remediation area at this location will be removed in the FSDE. Regarding Area 2 above, it was agreed that it would remain on the figures and be evaluated as part of the FSDE.

Comment 3

Section 1.0 Introduction – *"Operable Unit 1 is being addressed by others separately and …"* Please revise to read: "Operable Unit 1 is being addressed by responsible parties for the source sites under the oversight of the State of California and …"

EA's Response to Comment 3

The subject sentence in the FSDE will be revised to read as requested.

Comment 4

Section 1.2 Remedy Status – The text states, "*Five-year remedy reviews would be performed to track the progress and effectiveness of the interim remedy. The five-year remedy reviews also would evaluate the progress and effectiveness of the source site remedial efforts as they pertain to preventing off-property migration of Chemicals of Concern (COCs).*" It should be noted that if a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, such action should be reviewed no less often than every five years after the initiation of the selected remedial action. Given the complexity of the South Basin comingled plume and the various potentially responsible parties (PRPs) that are or will be implementing on-site and off-site assessment/remediation, it is prudent to frequently monitor the remedial action. This is to ensure that human health and the environment are being protected by the remedial action, and that changes are implemented expeditiously as needed.

EA's Response to Comment 4

The reference to five-year remedy reviews is not meant to imply that more frequent monitoring and adjustments to remedy would not occur, rather it was meant to indicate that formal remedy reviews would be conducted no less frequently than every 5 years to formally document performance of the remedies and ensure that protection of human health and the environment is maintained. Revisions to respective portions of the FSISE are not needed, as such, no changes to these sections will be indicated in the FSDE.

Comment 5

Section 1.3.1 Geologic and Hydrogeologic Framework – The referenced upper, middle, and lower portion of the Shallow Aquifer system and the attributed depth intervals have not been discussed in the FSISE. The investigation reports for many of the source sites within the Orange County South Basin have included the terms "A and B" (or 1^{st} and 2^{nd}) water-bearing zones. In the absence of any definition or explanation, the correlation between the upper, middle, and lower portions of the Shallow Aquifer with A/B zones at sources sites under our oversight remains unclear.

a. There are also inconsistencies in naming of the stratigraphic layers as presented in the FSISE and the Remedial Investigation (RI) Report (i.e., Layers 1-4 versus upper, middle, lower Shallow Aquifer). We recommend that you provide full definitions and explanations in the text and plume figures, so as to be consistent with the terminology in the RI Report. Depending on the location within the Study Area, the depth of each hydrostratigraphic unit (HSU) may vary significantly. Therefore, the detailed analysis of alternatives in the FS can greatly benefit from updated figures with location-specific plume contours and location-specific HSU labels that can be correlated with nearby source sites that are also being investigated.

EA's Response to Comment 5

It was agreed that the FSDE would retain the evaluation and description of the stratigraphic layers 1 through 4 as presented in Section 1.2.1 of the FSISE text which is based on the Supplemental Remedial Investigation Report (SRI Report, Hargis + Associates, Inc., 2020) cross sections (SRI Report Figures 5-16 through 5-17N). The FSDE will also indicate which HSUs are being remediated at nearby source sites, where appropriate.

Comment 6

Section 1.3.5.2 Active Water Supply Wells – The table that lists the eight active water supply wells within the Study Area has a caption that is not referenced within the table. Please identify the corresponding cathodic protection well with a superscript.

EA's Response to Comment 6

The subject table will be revised in the FSDE to add a superscript "[1]" to the corresponding cathodic protection well.

Comment 7

Section 1.7.1 Potential Human Health Risk – The text states, *"The remaining* [contaminants of potential concern] *COPCs were not retained as COCs, based on the following criteria: Did not appear to be related to sites (for example, dioxins, per- and polyfluoroalkyl substances [PFAS], and fluoride)."* Eight or more facilities within the South Basin study area were listed in the State Water Board Order WQ 2019-0045-DWQ for the determination of the presence of PFAS at chrome plating facilities. Pending additional site-specific data, the presence of PFAS may become more evident and may be of potential concern to the proposed remedial alternatives.

EA's Response to Comment 7

There was a brief description of PFAS and the results presented in the SRI Report. PFAS are not COCs identified in the FSISE; however, it is understood that PFAS and other emergent compounds may require evaluation during implementation of the Interim Remedy and at sites that are sources of these compounds. Revisions to respective portions of the FSISE are not needed, as such, no changes to these sections will be indicated in the FSDE.

Comment 8

Section 1.7.2 Potential Human Health Risk – Please explain why Freon-113, which has been detected in groundwater at concentrations above its maximum contaminant level (MCL) for drinking water in at least one source site within the Study Area, has not been listed as a groundwater COC for further evaluation.

EA's Response to Comment 8

As directed by the Office of Environmental Health Hazard Assessment (OEHHA), the 95-percent upper confidence limit of the mean concentration in groundwater (95% UCL) for each COPC was the assumed exposure point concentration (EPC) in the Revised Human Health and Ecological Risk Assessment (HHRA) (The Fehling Group, 2020). The 95% UCL for Freon 113 is 169.2 micrograms per liter (ug/l), which is well below the Freon 113 drinking water maximum Contaminant Level (MCL) of 1,200 ug/l. Therefore, Freon-113 was not listed as an OU2 groundwater COC for further evaluation. Revisions to respective portions of the FSISE are not needed, as such, no changes to these sections will be indicated in the FSDE.

Comment 9

Section 2.0 Remedial Action Objectives – "*In order to be compatible with remediation at source sites, the* [interim remedial measures] *IRMs would be implemented to avoid substantially negatively affecting groundwater quality … at or near the source sites with ongoing or planned remedial actions.*" Please note that it is our staff's position that any substantial effect on groundwater quality or flow near the source sites could potentially complicate the ongoing or planned execution of remedial actions by the responsible parties.

EA's Response to Comment 9

Comment noted.

Comment 10

Section 2 Remedial Action Objectives (RAOs) –

a. (RAOs-1 and 2), the terms "decreasing" as well as "to the extent practicable" and "to the extent practical" have been used for the lateral and vertical extent of COC impacts to lower concentration areas and the Principal Aquifer: "*1. Protect groundwater resources from further degradation by decreasing lateral and vertical migration of high concentration COCs into zones with lower concentrations of COCs within OU2, to the extent practicable; 2. Protect groundwater resources by decreasing potential for vertical migration of high concentration COCs from the upper/middle portions of the Shallow Aquifer System to the Principal Aquifer System through Legacy Water Supply Wells, to the extent practical.*" We ask that the term "preventing" in the RAOs be used with "to the extent practicable/practical."
b. RAO-5: The text states: "*Minimize discharge of COC exceeding ecological risk-based concentration from the Shallow Aquifer System to surface water channels*." It is unclear how this objective is achievable using Alternative 5 (i.e., application of ISCO).
c. We understand that OCWD is planning to implement an in-situ remediation barrier along the Armstrong Channel in the area south of the Baxter Healthcare and Edwards Lifesciences sites (Figure 2-4). Since the bottom of the channel is unpaved and its elevation is below the water table, please explain how this remedy could be implemented effectively. In addition, please explain how the release of ISCO reagent into the channel will be avoided.
d. RAO-6: "*Prevent unacceptable human exposure to groundwater contaminated by COCs*." The wording should be revised to "Prevent human exposure to contaminated groundwater with COC concentrations exceeding drinking water MCLs or any other applicable regulatory levels."

EA's Response to Comment 10a

In the FSDE, the term "preventing" in the RAOs will be used with "to the extent practicable."

EA's Response to Comment 10b

Conceptually, ISCO could be applied to shallow groundwater in areas upgradient of where it is discharging into surface water channels at concentrations above surface water toxicity benchmarks identified in the HHRA (Appendix to SRI Report), with the goal of in situ reduction of groundwater COC concentrations before entering the channels to levels below the surface water toxicity benchmarks. As discussed during the meeting, the ISCO chemicals and treatment byproducts will also be evaluated as part of the FSDE. Revisions to respective portions of the FSISE are not needed, as such, no changes to these sections will be indicated in the FSDE.

EA's Response to Comment 10c
OCWD is not planning to implement an in-situ remediation barrier along the Armstrong Channel in the area south of the Baxter Healthcare and Edwards Lifesciences sites. However, the FSDE will evaluate the feasibility of implementing an in-situ remediation barrier along the Armstrong Channel in the area south of the Baxter Healthcare and Edwards Lifesciences sites. Revisions to respective portions of the FSISE are not needed, as such, no changes to these sections will be indicated in the FSDE.

EA's Response to Comment 10d
The wording of the FSDE will be revised to "Prevent human exposure to contaminated groundwater with COC concentrations exceeding drinking water MCLs or other Applicable or Relevant and Appropriate Requirements (ARARs)."

Comment 11
Section 4.1 General Response Actions – Monitored natural attenuation (MNA) has been listed under "In-situ Treatment Cleanup Actions." Please be advised that we do not consider natural attenuation a "cleanup action," because it is a passive remedy. MNA is more fitting under the "Monitoring" category in this section and throughout the FSISE.

EA's Response to Comment 11
Comment noted. The USEPA considers MNA to be a cleanup action, which can be applied as a sole remedy, as part of a combined remedial action, or as a finishing step. For example, the USEPA Office of Solid Waste and Emergency Response (OSWER) Directive 9283.1-36, Use of Monitored Natural Attenuation for Inorganic Contaminants in Groundwater at Superfund Sites (states:

> *"In addition, MNA, whether selected as the sole remedial action or as a finishing step, may be appropriate when it can achieve a site's remedial action objectives in a reasonable timeframe; thus, MNA remedies should not extend over very long timeframes, and the anticipated timeframes should be reasonable compared with other potential alternatives being considered. However, the document acknowledges that longer timeframes may be needed for some contaminants that degrade or decay over a long time period."*

OSWER Directive 9200.4-17P, Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites states:

> *"EPA does not consider MNA to be a "presumptive" or "default" remedy-it is merely one option that should be evaluated with other applicable remedies. EPA does not view MNA to be a "no action " or "walk-away" approach, but rather considers it to be an alternative means of achieving remediation objectives that may be appropriate for specific, well-documented site circumstances where its use meets the applicable statutory and regulatory requirements."*

"As there is often a variety of methods available for achieving remediation objectives at any given site, MNA may be evaluated and compared to other viable remediation methods (including innovative technologies) during the study phases leading to the selection of a remedy."

"In the majority of cases where MNA is proposed as a remedy, its use may be appropriate as one component of the total remedy, that is, either in conjunction with active remediation or as a follow-up measure."

"Use of MNA does not signify a change in OSWER's remediation objectives. These objectives (discussed in greater detail under the heading "Implementation") include control of source materials, prevention of plume migration, and restoration of contaminated groundwaters, where appropriate. Thus, EPA expects that source control measures (see section on "Remediation of Sources") will be evaluated for all sites under consideration for any proposed remedy. As with other remediation methods, selection of MNA as a remediation method should be supported by detailed site-specific information that demonstrates the efficacy of this remediation approach."

"When relying on natural attenuation processes for site remediation, EPA prefers those processes that degrade or destroy contaminants. Also, EPA generally expects that MNA will only be appropriate for sites that have a low potential for contaminant migration."

We understand the Santa Ana Water Board's perspective on MNA and believe that the designation of MNA as a remedial alternative could be grouped under a monitoring category. The FSISE classifies MNA as a process option within the In-Situ Groundwater Treatment remedial technology. This classification of MNA will not affect the analysis of MNA in the FSDE. Revisions to respective portions of the FSISE are not needed, as such, no changes to these sections will be indicated in the FSDE.

Comment 12

Section 4.2 Identification of Remedial Technologies and Process Options – Treated Water Discharge or End Use Options have been listed under "Remedial Technology" within the table under this section. "End use options" for treated water are not considered remedial technologies for cleanup of contaminated groundwater.

EA's Response to Comment 12

The subject table column header will be revised in the FSDE to "Remedial Technology & Discharge or End Use".

Comment 13

Section 5.1 Effectiveness – In the screening of remedial technologies, the short- and long-term effectiveness and reduction achieved should include discussion regarding toxicity, mobility and volume for all technologies that were considered. The short-term effectiveness refers to the construction and implementation period, and the long-term effectiveness refers to the period after the remedial action is completed.

EA's Response to Comment 13
The short- and long-term effectiveness and expected reductions achieved, including discussion regarding toxicity, mobility and volume for retained technologies identified in the FSISE will be evaluated in detail in the FSDE. Revisions to respective portions of the FSISE are not needed, as such, no changes to these sections will be indicated in the FSDE.

Comment 14
Section 5.4.4.1 Groundwater Extraction – The document refers to two publications by the United States Environmental Protection Agency, and states that pump and treat (P&T) "*'is a common method for cleaning up groundwater and other aqueous media contaminated with dissolved chemicals, including industrial solvents, metals, and fuel oil.*" P&T technologies must often operate for an extended period of time (decades) to meet aquifer cleanup goals, and in many cases may fail to achieve those goals. Limitations and concerns with this technology are evident when an assessment of remaining contaminant concentrations indicates an asymptotic curve, or when concentrations rebound after system shutdown. The residual mass of volatile organic compounds (VOCs) in groundwater tends to adsorb to organic materials in less permeable soils, and may later migrate back into the groundwater via back-diffusion, thus acting as a long-term source of contamination.

EA's Response to Comment 14
Comment noted. All remedial technologies retained in the FSISE are subject to the potential treatment limitations and concentration rebound posed by matrix back-diffusion. It is likely that, if selected, ISCO also would need to be applied for a relatively extended period of time. Revisions to respective portions of the FSISE are not needed, as such, no changes to these sections will be indicated in the FSDE.

Comment 15
Section 5.4.5.1.3 Membrane Processes – The text states, *"the rejected concentrate/brine solution is typically 85-95% of the influent flow for nanofiltration and 80-90% of the influent flow for* [reverse osmosis] *RO and would require discharge to a* [publicly owned treatment works] *POTW."* The ratio of permeate flow (product water) to feed flow is often referred to as a percent recovery. Rejected water can range from 20% to 50% of the feedwater, and is dependent on the number of stages in which the membranes are configured and the feed pressure. Please verify that the text is accurately defining the rejected concentrate/brine solution, recovery and their respective percentages.

EA's Response to Comment 15
The text of the FSDE will accurately define the rejected concentrate/brine solution, recovery, and their respective percentages.

Comment 16
Section 5.4.6.1 Injection – "*State Water Resources Control Board Resolution 92-49 prohibits degradation of groundwater used for potable uses.*" The correct citation for the State Water Resources Control Board's Anti-Degradation Policy is Resolution 68-16.

EA's Response to Comment 16

Comment noted and the FSDE text will be revised to reflect the correct citation.

Comment 17

Section 5.4.7.1 Monitored Natural Attenuation –

a) *If applied at appropriate locations, with an adequate monitoring network and analytical schedule, MNA is effective…*" Please explain the proposed method for selecting appropriate locations for MNA. The occurrence and continued success of natural attenuation is interdependent on the geophysical and geochemical characteristics of the subsurface, as well as the physical and chemical characteristics of the contaminant(s) that are present. As such, the concept of "applying MNA at appropriate locations" appears to be misguided.

b) *However, as a stand-alone remedial action, MNA would require a substantial number of monitor wells and …*" Please replace 'remedial action' with 'process option.'

EA's Response to Comment 17a

Performance monitoring generally is more important for MNA than for other types of remedies as a consequence of the potentially longer remediation timeframes, potential for ongoing contaminant migration, and other uncertainties associated with using MNA. MNA monitoring programs should specify the location, frequency, and type of samples, analyses, and measurements required to evaluate whether the remedy is performing as expected and is capable of achieving the remedial objectives. Thus, MNA monitoring programs should be designed to accomplish the following:

- Demonstrate that natural attenuation is occurring as expected;
- Detect changes in environmental conditions (e.g., hydrogeologic, geochemical, microbiological, or other conditions) that may reduce the efficacy of any of the natural attenuation processes;
- Identify any potentially toxic and/or mobile transformation products;
- Verify that the plume(s) is not expanding (either laterally or vertically);
- Verify no unacceptable impact to downgradient receptors;
- Detect new releases of contaminants to the environment that could negatively alter the effectiveness of the MNA remedy;
- Demonstrate the efficacy of institutional or other controls that may be applied to protect potential receptors; and
- Verify attainment of remediation objectives.

The preceding items will be evaluated in the FSDE in the context of the OU2 groundwater plumes, including the source sites and the existing monitor well networks, sampling frequencies, analytical schedules, and groundwater parameter measurements to determine where MNA might be appropriately or effectively applied. Revisions to respective portions of the FSISE are not needed, as such, no changes to these sections will be indicated in the FSDE.

EA's Response to Comment 17b

The term 'remedial action' in the FSDE will be replaced with 'process option.'

Comment 18

Section 5.4.7.3 Chemical Processes – The text states that the "*potential challenges associated with ISCO in OU2 include an inability to reduce COC concentrations before they cross flow from the*

Shallow Aquifer System into the Principal Aquifer System through Legacy Water Supply Wells in part because the locations of these wells are not precisely known and the remedy duration." The challenge in having limited knowledge of the locations of legacy water supply wells pertains to any type of remedial action within the South Basin. The ISCO remedy can typically be utilized for COC mass destruction, thereby preventing further degradation of groundwater quality by decreasing the migration of high concentrations of COCs into zones with lower concentrations of COCs, especially in areas of the plume that are derived from multiple sources (comingled). We recommend either removing the statement quoted above, or applying it to all general response actions, with the exception of the "no action" alternative.

EA's Response to Comment 18

The likelihood of Legacy Water Supply Wells acting to reduce the effectiveness of remedial actions or process options other than ISCO was stated in the FSISE for Groundwater Extraction, Physical Barriers, Monitored Natural Attenuation, Active In-Situ Bioremediation, and Groundwater Injection end use. Revisions to respective portions of the FSISE are not needed, as such, no changes to these sections will be indicated in the FSDE.

Comment 19

Section 5.5 Retained Remedial Technologies and Process Options – *"The Institutional Controls, Monitoring, and Sealing Legacy Water Supply Wells process options are not considered stand-alone remedial alternatives."* We recommend adding MNA to this list.

EA's Response to Comment 19.

While MNA may not be selected as a stand-alone OU2 interim remedy, it was classified as such in the FSISE to allow for further detailed evaluation in the FSDE. Revisions to respective portions of the FSISE are not needed, as such, no changes to these sections will be indicated in the FSDE

Comment 20

Section 6.2.3 Alternative 3 – *"Groundwater would be extracted in higher concentration areas to: decrease lateral …; and begin to treat and reduce the concentrations of COCs in groundwater."* We recommend replacing 'concentrations' with 'mass' in the quoted sentence. The same sentence is repeated under the descriptions of Alternatives 5 and 6, and should also be revised.

EA's Response to Comment 20.

Concentration data are what is generated by laboratory analysis of groundwater samples and provides a quantifiable physical measure that can be mapped and trended. For the purposes of the quoted sentences identified in comment 20, the term 'concentration' can be understood to be synonymous with 'mass,' as it represents mass per a standard volume, and the FSDE text will be revised to address this comment.

Comment 21

Section 6.2.5 Alternative 5 Containment and Treatment of Relatively High Concentration and Leading-Edge Areas Using In-Situ Chemical Oxidation – The text proposes a Pre-Design Investigation (e.g., target contaminants, lithology, hydrogeology, and other site-specific conditions) if the selected alternative is ISCO (Persulfate activation). The Pre-Design Investigation should not be limited to Alternative 5 and it should be applied to other alternatives that also involve containment and MNA.

a) It would be prudent to conduct additional investigations with respect to data gaps, lithology, hydrogeology and site-specific conditions (e.g. geochemical data, bench scale testing, pilot studies, etc.), in order to optimize the design of OCWD's interim remedy. Improper design may result in remedy ineffectiveness (i.e. limited reduction in COC concentrations and extended cleanup timeframe), the inability to scale treatment of the IRM to a full scale remedy, and/or interference with current source site remedies or proposed future remedies (i.e. generating unfavorable byproducts, causing unwanted plume migration, altering groundwater geochemical conditions, dewatering monitoring wells). Periodic post-implementation monitoring will aid in confirming the remedy's effectiveness and performance.
b) The text states, "Persulfate activation is required to convert the persulfate into the highly reactive persulfate radical, …" For further clarification, please insert 'anion' after the second 'persulfate' in the quoted sentence.

EA's Response to Comment 21a
As discussed during April 7, 2021 TAC meeting, a Pre-Design Investigation would be implemented for ISCO and other potential remedial alternatives. Revisions to respective portions of the FSISE are not needed, as such, no changes to these sections will be indicated in the FSDE.

EA's Response to Comment 21b
The FSDE will incorporate the requested change.

Comment 22
Section 6.2.6 Alternative 6 – *"As conceptually illustrated on Figure 2-5, … and accessible locations within a selected high concentration area with OU2, …"* It seems that 'in' is missing between 'with' and 'OU2.'

EA's Response to Comment 22
The subject sentence in the FSDE will be revised to read: *"As conceptually illustrated on Figure 2-5, … and accessible locations within a selected high concentration area within OU2, …"*

Comment 23
Figure 1-5 – The monitoring well locations for the Former Standard Screw Products facility should be shown in the figure, and should be consistent with the information presented in Figure 5-1 in the RI Report.

EA's Response to Comment 23
The FSDE will incorporate the requested change.

Comment 24
Figure 1-14 – The extent of perchlorate impacts originating from the former LNP site within the upper portion of the shallow aquifer system as depicted for concentration ranges of 6 to 60 µg/L is not consistent with our records for perchlorate impacts originating from the referenced site in the A and B water-bearing zones (also refer to comment 5, above).

EA's Response to Comment 24

Comment noted. We understand that there may be differences in the way that perchlorate distributions are illustrated by different parties, using different HSUs and different datasets. We also understand that the perchlorate plume originating from the LNP source site will be managed and remediated by the responsible party and as such, the FSDE will not consider interim remedial actions in this area. However, perchlorate is an OU2 COC, and figures illustrating the distributions of perchlorate will be included in the FSDE (also see EA's response to Comment 25a).

Comment 25

Figures 1-18 through 1-23 – The figures depict cis-1,2-dichloroethene (cis-1,2-DCE) and hexavalent chromium detections throughout the study area. Please address the following:

a) Provide plume contours for cis-1,2-DCE and hexavalent chromium.
b) The figure legend and icons should be revised to be consistent with Figures 1-6 through 1-15 as presented in the RI Report.
c) The vertical depth intervals should be revised to be consistent with other related figures (i.e., Upper and Middle portions of the shallow aquifer versus Layers 1-4).

EA's Response to Comment 25a

It was agreed during the April 7, 2021 TAC meeting that the FSDE would include figures illustrating color-coded symbols classified by concentration ranges ('color dot maps') for each COC, for each of Layers 1 through 4; that contours for individual COCs would not be prepared; and that additional figures may be considered after the TAC reviews these figures in the draft FSDE.

EA's Response to Comment 25b

The FSDE figures will be prepared consistent with EA's response to Comment 25a.

EA's Response to Comment 25c

It was agreed that the vertical depth intervals for these figures would remain as-is: this provides consistency with the cross sections in the SRI Report, with the groundwater flow model, and with the figures that will be prepared as part of the FSDE. Revisions to respective portions of the FSISE are not needed, as such, no changes to these sections will be indicated in the FSDE.

Comment 26

Figure 2-4 and Figure 2-5 – The figures include implementation of "Alternative 5- ISCO" and "Alternative 6-groundwater extraction and treatment combined with ISCO" immediately downgradient of the Embee Plating facility. The Santa Ana Water Board has authorized discharges of amendment at the Embee site, in accordance with the General Waste Discharge Requirements for In Situ Groundwater Remediation (Order No. R8- 2018-0089), since 2016. Groundwater treatment has been ongoing at the site, using bioremediation and in-situ chemical reduction for treatment of VOCs, perchlorate, and hexavalent chromium. It appears that implementation of Alternative 5, downgradient of Embee Plating, may not be compatible with the efforts of the responsible party (RP) to create oxygen-reducing conditions in the subsurface, and thereby remediate the hexavalent chromium contamination attributable to the Embee facility. Application of extraction activities per Alternative 6 may potentially impact groundwater flow around the Embee site. This effect should be evaluated to ensure that capture zones of the extraction wells and implementation of ISCO will not have negative effects on in-situ remediation efforts that are based on reducing geochemical conditions. Specifically, remediation of the hexavalent chromium plume that originated from the referenced site may negatively be impacted by implementation of ISCO.

EA's Response to Comment 26
The FSDE will include evaluations to determine whether extraction well capture zones and/or implementation of ISCO will likely or potentially have substantial negative impacts on in-situ remediation efforts at the Embee Plating facility source site that are based on reducing geochemical conditions. Revisions to respective portions of the FSISE are not needed, as such, no changes to these sections will be indicated in the FSDE.

Comment 27
Figure 2-4 – Please remove the proposed application area next to the ITT Cannon's planned in-situ remediation area. We have already discussed the expansion of the planned remedy with the RP to include areas further to the south.

EA's Response to Comment 27
The FSDE will be revised to incorporate the requested change per Santa Ana Water Board Comment 2.

Comment 28
Appendix A Applicable or Relevant and Appropriate Requirements (ARARs) – Santa Ana Water Board staff have provided comments to the ARARs in a letter dated July 25, 2018. Please ensure these comments are addressed.

EA's Response to Comment 28
The FSDE will include updated ARARs, which will incorporate the Santa Ana Water Board comments on the ARARs in their referenced letter.

3.0 RESPONSE TO DFA COMMENTS

Comment 1. Specific Recommended Remedial Action Objectives (RAO), Page 12– The RAOs do not include proposed groundwater cleanup goals, the area that would be addressed by the groundwater cleanup activities and, estimated timeframe for achieving the groundwater cleanup goals. The RAOs should be updated to include groundwater cleanup goals, the area addressed by groundwater cleanup activities and estimated timeframes for achieving the proposed groundwater cleanup goals.

EA's Response to Comment 1
Interim Remedial Actions do not require numeric cleanup goals as part of RAOs, nor do they provide an estimate for cleanup times (USEPA, 1991 and 1999b). In accordance with the USEPA guidance, OCWD intends to implement IRMs that will be consistent with and transition to a final remedy. Revisions to respective portions of the FSISE are not needed, as such, no changes to these sections will be indicated in the FSDE.

Comment 2. Geologic and Hydrogeologic Framework, Page 20: The description of hydrogeologic zones in the Project area appears to be inconsistent with the description provided in the Supplemental Remedial Investigation Report (Supplemental RI Report), dated July 1, 2020. The description of the Shallow Aquifer System, which ranges from near land surface to a depth of approximately 162 ft below ground surface (bgs), was divided into the four layers (Layer 1 through 4). No explanation or justification was provided in the FSISE Report describing why this change was made. Furthermore, inconsistencies between the Supplemental RI and FSISE Report raises concern that contaminant plume maps provided for the Shallow Aquifer System may not be consistent with the contaminant distribution and data gaps described in the RI Report (i.e. extent of groundwater contamination and data gaps) and the development and evaluation of feasible remedial alternatives provided in the FSISE Report. The interpretation of the Shallow Aquifer System layer provided in the FSISE Report should be revised to be consistent with the hydrogeologic interpretation provided in the Supplemental RI Report, or the FSISE Report should be updated to justify these changes. In addition, if changes to the hydrogeologic interpretation are made, the FSISE Report should include updated groundwater plume maps that incorporate changes to the Shallow Aquifer System layer.

<u>EA's Response to Comment 2</u>
As discussed during the April 7, 2021 TAC meeting, the geologic and hydrogeologic framework used in the FSISE is consistent with the SRI Report. Also refer to our responses to Santa Ana Water Board Comments 5 and 25a above for additional clarification.

4.0 REFERENCES

California Regional Water Quality Control Board, Santa Ana Region (Santa Ana Water Board, 2021. Letter from N. Amini, Santa Ana Water Board, to B. Leever, Orange County Water District re: Comments on the Draft Feasibility Study Initial Screening Evaluation for the Orange County South Basin Groundwater Protection Project, Operable Unit 2. March 25, 2021.

Engineering Analytics, Inc., 2021. Draft Feasibility Study Initial Screening Evaluation, South Basin Groundwater Protection Project, Operable Unit 2. February 3, 2021.

Hargis + Associates, Inc., 2020. Supplemental Remedial Investigation Report, Orange County Water District, South Basin Groundwater Protection Project, Operable Unit 2. July 1, 2020.

USEPA, 1991. Guide to Developing Superfund No Action, Interim Action, and Contingency Action RODs. April 1991.

USEPA, 1999a. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites. April 1999.

USEPA, 1999b. A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents. July 1999.

USEPA, 2015. Use of Monitored Natural Attenuation for Inorganic Contaminants in Groundwater at Superfund Sites. August 2015.

APPENDIX L
05/26/21 OCWD SOUTH BASIN TECHNICAL ADVISORY COMMITTEE MEETING MINUTES (D1712505)

MINUTES

OCWD South Basin Technical Advisory Committee Meeting (D1712505)

May 26, 2021
2:30 pm – 3:30 pm

MS Teams Link click here
Phone only: +1 (916) 535-3094, Phone Conference ID: 943 955 973#

Attendees:

X	Robert Reeves	DFA	Prop 1 Program Manager	Robert.Reeves@waterboards.ca.gov
X	Aparjeet Rangi	DFA	Project Manager	Aparjeet.Rangi@Waterboards.ca.gov
X	Jessica Law	RWQCB	Site Cleanup Program	Jessica.Law@Waterboards.ca.gov
X	Meghan Tosney	DFA	Chief Prop 1 GWGP	Meghan.Tosney@waterboards.ca.gov
X	Chad Nishida	RWQCB	Site Cleanup Program (Prop 1)	Chad.Nishida@Waterboards.ca.gov
X	Mehrnoosh Behrooz	RWQCB	Site Cleanup Program	Mehrnoosh.Behrooz@Waterboards.ca.gov
	Carl Bernhardt	RWQCB	Site Cleanup Program	Carl.Bernhardt@Waterboards.ca.gov
X	Kayla Kawamura	RWQCB	Site Cleanup Program	Kayla.Kawamura@Waterboards.ca.gov
X	Nick Amini	RWQCB	Chief, Site Cleanup Program	Nick.Amini@waterboards.ca.gov
X	Ann Sturdivant	RWQCB	Supervising Engineering Geologist	Ann.Sturdivant@waterboards.ca.gov
X	Bill Leever	OCWD	Project Manager	wleever@ocwd.com
X	Roy Herndon	OCWD	Chief Hydrogeologist	rherndon@ocwd.com
X	Chris Ross	EA	Project Manager	CRoss@enganalytics.com
X	Errol Lawrence	EA	Project Hydrogeologist	elawrence@enganalytics.com

2:30-2:35	**Roll Call/Introduction**	Bill Leever

2:35-3:25	**Groundwater Model and Overview of CSM/Model Laying**	Errol Lawrence/Chris Ross

Errol used the PowerPoint slides attached to these minutes to present the SBGPP numerical flow model development and calibration. The top of Layer 1 is ground surface derived from LIDAR data. There is a muted water level response shown in hydrographs in the Shallow aquifer system (Layers 1-4) relative to Principal aquifer system (Layer 6). Coloration of K values and orientation of K zones are influenced by depositional environment. 56 well point calibration targets were used in the model. Roy mentioned that a separate hydrogeologic investigation by OCWD south of the 405 freeway identified aquifer mergence zones on either side of the Orange County Airport, near the southern model domain boundary. RMSE calibration values are included in the analysis and will be included in the detailed remedial alternatives evaluation tech memo. The “Basin Model” Errol referred to during the presentation is OCWD’s regional model groundwater flow model that covers the entire Orange County Groundwater Basin. The calibration period (2007 to 2017) was selected to include a range of hydraulic conditions (both high and low water levels) where high quality regional groundwater level data was available. The older non-District wells in the southern part of the Study Area were used in the calibration and new SAM wells (SAM 7 to SAM 13) were assigned synthetic values, or projections of potentiometric surface and both were extrapolated backwards in time. Vertical gradients representative of both the north and south parts of the Study Area were captured in the model. The calibration is reasonable, and the TM will include calibration hydrographs for all target wells. The model cell size is 125'x125' throughout the Study Area. Chad asked whether MCAS Tustin has a groundwater flow model and if so whether any analysis was done to evaluate and compare the results to the SGBPP model, specifically near SAM-11 and the MCAS boundary. The SGBPP model was not compared to any MCAS Tustin model, if available, and it is unknown if the model layering and calibration is comparable. All source area extraction wells were used in model calibration. All the extraction well data was obtained through online sources, including Geotracker, and will be summarized in the detailed remedial alternatives evaluation TM. Responding to a question, Chris said a model is typically updated based on new information collected during pre-design and within a year of operation of a remedial system.

3:25-3:27	**Schedule Update, Next Steps on the TM**	Bill Leever/Chris Ross

No changes to the current schedule submitted during the February 2021 TAC meeting are currently projected.

3:27-3:30	**Walk-in Items, Action Item Recap, Adjourn**	

None.

Action Items:

1. **Bill to provide copy of model presentation to TAC and upload to Geotracker with final meeting minutes.**

GROUNDWATER MODEL STATUS UPDATE

SOUTH BASIN GROUNDWATER PROTECTION PROJECT

May 26, 2021

SBGPP MODEL OBJECTIVES

- Groundwater flow modeling is developed in support of the SBGPP RI/FS being conducted by OCWD to address groundwater contamination in the south-central portion of the Orange County Groundwater Basin.

- The modeling is developed to support OCWD in evaluation of groundwater extraction and insitu remedial alternatives identified in the FS screening process.
  - The remedial alternatives are intended to address groundwater contamination in OU2 within the SBGPP.

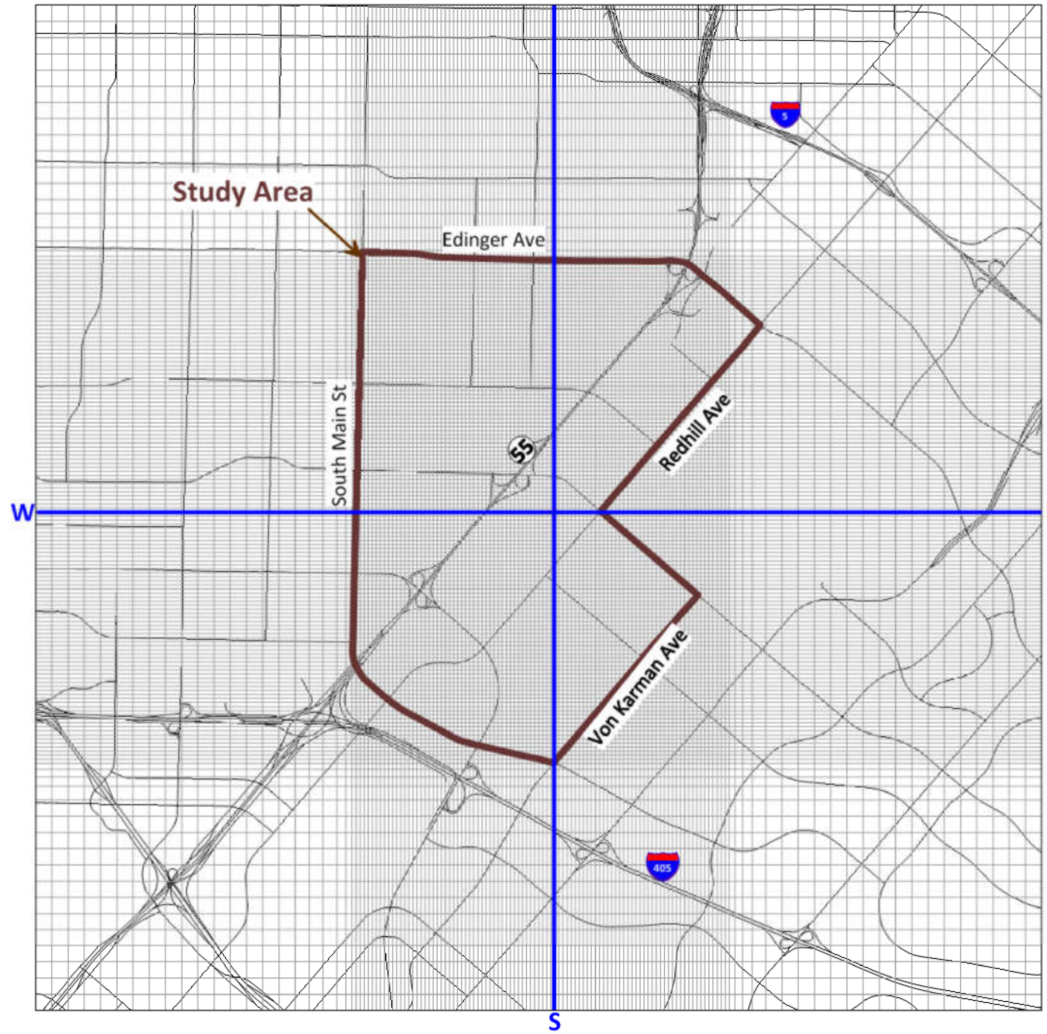
KEY FEATURES OF THE SBGPP MODEL

The SBGPP Groundwater flow is based on the current site conceptual hydrogeologic model (SCHM). The numerical model:

- replicates low and high potentiometric cycles observed in the Shallow Alluvial Aquifer System;
- incorporates horizontal and vertical aquifer heterogeneity demonstrated from extensive aquifer testing;
- includes ongoing and historic source site remedial extraction systems;
- is calibrated to observed water level conditions and hydraulic gradients; and
- is suitable for evaluation of remedial alternatives identified in the FS for OU2 groundwater contamination.

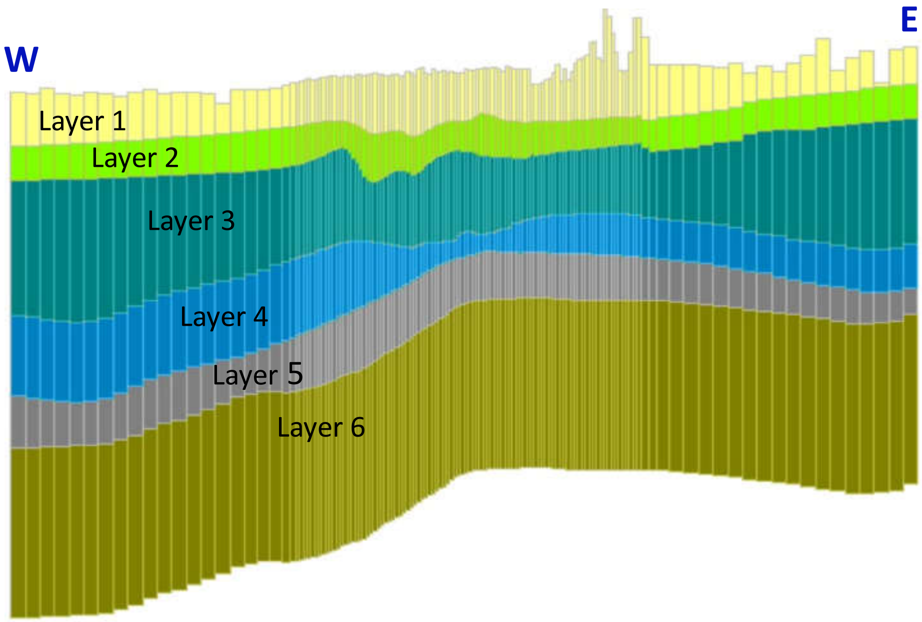
MODEL DOMAIN, GRID and CODE

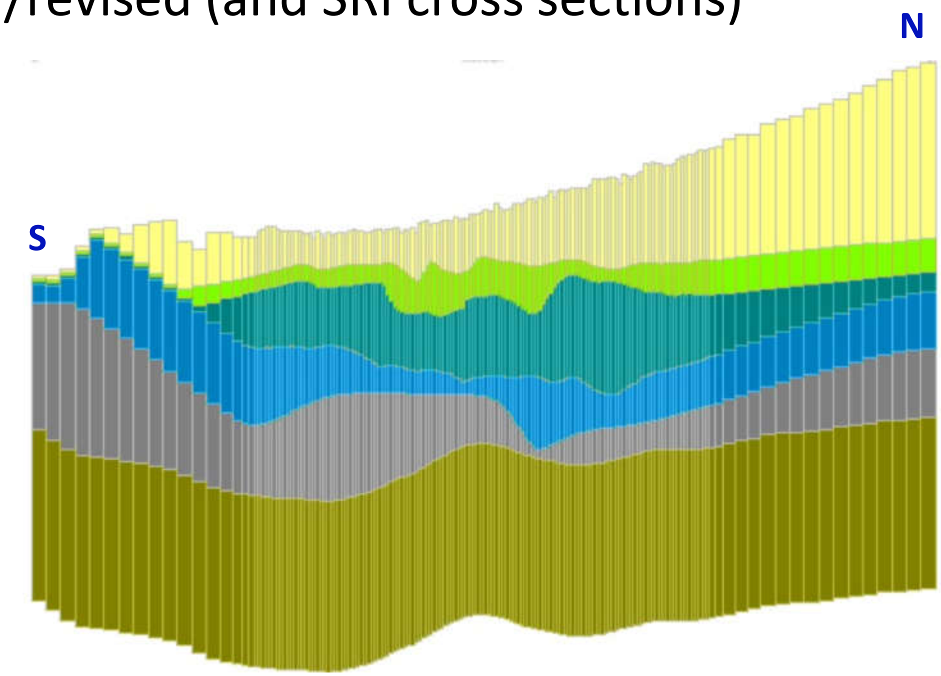
- Model Domain is
  31,000 ft x 31,000 ft
- Finite Difference Grid
  - 159 Rows and 135 Columns
  - Variable Grid Spacing
    125 ft to 500 ft
- Model Code is
  MODFLOW–SURFACT



MODEL LAYERING

- Six Layers based on Basin Model-updated/revised (and SRI cross sections)
  - Layer 1 to 4 = Shallow Aquifer System
  - Layer 5 = Aquitard
  - Layer 6 = Upper Principal Aquifer (100 ft)



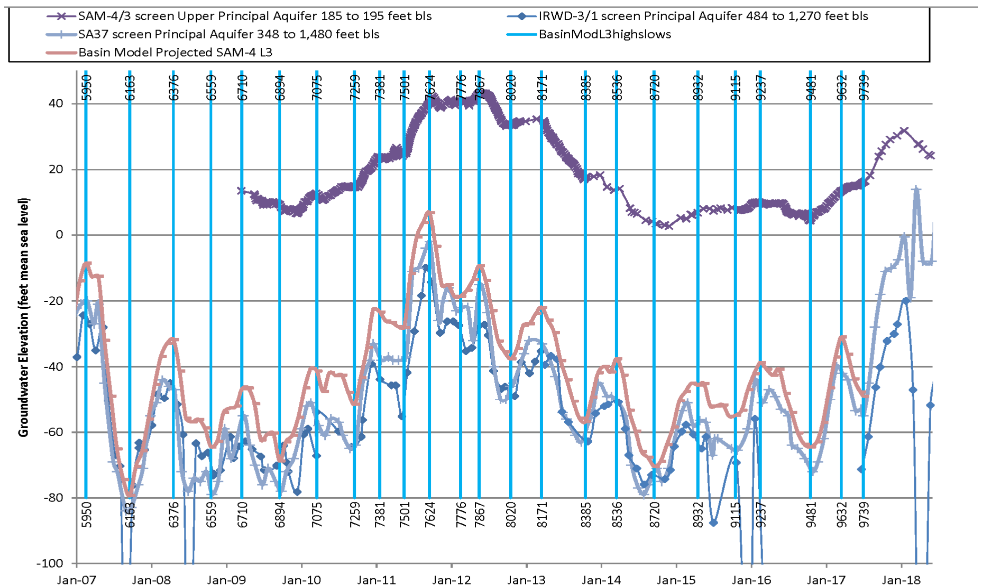


Simulation Period-Feb 15, 2007 to July 1, 2017

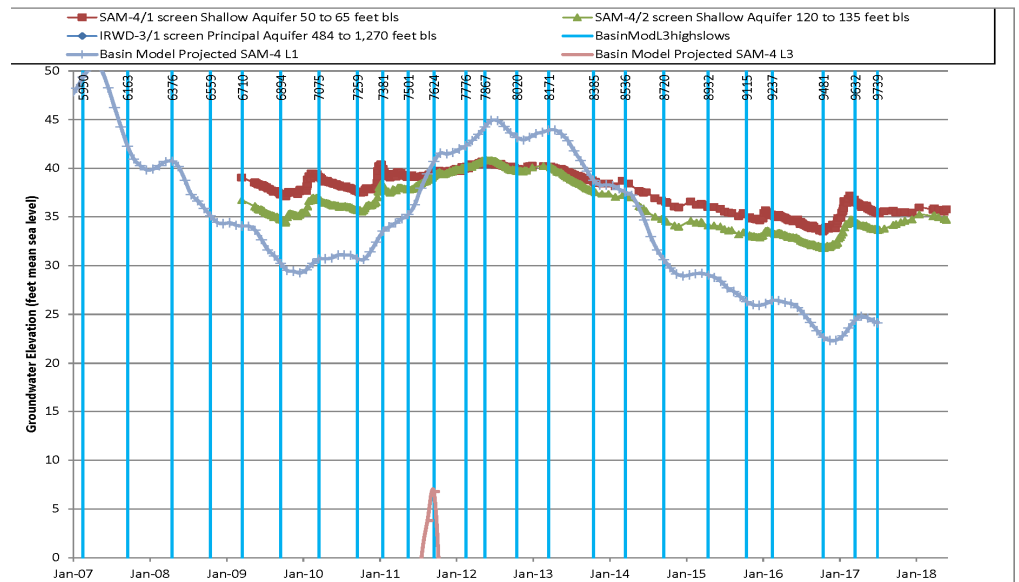
Encompasses regional low and high potentiometric cycles

23 Stress Periods covering 3789 days, SPs ranging from 91 to 244 days long

Upper Principal L6



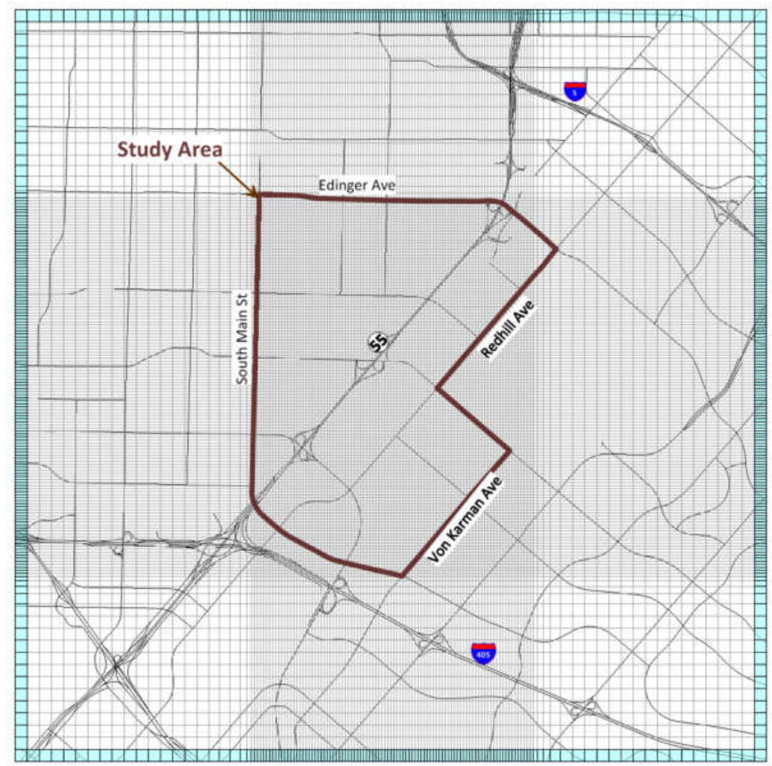
Shallow L1 to L4



BOUNDARY CONDITIONS (I)

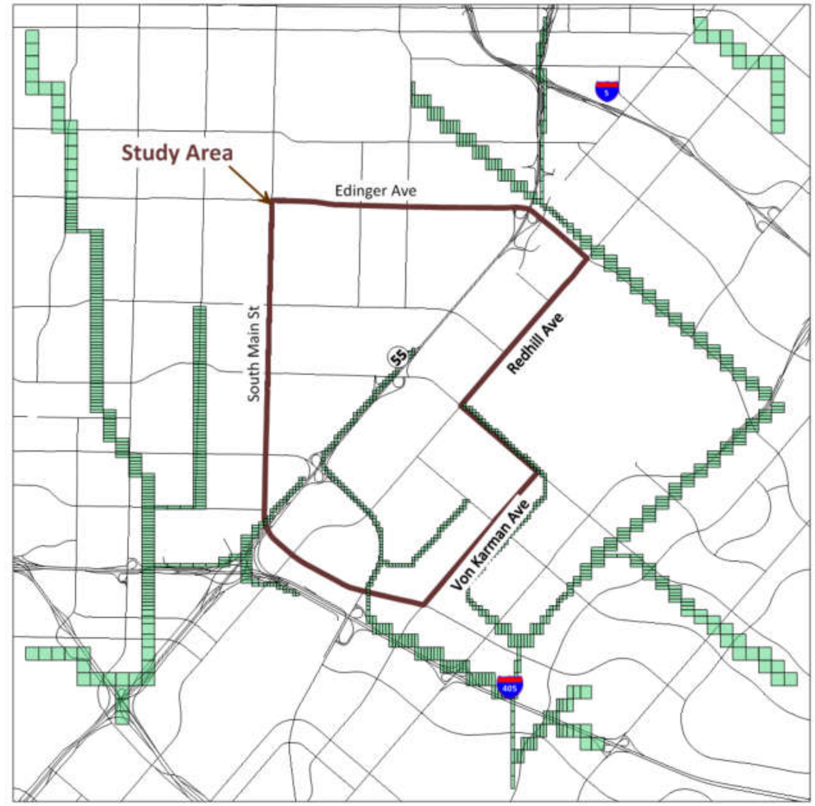
Constant Head Boundaries assigned around perimeter of the model in Layers 1, 2 and 4 (Shallow), and Layer 6 (Upper Principal)

- Shallow Aquifer Layers
  - Water Levels originally exported from Basin Model Layer 1 (Shallow)
  - Revised to reflect 2008 (Low), 2012 (High) and 2016 (Low) Potentiometric Conditions
  - CHs are interpolated between Stress Periods
- Upper Principal
  - Derived from Basin Model -projected Principal Aquifer water levels corrected using a ratio based on observed water levels at Shallow SAM-4/2, Upper Principal SAM-4/3, and Principal IRWD-3



BOUNDARY CONDITIONS (II)

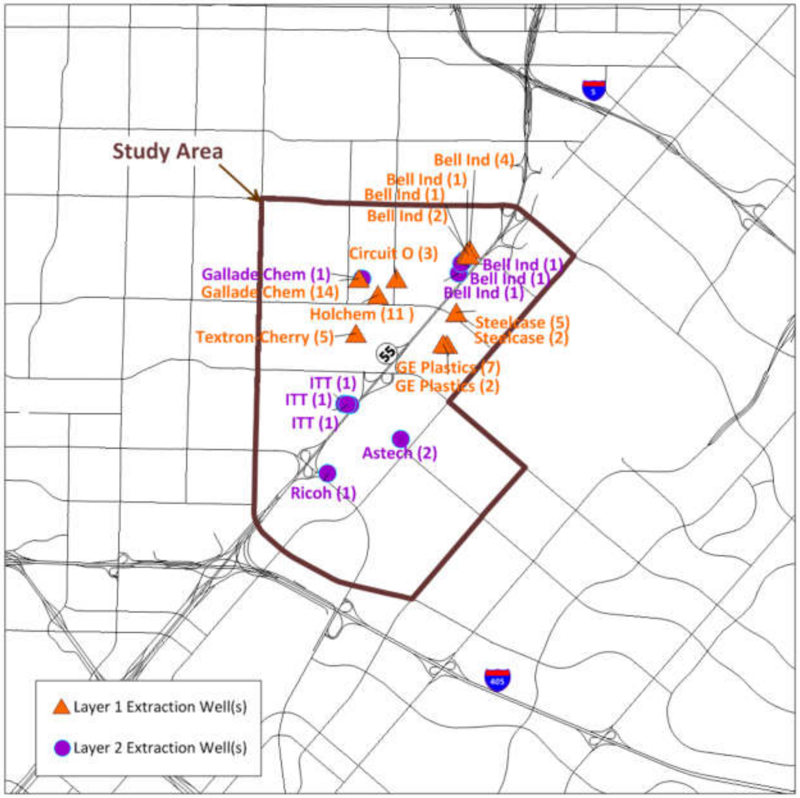
- Surface channels simulated using the river boundary condition
- River BC allows water to flow into or out of the model
- Model Inputs:
  - Channel bottom elevation-land surface (Lidar)
  - Stage =0.5 ft above channel bottom
  - Channel bed conductance
    - Calculated from channel length, width, bed thickness, and hydraulic conductivity,
  - Only conductance was varied during calibration



BOUNDARY CONDITIONS (III)

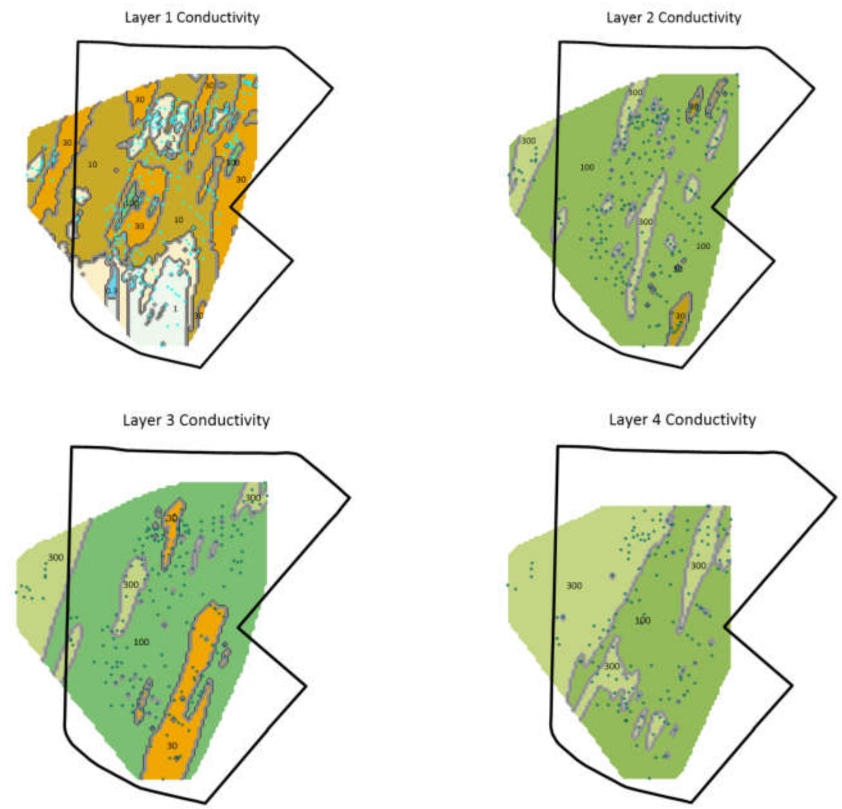
- Source Site Extraction Systems simulated using the well package of MODFLOW

- Model Inputs:
  - Model Layer
  - Stress Period of Operation
  - Extraction Rate (average during Stress Period)
  - At some source sites, multiple wells are combined due to proximity to each other or to very low pumping rates.

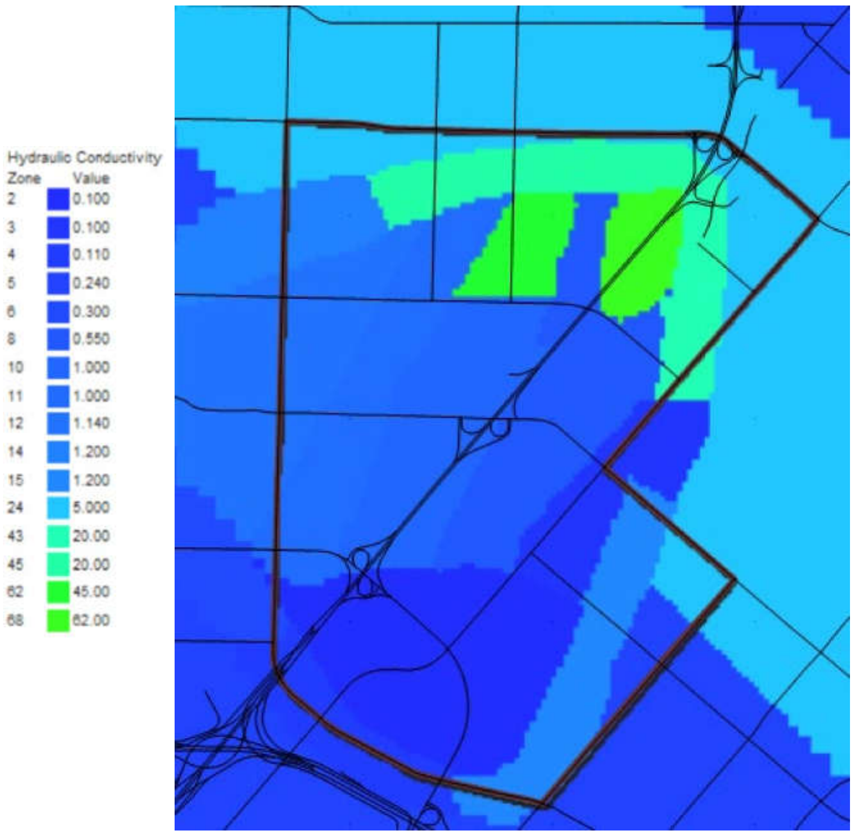


STUDY AREA - INITIAL HYDRAULIC CONDUCTIVITY ESTIMATE

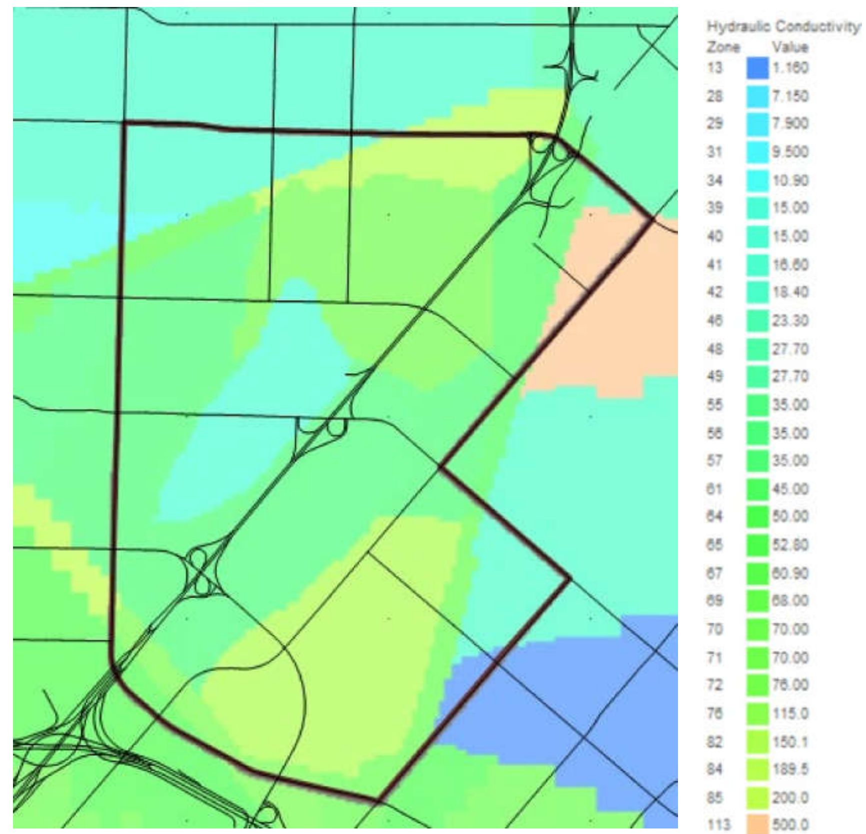
- Calculated thickness weighted average conductivity within each layer at each cell using published SBT-K relationship (Robertson, 2000) (used the geometric mean of range).
- Kriged the layer weighted hydraulic conductivity for each layer independently, using a distance weighting (5 times at 70 degrees) and setting conductivities at about half log scales between 1 and 300 feet per day



CALIBRATED HYDRAULIC CONDUCTIVITY ZONES
LAYERS 1 & 2



Layer 1



Layer 2

MODEL CALIBRATION

- Calibration Targets
  - Observed Water Level Elevations for Key Wells from RI
  - Synthetic values derived for wells 2Sam-7 through 2Sam-13
  - Vertical gradients between upper and lower shallow aquifers (qualitative)
- Achieved through combination of manual (trial and error) and inverse modeling (PEST)
- Additional model validation through particle tracking (flowpaths)

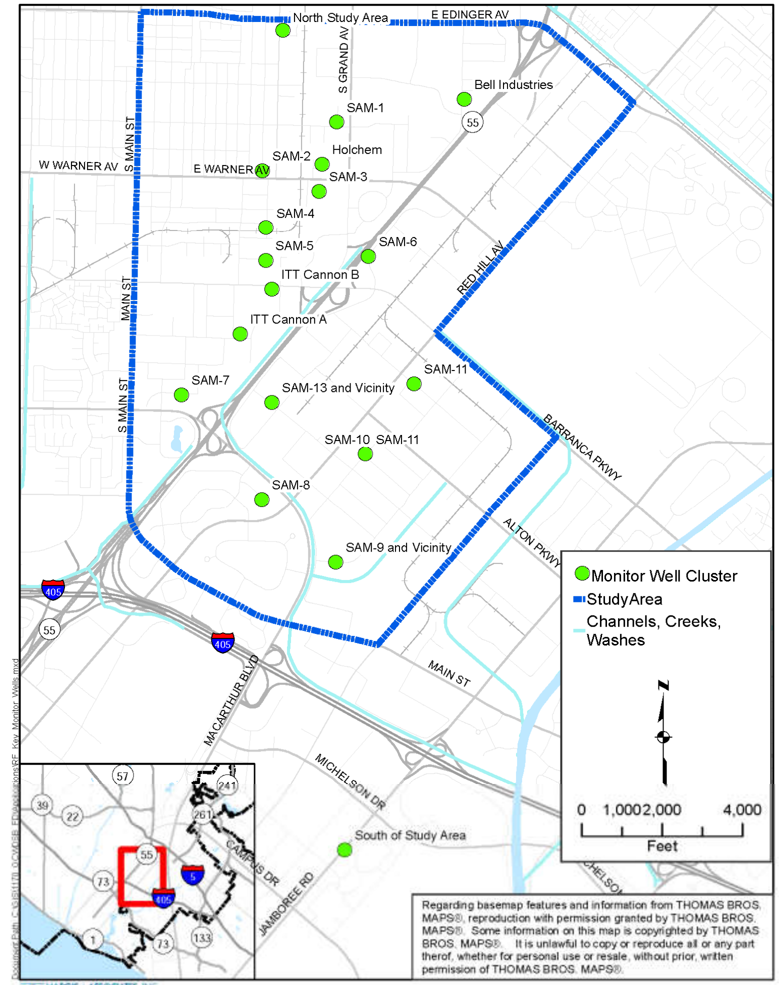


FIGURE 4-8: KEY MONITOR WELL CLUSTERS

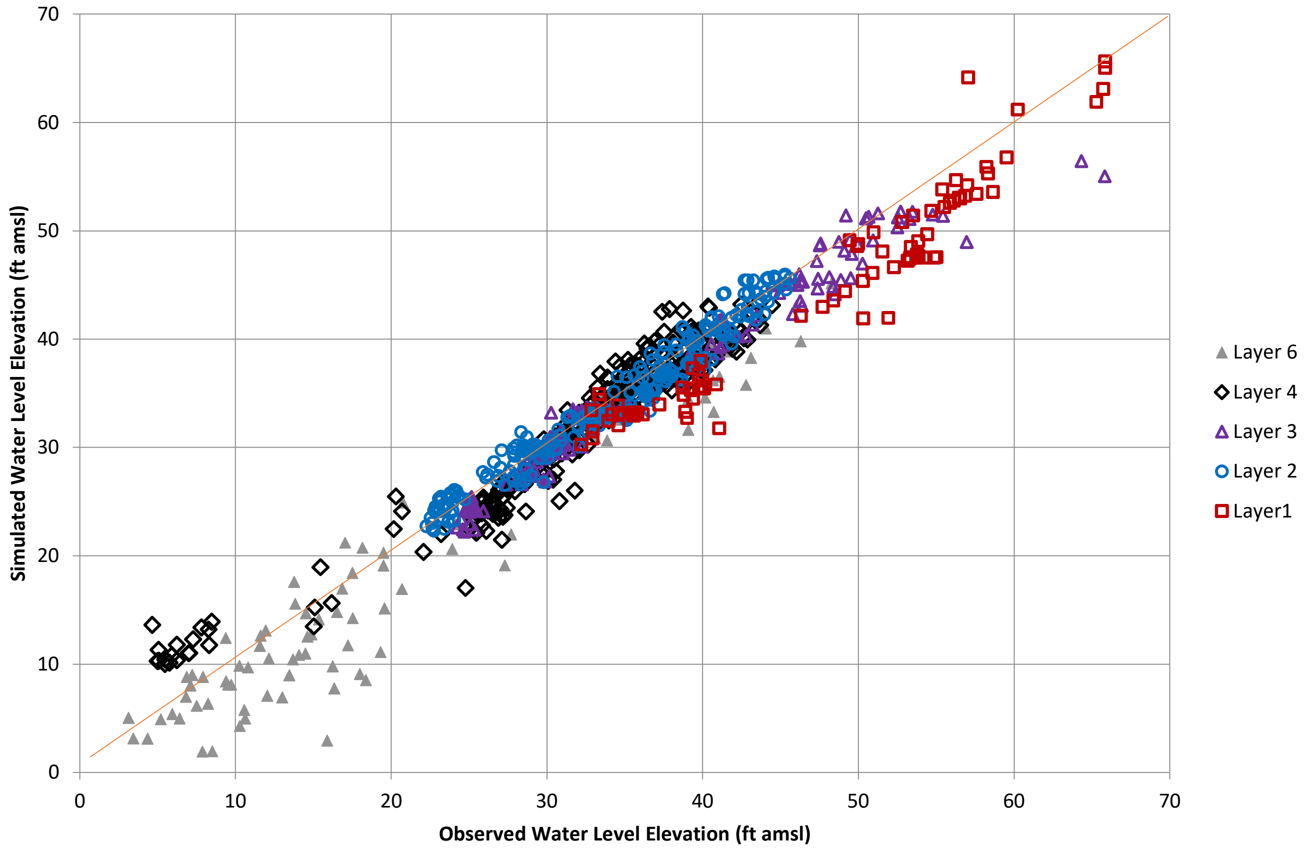
SBGPP MODEL CALIBRATION (3/05/21)

CALIBRATION STATISTIC	All Layers	Layer 1	Layer 2	Layer3	Layer 4	Layer 6
Residual Mean	0.75	3.38	-0.13	0.90	0.16	2.39
Absolute Residual Mean	1.75	3.64	1.06	1.24	1.67	3.10
Residual Std. Deviation	2.36	2.46	1.28	1.66	2.24	3.28
Sum of Squares	5455	1503	431	586	1421	1514
RMS Error	2.48	4.18	1.28	1.88	2.24	4.06
Min. Residual	-8.97	-7.10	-3.10	-2.94	-8.97	-4.19
Max. Residual	12.94	9.98	3.22	10.78	7.74	12.94
Number of Observations	888	86	262	165	283	92

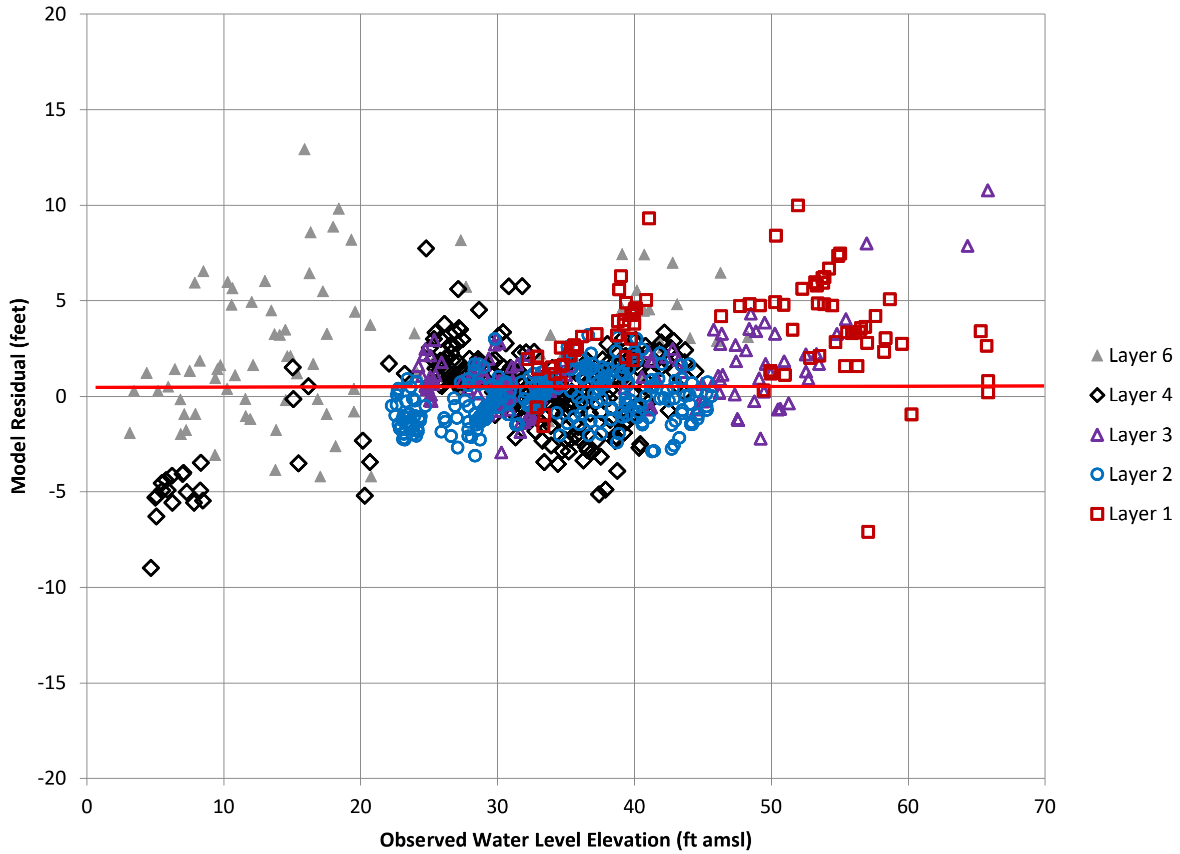
CALIBRATION STATISTIC	All Layers (Wtd*)	Layer 1 (Wtd*)	Layer 2 (Wtd)	Layer 3 (Wtd)	Layer 4 (Wtd)
Residual Mean	0.39	3.39	0.00	0.40	-0.04
Absolute Residual Mean	0.92	3.47	0.79	0.64	0.72
Residual Std. Deviation	1.61	2.27	1.12	1.14	1.26
Sum of Squares	2450	1432	330	240	448
RMS Error	1.66	4.08	1.12	1.21	1.26
Min. Residual	-5.12	-1.56	-3.10	-2.94	-5.12
Max. Residual	9.98	9.98	3.22	4.32	3.35
Number of Observations	487	80	193	71	143

Wtd* - Weighted values exclude synthetics, observations outside of Study Area and in Layer 6

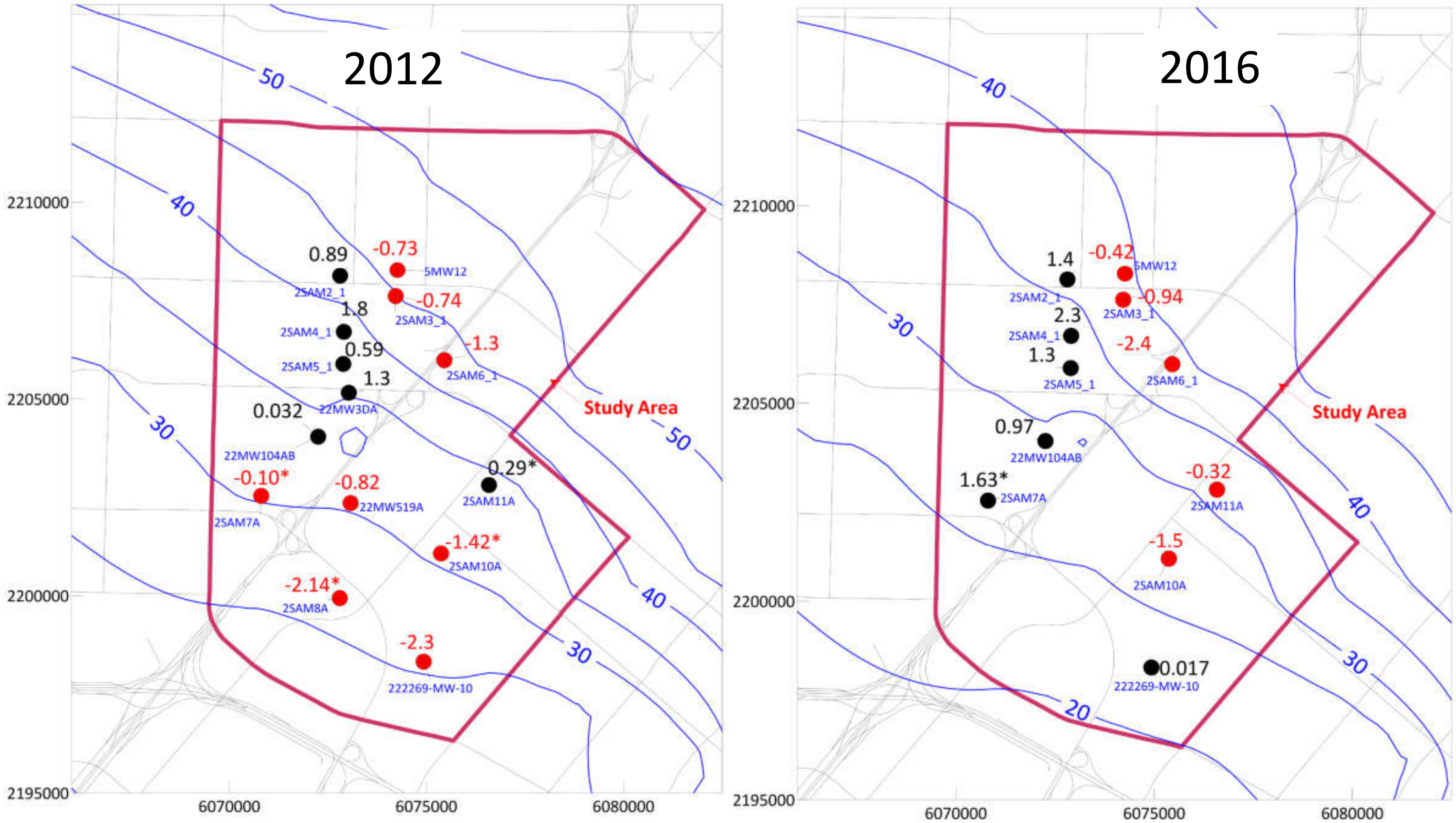
Observed vs Simulated Heads (All Targets)



Observed vs Residuals (All Targets)



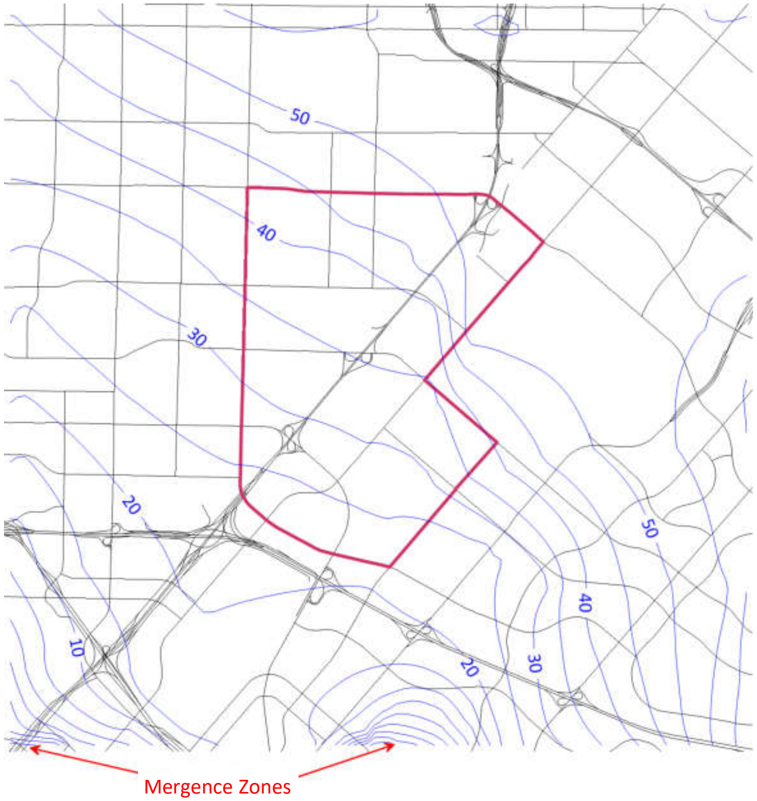
Simulated Potentiometric Surface-Layer 2



Negative Residual=overpredicted head   Positive Residual=underpredicted head

* Residual from synthetic head

Simulation of the "Mergence Zone"

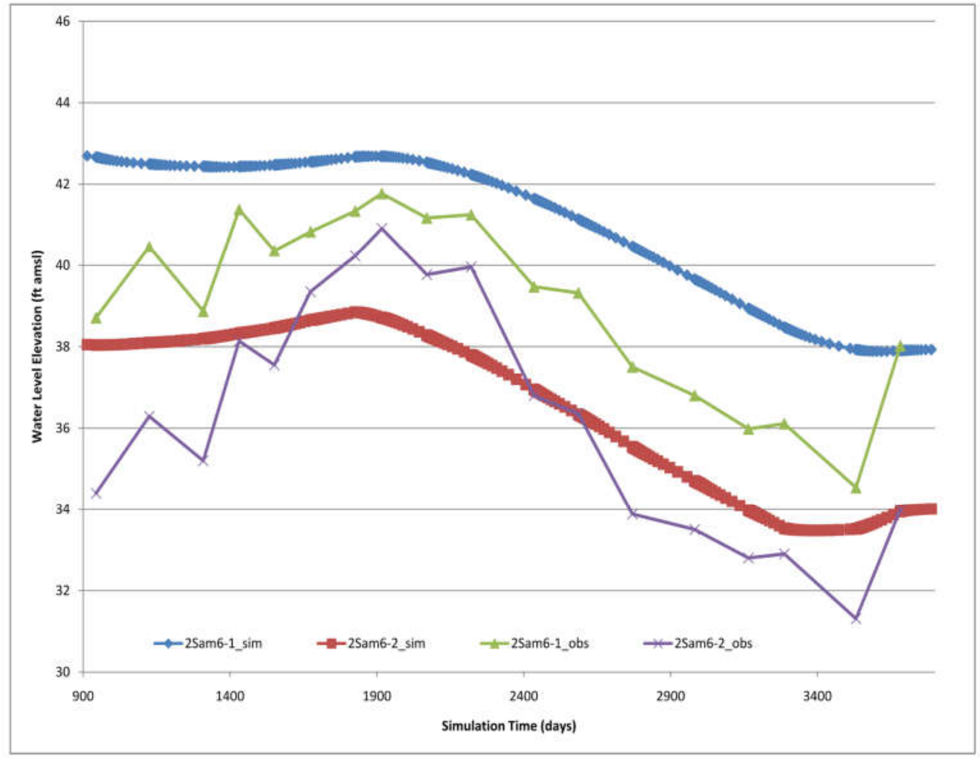


Simulated Potentiometric Surface-Layer 4

- Revised conceptual model suggests the presence of mergence zones near the southern model boundary
  - These are areas where the confining unit between the Shallow and Upper Principal Aquifers may be absent
  - Groundwater may flow from the Shallow to the Upper Principal Aquifer at those locations
- Mergence zones were incorporated into the numerical model by increasing hydraulic conductivity in Layer 5

Vertical Hydraulic Gradients

2Sam 2-1 and 2-2



2Sam 6-1 and 6-2

Summary

- SBGPP Model was developed based on the Basin Model and current conceptual hydrogeologic site model
  - Changes in layering, BCs, K zones, extraction wells, added mergence zone
- Calibration appears reasonable across the simulated time period
- Calibration match is very good within Study Area for Layers 2, 3 and 4
- Simulated Potentiometric surfaces reasonably reflect observed gradients within and between subunits of the Shallow Aquifer
- The calibrated model is suitable for evaluation of remedial alternatives developed from feasibility study screening.

Next Steps

- Currently conducting remedial simulations
- Focus on
  - Capture zone along groundwater extraction transects
  - Groundwater flux through insitu transects
  - Changes in velocity and direction of groundwater flow in vicinity of active and planned source site remedial measures
- Simulation results to be included in the Feasibility Study Detailed Evaluation Tech Memo

APPENDIX M
06/17/21 RWQCB COMMENTS ON THE DRAFT FSISE FOR OCWD SOUTH BASIN

Nishida, Chad@Waterboards

From: Amini, Nick@Waterboards
Sent: Thursday, June 17, 2021 10:29 AM
To: wleever@ocwd.com
Cc: RHerdon@ocwd.com; CRoss@enganalytics.com; KPuentes@enganalytics.com; Tosney, Meghan@Waterboards; Reeves, Robert@Waterboards; Rangi, Aparjeet@Waterboards
Subject: RE: Comments on the Draft FSISE for OCWD South Basin

Hi Bill,

The following is our comments to the EA's response to our comments on the Draft FSISE for the South Basin:

1. **EA Response to Comment 5 (Section 1.3.1 Geologic and Hydrogeologic Framework:** The response should indicate: "*additional figures may be considered after the TAC reviews these figures in the draft FSDE.*" This is consistent with the meeting minutes dated April 7, 2021.

   FSISE indicates that Layers 1-4 typically correspond to the Upper/Middle/Lower portions of the aquifer. The FSDE will need more detailed descriptions of the layering system with respect to vertical depth intervals since several of the correlations between Upper/Middle/Lower portions of the aquifer and Layers 1-4 are "*sometimes included… depending on location within the Study area*" which is not detailed enough to provide informed decisions making. As discussed in the meeting minutes, this is where Study area specific figures will be beneficial in defining vertical boundaries. We indicated that the layering system should be thoroughly explained, as mentioned in our comments and we may request plume maps in the detailed evaluation in higher density areas where an interim remedy may likely be implemented.

2. **EA Response to Comment 7 (Section 1.7.1 Potential Human Health Risk):** This comment remains unaddressed. The quoted text and explanation have no basis when data suggests PFAS concentrations are related to source Sites within the Study Area. PFAS should be included as a COC and may have an impact on the design and implementation.

3. **EA Response to Comment 10c (Section 2 Remedial Action Objectives (RAOs)):** It should be noted that the alternative for implementation of ISCO has been illustrated around the Armstrong channel. Considering the structure of the channel and hydrogeology of the area, applicability and potential negative impacts of any in-situ remedial actions on the water quality in the channel or reduction of effectiveness of the remedy should be evaluated and discussed in detail in the FSDE.

4. **EA Response to Comment 11 (Section 4.1 General Response Actions):** MNA is a general response action and is not a process option under treatment. Treatment is its own general response action that does not have MNA as a process option. MNA ICs should be evaluated as its own general response action and have monitoring as a process option.

   Monitoring is already an IC to be implemented under all process options. Though MNA does not meet the RAOs by themselves, they may be used in conjunction with other technologies as part of alternative development. We still recommend this change be made as to not misinterpret MNA as a treatment.

5. **EA Response to Comment 13 (Section 5.1 Effectiveness):**
   Guidance for conducting RI/FS under CERCLA indicate, information available at the time of screening should be used primarily to identify and distinguish any differences among the various alternatives and to evaluate each alternative with respect to its effectiveness, implementability, and cost.

   The analysis should be conducted at this phase, since some of the screened technologies did not have enough detail to support their screening with respect to effectiveness. It is understood that the purpose of the screening is to reduce the number of alternatives that will undergo more thorough analysis; however, evaluations should provide enough detail to distinguish it among other alternatives and justify the screening determination. The detailed evaluation should reevaluate the effectiveness, and the analysis should be conducted with sufficient detail so that decisionmakers understand the significant aspects of each alternative and any uncertainties associated with the evaluation.

   During the detailed analysis, the alternatives brought through screening are further refined, as appropriate, and analyzed in detail with respect to the evaluation criteria. Alternatives may be further refined and/or modified based on additional site characterization or treatability studies conducted as part of the RI (i.e. geochemical analysis). The detailed analysis should be conducted so that decision-makers are provided with sufficient information to compare alternatives with respect to the evaluation criteria and to select an appropriate remedy.

Thanks,

Nick

APPENDIX N
10/26/21 OCWD SOUTH BASIN TECHNICAL ADVISORY COMMITTEE MEETING MINUTES (D1712505)

MINUTES

OCWD South Basin Technical Advisory Committee Meeting (D1712505)

October 26, 2021
9:00 am – 10:00 am

MS Teams Link click here
Phone only: +1 (916) 535-3094, Phone Conference ID: 298 887 2#

Attendees:

X	Alex Huang	DFA	Prop 1 Program Manager	Alex.Hwang@waterboards.ca.gov
X	Aparjeet Rangi	DFA	Project Manager	Aparjeet.Rangi@Waterboards.ca.gov
X	Jessica Law	RWQCB	Site Cleanup Program	Jessica.Law@Waterboards.ca.gov
X	Chad Nishida	RWQCB	Site Cleanup Program (Prop 1)	Chad.Nishida@Waterboards.ca.gov
X	Mehrnoosh Behrooz	RWQCB	Site Cleanup Program	Mehrnoosh.Behrooz@Waterboards.ca.gov
X	Carl Bernhardt	RWQCB	Site Cleanup Program	Carl.Bernhardt@Waterboards.ca.gov
X	Kayla Kawamura	RWQCB	Site Cleanup Program	Kayla.Kawamura@Waterboards.ca.gov
X	Nick Amini	RWQCB	Chief, Site Cleanup Program	Nick.Amini@waterboards.ca.gov
	Ann Sturdivant	RWQCB	Supervising Engineering Geologist	Ann.Sturdivant@waterboards.ca.gov
X	Nick Ta	DTSC	Project Manager	Nicholas.Ta@dtsc.ca.gov
	Paul Pongetti	DTSC	GSU	PPongett@dtsc.ca.gov
X	Bill Leever	OCWD	Project Manager	wleever@ocwd.com
X	Roy Herndon	OCWD	Chief Hydrogeologist	rherndon@ocwd.com
X	Chris Ross	EA	Project Manager	CRoss@enganalytics.com
X	Ken Puentes	EA	Project Hydrogeologist	KPuentes@enganalytics.com

9:00-9:05 Roll Call/Introduction Bill Leever

9:05-9:45 Discussion - Incorporation of FSISE comments into FSDE All

A summary of the FS-related documents and review process that has occurred to date was provided for the new TAC members (Alex Hwang and Nicholas Ta). The TAC then discussed the June 17, 2021 RB response to EA's responses to the March 2021 TAC comments on the FSISE. The following numbered items correlate with the five June 17, 2021 RB comments:

1) Chris provided an explanation of how the conceptual hydrogeologic model layers are consistent with the numerical model and how EA prepared water quality dot-maps to represent CoCs in each layer (Layers 1 to 4). Following Chris's explanation, Chad indicated the RB will continue to review the FSDE and have no additional comments at this time. As discussed before, RB will likely request additional figures with more details for remedial design.

2) The RB commented that PFAS is an emerging compound and should be included as a CoC. Chris explained that PFAS was not included as a CoC because of the relatively low concentrations observed at the time the HHERA was being prepared and that there are no regulatory cleanup standards for PFAS. There was discussion by the group that some source sites in the South Basin have PFAS

detections, including a site north of Warner Ave. Chris asked the TAC if any sites in the SB have PFAS as a CoC, and Nick Ta responded that to his knowledge they do not[1]. Chris suggested PFAS and other emergent compounds be addressed, as necessary, during the 5-year remedy review. Nick Ta indicated that was a good approach as the DTSC and OEHHA have not promulgated any PFAS remediation standards. RB recommended sampling and analysis of the PFAS compounds in the preliminary design investigation (PDI).

Nick Amini indicated that MCAS Tustin has a significant PFAS plume that is moving off its site and that any SB remedy have a safety factor built in to address potential impacts on the remedy from offsite PFAS migration from MCAS Tustin. Nick Ta stated that he was the PM for the MCAS Tustin site and that their treatment system currently uses GAC and that it is effective at removing PFAS during treatment. Nick Amini stated that the PFAS plume from MCAS Tustin has already migrated off site and that on-site remedies will not capture the off-site plume.

DFA commented that City of Santa Ana drinking water wells also have PFAS contamination and because of that there are significant PFAS occurrences within the Basin. Hence, DFA recommends including PFAS evaluation in the FSDE or at least consider it during the pre-design phase.

3) The ISCO alignment along Armstrong Channel is a concern of the RB because of the groundwater/surface water connection in Armstrong Channel. Chris indicated that this is addressed in the FSDE. Nick Amini asked if those alignments that are within the RB's exclusion zone were scored lower than those outside of the exclusion zone. Chris indicated the only ISCO alignment within the exclusion zone, the Armstrong Channel alignment, was scored lower because of its proximity to Armstrong Channel and its potential for negative impacts. One other alignment, the alignment south of ITT, was removed from the FSDE in response to RB comments on the FSISE. However, Figure 2-4 of the FSDE erroneously showed the alignment south of ITT and would be corrected.

4) The FSISE and FSDE designated MNA as an in-situ technology process option and not a general response action. Roy stated that OCWD's goal is to handle MNA in the feasibility study consistently with CERCLA guidance. Chris indicated that he would research this further and revise the designation of MNA as needed. Nick Amini said he would research this issue further as well.

5) This RB comment is related to the level of detail needed to screen the alternatives in the FSISE. Chris indicated that the level of detail in the FSDE will be sufficient to evaluate remedial alternatives.

Aparjeet stated he would like the June 17, 2021 RB comment letter and a RTC table included in the FSDE. It was agreed that the letter and RTC table would be included in the FS report.

9:45-9:55 Schedule Update — Bill Leever

Bill provided an updated schedule that shows the draft TAC comments on the FSDE will be received in mid-November 2021 and the draft FS will be submitted for TAC review by mid to late January 2022. Schedule attached.

9:55-10:00 Walk-in Items, Action Item Recap, Adjourn

Chad asked how EA established the 1.5x flux factor from ambient (non-IRM pumping) in the FSDE that was used to establish a significant water flow below which groundwater fluxes are considered negligible. Chris indicated there is no established standard for this type of evaluation and in his professional opinion, a change in flow velocity less than 1.5x would be insignificant in evaluating impact to source site remedial measures. He also

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[1] After the TAC meeting, Nick Ta provided an email to Bill Leever stating that Embee detected PFAS in soil and groundwater during a November 2020 investigation.

noted that natural conditions can change the groundwater gradient, and in-situ remediation methods are typically driven and dictated by the delivery and consumption of amendments.

Chad and Aparjeet had questions on the groundwater modeling and backward particle tracking. Chad asked why a 10-year particle track was used instead of a 30-year, as was used in the cost analysis. Chris indicated the 10-year particle tracks analysis was sufficient to show hydraulic influence and the most impact to the source sites and therefore could be used to analyze flow direction changes; extending the particle track analysis beyond 10 years would result in particles following the ambient groundwater flow direction. Aparjeet asked why reverse particle tracking was used in the impact analysis. Chris indicated reverse particle tracking was preferred over forward tracking because it was better at showing groundwater flow direction changes. Forward particle tracking was better at showing capture zones, which becomes more important during remedial design. The FSDE indicated that the PDI will refine the design of the remedial action.

Action Items:

1. OCWD and RB will independently review CERCLA guidance on clarification of MNA as an institutional control or general response action

2. Bill to set next TAC meeting for 2-weeks after receipt of TAC comments on FSDE

APPENDIX O
11/10/21 & 11/15/21 DTSC REVIEW OF DRAFT FEASIBILITY STUDY DETAILED EVALUATION, SOUTH BASIN GROUNDWATER PROTECTION PROJECT, OPERABLE UNIT 2, IRVINE, CALIFORNIA

Jared Blumenfeld
Secretary for
Environmental Protection

Department of Toxic Substances Control

Meredith Williams, Ph.D., Director
8800 Cal Center Drive
Sacramento, California 95826-3200

Gavin Newsom
Governor

M E M O R A N D U M

TO: Nicholas Ta
Project Manager
Site Mitigation and Restoration Program
Cypress Office

FROM: Jesse Negherbon, Ph.D., P.E.
Senior Hazardous Substances Engineer
Engineering and Special Projects Office

REVIEWER: Perry Myers, P.E.
Unit Chief, Engineering Services North
Engineering and Special Projects Office

11/15/2021

REGISTERED PROFESSIONAL ENGINEER
JESSE P. NEGHERBON
NO. 85988
CIVIL
STATE OF CALIFORNIA

SUBJECT: REVIEW OF DRAFT FEASIBILITY STUDY DETAILED EVALUATION, SOUTH BASIN GROUNDWATER PROTECTION PROJECT, OPERABLE UNIT 2, IRVINE, CALIFORNIA (Site Code: dtsc401983)

DATE: November 10, 2021

DOCUMENT REVIEWED

Feasibility Study Detailed Evaluation (Draft), South Basin Groundwater Protection Project, Operable Unit 2; dated September 2021 and prepared by Engineering Analytics, Inc for Orange County Water District.

INTRODUCTION

The Engineering and Special Projects Office (ESPO) of the Department of Toxic Substances Control (DTSC) has completed its review of the above-referenced draft feasibility study detailed evaluation ("FSDE") for Operable Unit (OU) 2 of the South Basin Groundwater Protection Project in Orange County, California. If you have any questions, please contact me at 916-255-6577, or via email at Jesse.negherbon@dtsc.ca.gov.

COMMENTS AND RECOMMENDATIONS

1. General Comment 1. The document does not contain conclusions or recommendations for the remedial alternatives and should be clearly marked "Draft".

2. General Comment 2. The FSDE includes cost estimates associated with civil infrastructure and should thereby be signed and stamped by a California licensed civil engineer with current registration, in accordance with the California Business and Professional Code Section 6735.

3. Section 54.4.73, Chemical Processes, Screening Determination. It's not clear why the FSDE identifies activated sodium persulfate as the recommended in-situ chemical oxidation (ISCO) oxidant at this stage of the evaluation process, beyond the observation that is has been used with some success for groundwater treatment at source areas located within OU-2. It may be more appropriate to include costs for a more comprehensive bench-scale study to evaluate multiple oxidants, and perhaps a pilot test, to identify the most suitable oxidant(s) and oxidant delivery methods for the conditions present across OU-2.

4. Section 7.2 Scope of Alternatives and Common Elements. The FSDE allocates $50,000 per year to address activities associated with sealing legacy water supply wells within the OU. The basis for annual allocated sum is not clear, and it is not apparent that it is appropriate for the money allocated for this work to be distributed equally across each year of work included in the cost estimate. Given that these legacy wells may serve as continuing vertical conduits for contaminant transfer within OU-2, it may be of value to frontload the estimate with the money for this work to identify and seal these wells on a more expeditious schedule.

5. Figure 1-8, Trichloroethylene in Layer 3 Groundwater. This figure doesn't show any TCE data on it. It is unclear if TCE data is not available for Layer 3, or if the data was simply not shown on the figure. Please revise as necessary.

6. Appendix D, Detailed Cost Estimates for OU2 Interim Remedial Alternatives.

    a. Table D-1 indicates that a discount rate of 2.5% was used for the net present value (NPV) evaluation. The NPV should be based on the applicable Real Discount Rate from the most current White House Office of Management and Budget Circular for 2020 A-94 Appendix C.
    b. The cost estimate incorporates varying contingency factors across different elements of the remedial alternatives, with a maximum contingency of 35%. We consider this to be too low of a contingency for this FSDE and recommend that it is increased to align more closely with the US EPA and US Army Corps of Engineers guidance for

developing and documenting cost estimates during the feasibility study (EPA 540-R-00-002, July 2000).

c. The remedial alternative cost estimates include costs for investigation activities that range between $1,000,000 and $1,500,000 with the note that they are rough-order-of-magnitude estimates. The estimated investigation costs should be further substantiated for each individual remedial alternative.

Jared Blumenfeld
Secretary for
Environmental Protection

Department of Toxic Substances Control

Meredith Williams, Ph.D., Director
5796 Corporate Avenue
Cypress, California 90630

Gavin Newsom
Governor

MEMORANDUM

TO: Nicholas Ta
Senior Environmental Scientist
Site Mitigation and Restoration Program - Cypress

FROM: Paul Pongetti, P.G.
Senior Engineering Geologist
Geological Services Branch – Cypress

PROFESSIONAL GEOLOGIST PAUL J. PONGETTI No. 7935 STATE OF CALIFORNIA

DATE: November 15, 2021

SUBJECT: FEASIBILITY STUDY DETAILED EVALUATION, SOUTH BASIN GROUNDWATER PROTECTION PROJECT OPERABLE UNIT 2

PCA 11018 SITE CODE 401983 WP 11 MPC RIFS WR# 20079420

As requested, the Geological Services Branch (GSB) reviewed the “Feasibility Study Detailed Evaluation, South Basin Groundwater protection Project, Operable Unit 2." The Feasibility Study Detailed Evaluation (FSDE) is dated September, 2021 and was prepared by Engineering Analytics, Inc. (EA) for Orange County Water District (OCWD).

The FSDE was prepared in in support of the South Basin Groundwater Protection Project (SBGPP) Remedial Investigation/Feasibility Study (RI/FS) being conducted by OCWD to address Operable Unit 2 (OU2) groundwater contamination in the south-central portion of the Orange County Groundwater Basin. OCWD is conducting the SBGPP RI/FS in cooperation with Department of Toxic Substances Control (DTSC) and Regional Water Quality Control Board (RWQCB) to develop an interim remedy or remedies to address groundwater contamination. The SBGPP Study Area is approximately five square miles and is located within the southeastern portion of the city of Santa Ana, the western portion of the city of Irvine, and the southwestern portion of the city of Tustin. The Shallow Aquifer System of the SBGPP Study Area is impacted by chemical contaminants derived from multiple industrial source sites. Most prevalent contaminants are volatile organic compounds, 1,4-dioxane, perchlorate, and hexavalent chromium (Cr6) which have been identified as constituents of concern (COCs).

The FSDE proposed the following Remedial Action Objectives (RAOs) for interim remedial measures (IRMs).

1. Protect groundwater resources from further degradation by preventing lateral and vertical migration of high concentration COCs) into zones with lower concentrations of COCs within OU2, to the extent practicable;

2. Protect groundwater resources by decreasing potential for vertical migration of high concentration COCs from the upper/middle portions of the Shallow Aquifer System to the Principal Aquifer System through Legacy Water Supply Wells, to the extent practical;

3. Protect groundwater resources from further degradation by preventing the spread of COCs exceeding MCLs in the Leading-Edge areas of the plume, to the extent practicable;

4. Implement a reliable interim groundwater remedy(s) that is compatible with ongoing and planned remediation at source sites and associated off-property locations, where applicable;

5. Prevent discharge of COCs exceeding ecological risk-based concentrations from the Shallow Aquifer System to surface water channels; and

6. Prevent human exposure to contaminated groundwater with COC concentrations exceeding MCLs or other ARARs.

General Response Actions were identified as remedial technology categories that can achieve the RAOs for OU2 groundwater. The General Response Actions were used as a basis for identification and screening of groundwater remedial technologies and process options against three performance criteria: effectiveness, implementability, and cost. Based on their relative performance against the three criteria, some of the remedial technologies and process options were retained for assembly into remedial alternatives and further evaluation. The retained remedial technologies were developed into candidate remedial alternatives and then underwent a detailed evaluation.

Six candidate remedial alternatives were evaluated against performance criteria defined by the National Contingency Plan (NCP). The criteria consisted of threshold criteria and primary balancing criteria. The remedial alternatives were then compared and ranked based on the findings of the detailed analysis. The NCP modifying criteria, Regulatory agency acceptance, and Community acceptance were not included and will be evaluated and documented later.

The six remedial alternatives were ranked according to the two threshold criteria, the five balancing criteria, and overall sustainably. Remedial alternatives were also evaluated for compatibility with source site remediation and the surface water channel in the study area (Armstrong Channel). The remedial alternative recommendation will be provided in the FS following Technical Advisory Committee (TAC) review of detailed evaluation of alternatives.

Comments and Recommendations

1. Executive Summary: *"In response to DFA comments on the FSISE, it is noted that Interim Remedial Actions do not include numeric cleanup goals as part of RAOs, nor do they provide an estimate for cleanup times."* 30 year project lifetime costs were presented for all alternatives. GSB understands there is significant uncertainty with cleanup time estimates given the unspecific numeric cleanup goals and variable source site remedial efforts; however, GSB recommends relative cleanup timeframes for remedial alternatives be provided in the FS to evaluate alternatives and associated cost more accurately.

2. Executive Summary: *"Consistent with the preceding USEPA guidance, OCWD intends to implement IRMs that will be consistent with any final remedy, if required."* GSB recommends the FSDE include a discussion of possible final remedy RAOs to evaluate consistency of the IRMs with a future final remedy. For example, it would be useful to understand if the final remedy RAOs are expected to include restoration of groundwater to its designated beneficial use.

3. Section 1.5, Conceptual Site Model: *"There are numerous contaminant source areas within the Study Area. Some of the VOC source areas contain dense non-aqueous phase liquid (DNAPL) or residual DNAPL (Aquilogic, 2015) that will continue to act as long-term sources of contamination to off-property groundwater if not contained or removed."* GSB agrees that DNAPL is a long-term source for dissolved-phase groundwater contamination and identifying DNAPL source zones is an important component of the conceptual site model and critical to the selection of IRMs. GSB recommends that boundaries of suspected DNAPL source zones be identified in the FS and investigated further, if necessary. Additionally, GSB recommends phasing the construction of monitoring wells in these areas so information obtained from initial drilling and well installation informs the Conceptual Site Model (CSM) and decisions about siting subsequent monitoring, extraction and/or injection wells.

4. Section 1.5, Conceptual Site Model: *"Remediation of source areas is expected to be conducted by potential responsible parties in tandem with the interim remedy resulting from this RI/FS."* Source removal is the most effective way to prevent further degradation of groundwater resources (RAO 1) and source removal is relevant to the effectiveness, reliability, and cost of the interim and final remedies selected for OU2. For the interim and final remedies to be successful, groundwater upgradient of the treatment areas must make progress towards consistent RAOs. GSB recommends the remedial design include standardized advisory RAOs and performance goals for source site remedial efforts to ensure compatibility with the selected IRMs for OU2.

5. Section 1.6.1, Potential Human Health Risk. This Section explains that Per- and polyfluoroalkyl substances (PFAS) did not appear to be related to sites and were not retained as COCs. GSB is concerned about the representativeness of PFAS sampling results used for this evaluation and GSB recommends OCWD provide more explanation as to how their evaluation was completed. It's not clear how many source sites were sampled for PFAS and GSB recommends PFAS be retained as a COC until more sites are sampled. GSB notes that Embee Plating is located within OU2 and completed a preliminary investigation for PFAS in 2021. The PFAS investigation included collection of 15 soil samples from five soil borings and groundwater samples from 13 wells. PFAS was detected in both soil and groundwater. Perfluorooctanesulfonic acid (PFOS) was detected in 10 of the 13 groundwater samples with the highest concentration of 15,200 ng/L reported at EP-16C. Perfluorobutanesulfonic acid (PFBS) PFBS was also detected. DTSC has requested a workplan for additional PFAS investigation. Details can be found on Envirostor: https://www.envirostor.dtsc.ca.gov/public/final_documents2?global_id=30340013&doc_id=60484984.

6. Section 5.4.3, Monitoring: This Section describes long-term groundwater monitoring as a component of containment and in-situ response actions and explains how monitoring data will be used. GSB recommends groundwater monitoring data also be used to demonstrate continued IRM compatibility with ongoing and planned remediation at source sites. GSB recommends the groundwater monitoring objectives be better aligned to the RAOs as follows:

    a. GSB recommends monitoring data be used to provide an interpretation of upgradient groundwater conditions and trends in contaminant concentrations (RAO1, RAO4). For example, identify rebounding concentrations from a previous source site remedial effort.

b. GSB recommends monitoring include surface water sampling results, if needed, to determine exceedance of ecological risk-based concentrations or other ARARs (RAO 5).

c. Groundwater monitoring should include a discussion of the any water supply well COC concentrations exceeding drinking water MCLs or other ARARs (RAO 6).

d. For in-situ technologies, GSB recommends that groundwater monitoring data be used to evaluate treatment byproducts detrimental to source site remedial efforts (RAO 4).

e. For groundwater extraction and treatment (GET), GSB recommends that groundwater monitoring data be used to evaluate changes in groundwater fluxes and directions of flow near source sites that may affect their remedial efforts (RAO 4).

7. Discharge to the Orange County Sanitation District (OCSD) publicly owned treatment works (POTW) Reclamation Plant No. 1 in Fountain Valley was retained in the FSDE as a discharge option for groundwater extraction and treatment (GET), and included in Remedial Alternatives 3 and 6. GSB recommends the discharge standards be included in the FSDE and compared to the expected GET effluent concentrations. In the event that discharge standards are modified or exceeded, or unanticipated concentrations of COCs are encountered in extracted groundwater, contingency groundwater treatment costs should be provided and discussed.

8. The screening of remedial technologies and process options in Section 5 indicates that perchlorate and Cr6 have not been identified as significant contaminants in the areas that may be considered for OU2 IRMs, although they were designated as OU2 groundwater COCs. Membrane processes were retained as a response action related to the injection of treated groundwater for Remedial Alternative 4, while ion exchange was not. GSB recommends retaining these two technologies and comparing the costs. Additionally, GSB recommends including the costs for perchlorate and Cr6 analysis in the cost estimates due to their designation as OU2 groundwater COCs.

9. Groundwater extraction and in situ chemical oxidation (ISCO) transects located south of East Warner Avenue, north of Dyer Road and east of Cherry Aerospace are presented as alternatives (e.g., Remedial Alternative 5). On October 12, 2021 DTSC participated in a meeting with SOCO West consultants (Geosyntec) to discuss potential locations for a replacement monitoring well which was installed in 2016 at 1312 East Warner Avenue. The general location of the well

is south of East Warner Avenue and east of Cherry Aerospace and Geosyntec reported difficulty in obtaining site access for a replacement well. This property is currently owned by Calpine Corporation (Calpine) and used as a battery energy storage project. Southern California Edison (SCE) operates an electrical substation to the South. Access for well installation purposes may be challenging at these two properties and GSB recommends OCWD explore accessibility with Calpine and SCE as soon as possible and incorporate the findings into the FSDE.

If you have any questions, please telephone me at (714) 484-5481 or e-mail me at Paul.Pongetti@dtsc.ca.gov.

Peer Reviewed by: Natasha DiPietro, P.G.

APPENDIX P
11/24/21 RWQCB COMMENTS ON FEASIBILITY STUDY DETAILED EVALUATION FOR THE ORANGE COUNTY SOUTH BASIN GROUNDWATER PROTECTION PROJECT, OPERABLE UNIT 2 (GRANT AGREEMENT NO. D1712505)

Santa Ana Regional Water Quality Control Board

November 24, 2021

Bill Leever
Principal Hydrogeologist
Orange County Water District
18700 Ward Street
Fountain Valley, CA 92708
(wleever@ocwd.com)

COMMENTS ON FEASIBILITY STUDY DETAILED EVALUATION FOR THE ORANGE COUNTY SOUTH BASIN GROUNDWATER PROTECTION PROJECT, OPERABLE UNIT 2 (GRANT AGREEMENT NO. D1712505)

Dear Mr. Leever,

We have completed our review of the "*Feasibility Study Detailed Evaluation*" (FSDE) for the South Basin Groundwater Protection Project Operable Unit 2 (OU2) submitted on September 20, 2021. The FSDE was prepared by your consultant Engineering Analytics, Inc. (EA) and was submitted for our technical review as part of the reporting requirements listed in the Proposition 1 Grant Agreement (No. D1712505) for the Remedial Investigation and Feasibility Study (RI/FS) between the Orange County Water District (OCWD) and State Water Resources Control Board (State Water Board), Division of Financial Assistance (DFA). This letter provides our comments on the FSDE.

Comments:

1. General – The U.S. EPA *Guidance on Feasibility Studies under* [Comprehensive Environmental Response, Compensation, and Liability Act] *CERCLA* and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 Code of Federal Regulations [CFR], Part 300) do not reference a sustainability assessment. Please explain how this assessment impacts the remedy selection.

2. Section 2.2 Screening Levels – The text states, "*The US Environmental Protection Agency (EPA) adopted the same 50* [micrograms per liter] *µg/L standard for total chromium, but in 1991 raised the federal* [maximum contaminant level] *MCL to 100 µg/L. California did not follow US EPA's change and stayed with its 50 µg/L standard.*" We recommend using the hexavalent chromium MCL as soon as it is established. Please note, at the time of this letter the State Water Resources Control Board, Division of Drinking Water (DDW) proposed adopting and implementing a regulation that establishes an MCL for hexavalent chromium in drinking water provided by public water systems in California. The State Water Board is considering adopting and implementing 1 of 17 proposed MCLs ranging from 1 to 15, 20, and 25 µg/L.

3. Section 5.3 Relative Cost – A sensitivity analysis should be conducted to assess the variations in specific assumptions associated with design, implementation, operation, discount rate and the effective life an alternative can have on the costs estimated. The results of the analysis can be used to identify upper and lower limits of cost estimates and will allow for more accurate contingencies or reserve funds. For projects with high operations and maintenance costs extending over a 30-year lifecycle or more, it is encouraged to include a sensitivity analysis with different discount rates.

4. Section 7.2.2 Incorporation of RWQCB Data Gap Analysis –
This comment and associated sub-sections (a-k) reiterate areas where data is missing downgradient (or off-site) from sources of contamination, as stated in our November 21, 2019 letter titled, "*Summary of Data Gaps for The Supplemental Remedial Investigation Report – Orange County South Basin Groundwater Protection Project, Operable Unit 2 (Grant Agreement No. D1712505)*". The following were either not mentioned or not fully addressed in the FSDE.
Alternative 2 Monitored Natural Attenuation (MNA):
    a. Bell Industries Off-Site (2) – We do not believe that the data gaps identified apply only to Alternative 2. The same consideration of data gaps should also apply to Alternatives 3-6. The Area 2 G/I-1 alignment near Warner Avenue and the 55-freeway (55FWY) is located downgradient of MW-24, -24C, cone penetrometer test (CPT)-15, -114, -17, and -111. Additional sampling in this area is necessary for determining the lateral and vertical extent of contamination, since the existing CPT data (collected in approximately 2012) are outdated and are not representative of current conditions. In addition, this information will be useful in defining the extent of migration of contaminants of concern (COCs) across the 55FWY and the adjacent alignment length (G/I-1). This information will be beneficial to the development and effective implementation of an interim remedy.
    b. Holchem and Circuit One (5) - We do not believe that the data gaps identified apply only to Alternative 2.and the same consideration of data gaps should also apply to Alternatives 3-6 below. The data gaps are directly related to Area 1 G/I-2. Specifically, CPT-100, -206, -104, and -180 were referenced, since the plume has comingled with historical discharges from other facilities in this area (bounded to the west by Holchem and Embee Plating sites, to the south by East Warner Avenue, to the east by Circuit One, and to the north by Barlen Enterprises). Investigation of this area will establish baseline conditions with respect to OU2, and provide vertical characterization of the subsurface zones that may benefit most from an interim remedy. Please note, Circuit One will be performing CPT/membrane interface probe (MIP) profiling, and will be collecting groundwater grab samples. The data from these efforts may contribute to the pre-design investigation (PDI) (e.g. used in the monitoring well installation and design).
    c. Cherry Aerospace Off-Site (8) - For Alternative 2, we recommend this area encompass drinking water production well IRWD-3, since COCs were detected in nearby monitoring well, SAM-4. IRWD-3 was previously identified as the impaired drinking water source and is one reason for implementing interim remedial measures.

Alternative 3-6 Proposed Interim Remedial Measures:
    d. Steelcase off-Site (4) – Our comments indicated the need for additional delineation adjacent to the 55 FWY between Bell Avenue and Valencia Avenue, since comingling of 1,1-dichloroethylene (1,1-DCE) and 1,4-dioxane have been

detected upgradient of Steelcase (MW-29B). More recent data that have been obtained since our issuance of that letter further support the need for the additional delineation. Results of additional groundwater investigation upgradient of the on-site source are available in the Second Half 2020 report prepared by Environmental Resources Management. Information in the report may be useful in your efforts to determine the extent of contaminant migration across the 55 FWY and the adjacent alignment length (Area 2 G/I-1).

e. Area Bounded by South Grand Avenue, East Warner Avenue and the 5 FWY (7) - This area extends south and downgradient of Area 2 G/I-1 and the eastern edge of Area 1 G/I-2. Please revise the associated Areas in the figures.

f. Cherry Aerospace (8) – Our comments (8.a) also discussed the area southwest of Cherry Aerospace and west of drinking water production well IRWD-3; please include the area as per our request, or provide justification as to why this area was not included. Data from this area may be beneficial for designing the western edge of alignment Area 4 G/I-5. Similarly, comment (8.b) suggested future impacts to IRWD-3 and the possibility that pumping from IRWD-3 could cause vertical downward migration in monitoring well SAM-4. We recommend this area be further investigated if impacts to drinking water production well IRWD-3 remain a concern.

g. Not included as a data gap within the FSDE: ITT Cannon (9) – This comment was included for Alternative 2 only; however, we recommend this also be included for Alternatives 3-6. Our comment discussed the data gaps between SAM-5 and SAM-6 and CPT-123, -124, and -190. These data gaps are near Dyer Road and will apply to design and implementation of Alternatives 3-6, more specifically Area 1 G-8/I-10&11 and Area 4 G/I-5.

h. Not included as a data gap within the FSDE: Dyer Business Park off-site (10) – One of our comments was not included for both Alternative 2 and Alternatives 3-6, with respect to Area 7 G/I-6. The omitted comment states, *“a. Since 2012, no data has been collected southwest of Dyer Business Park and north of SAM-7, therefore, the extent of the comingled COC plume may have migrated beyond the contour boundary since the time the groundwater grab samples were obtained. b. In addition, data gaps exist in the vicinity of SAM-7.* [trichloroethylene] *TCE concentrations in SAM-7A (39.5-49.5* [feet below ground surface] *ft bgs) have fluctuated from approximately 32. 1µg/l to 49 µg/L. No data exists from 0-39.5 ft bgs and step-out borings in all directions have not delineated nor identified an upgradient source/potential downgradient impacts.”* Data from the Dyer Business Park would be relevant to help design G/I-6 near SAM-7. Without additional monitoring points in the area, SAM-7 will be the only monitoring well north of the intersection of West MacArthur Blvd and the 55 FWY. Please include the omitted comment in the discussions for Alternative 2 and Alternatives 3-6.

i. South of the intersection of Redhill Avenue and Gillette Avenue (14) - Please explain why Area 6 and Area 8 for Alternative 2 (MNA alternative) have more extensive coverage when compared to Area 6 and Area 8 of Alternatives 3-6. We recommend that Area 6 and Area 8 be consistent for both Alternative 2 and Alternatives 3-6. Data from Areas 6 and 8 will aid in the design of Area 8 G/I-7, since those areas are upgradient of the proposed remedial action.

j. South of the 55 FWY and MacArthur Blvd (15) – The data gap analysis did not address our comment (15.b), which states, “*In addition, SAM-8A is screened from 33-43 ft bgs and does not address shallow contamination from 0-33 ft bgs.*” Shallow groundwater grab samples ranged from 25-30 ft bgs, and monitoring wells near MacArthur Blvd. are screened from ~10-20 ft bgs with depth to water of approximately 10 ft. Please include/address this data gap.

k. Baxter Healthcare and Edwards Lifesciences off-site (16) – The data gap analysis did not address our comment (16.a), which states, "*Further delineation of the leading edge of the plume is needed vertically and laterally located to the west of MacArthur Blvd, bounded by Redhill Avenue and Main Street, and in the general vicinity of CPT-174.*" Contaminants may have migrated beyond the locations where groundwater grab samples were collected in approximately 2012. The extent of contamination is not delineated. Updated and complete information and clear delineation of the extent of contamination will benefit the design and optimization of G/I-7 alignment, which may need to be extended westward across MacArthur Blvd.

5. <u>Section 7.2.3.2 Alternative 2</u> - Monitored Natural Attenuation - The text states, "*Biodegradation of 1,4-dioxane has been observed to occur under aerobic conditions at many other sites but not all. Although slightly aerobic conditions exist in the shallow aquifer, the length of the 1,4-dioxane plumes (greater than several thousand feet) indicates the 1,4-dioxane plumes are not being controlled by natural biodegradation or any other destructive process…*". The statement is inaccurate, since anaerobic conditions are typically observed in the subsurface of the South Basin; however, it is true that appropriate microorganisms that degrade 1,4-dioxane are neither native nor dominant in the South Basin. Aerobic conditions have been seen at some, but not the majority of sites. Similarly, other prevalent COCs in the South Basin (such as 1,1-dichloroethene at concentrations as low as 5 µg/L) are shown to inhibit the destruction of 1,4-dioxane. Please remove, or provide justification for, the statement that biodegradation of 1,4-dioxane has been observed to occur under aerobic conditions at many sites.

6. <u>Section 7.2.3.5 Alternative 5</u> – The text states, "*Based on an average injection* [radius of influence] (*ROI*) *of 12 feet, injection wells would be installed on 24-foot spacings.*" There is a large variation in hydraulic conductivity with depth and location within the study area; therefore, it is unlikely that an "average" ROI can be realistically applied to the entire study area. The summary table of source site injection spacing should be dependent on its location within the study area and the targeted vertical intervals, which may be significantly more or less transmissive. We recommend proposing appropriate values for ROI in the different and varying hydrogeologic conditions that exist in the study area. Alternatively, please provide sufficient technical details to justify the selection of the average 12 ft ROI and its application to Layers 1, 2, and 3.
   a. Please note, this generalized ROI assumption is likely to influence costs associated with Alternative 6 and its overall ranking, not the overall ranking of Alternative 5. Alternative 6 incorporates fewer injection wells compared to Alternative 5 (In-situ Chemical Oxidation [ISCO] only), but still assumes an average 12 ft ROI, even though the injections are located within Area 1 as opposed to spanning the entire study area. A more careful assessment of realistic ROI values, based on local lithology and horizontal and vertical extent of COCs, may identify portions of the study area that would benefit from targeted injection instead of implementing a full injection alignment.

7. <u>Section 7.3.3. Alternatives 3 through 6</u> - The text states, "*For the purposes of this evaluation, simulated groundwater flux increases of less than a factor of 1.5 from ambient (non-IRM pumping conditions) are considered negligible and are not further*

discussed below." Please provide justification for determining that a flux factor of 1.5 from ambient conditions is negligible.

8. <u>Section 7.3.3.7: Steelcase Incorporated</u> – Please note that the RP has recently informed us about their plan to submit a work plan proposing mass removal for impacted soil and in-situ remediation of contaminated groundwater at this source site.

9. <u>Section 7.3.3.8: Troy Computer</u> – The responsible party for this site is no longer planning to perform groundwater remediation; please update this section and associated sections. Please refer to our September 20, 2021 comment letter, which discusses source zone impacts. The potential selection and implementation of a groundwater remedy is on hold, pending further groundwater investigation and a feasibility study.

10. <u>Section 7.3.3.9: GE Plastics</u> – The downgradient in-situ bioremediation of perchlorate has been conducted through the use of biobarriers installed along Deere Avenue in both the first and second water-bearing zones, and in Alton Parkway in the second water-bearing zone. Please refer to the "*off-site biobarrier*" Waste Discharge Requirements (WDRs) monitoring reports from 2018 to the present for details.

11. <u>Section 7.3.3.12: Baxter Healthcare</u> – The text states that the site "*is planning to perform additional ISCO using activated persulfate into the intervals 28 to 38 feet bgs (Layer 1) and 40 to 50 feet bgs (Layer 2) on the property.*" The Site has already implemented pilot scale remediation using persulfate activated with sodium hydroxide. Please refer to the WDRs monitoring reports from February 2020 to the present for details.

12. <u>Tables 7-1 and 7-2</u> – Operations, maintenance and monitoring (OM&M). We recommend the addition of per- and polyfluoroalkyl substances (PFAS) as monitoring parameters, using U.S. EPA Method 537.1 for chemical analysis. This information will benefit the PDI by determining the current extent of PFAS. In addition, this information will be required in the monitoring and reporting plan established by the WDRs.

13. <u>Table 8-2</u> – This table indicates the degree to which the treatment process is irreversible and states, "*Once COCs are removed from groundwater, the process is irreversible.*" It should be expected that treatment processes are irreversible; however, the analysis should be done with respect to the remedial action (i.e. extraction and injection [E&I]). Please identify and evaluate any expected adverse effects of remedial construction and operation to the groundwater basin and state whether the effects are reversible or irreversible (i.e. modification to extraction frequency and rates; response to inducing unfavorable gradients; contingencies if higher than expected contaminant concentrations must be treated; conflicts with implementation of a final remedy, and the potential for back-diffusion to occur).
    a. If any alternative appears to have significant irreversible effects, the user should state the mitigative measures (i.e. reduction in E&I flow rates, halt E&I in all or portions of the alignments) to be taken in conjunction with the alternative. If success of the remedial alternative may be compromised by the mitigative measures, this should also be explained.
    b. Please explain to what extent the operation of extraction and injection alternatives can be modified (extraction/injection rates reduced or halted in the event that unfavorable gradients may be induced).
    c. The footnotes for Criteria Ranking do not match Alternatives 1-6; please revise.

14. Figure Series 1 – Figures depicting the Former Standard Screw products site are inaccurate. The figures inconsistently identify well screens in either Layer 2, Layer 3, or the wells are omitted when they should have been included. In addition, hexavalent chromium data were included, yet it has not been identified as a COC for the site, nor has it been quantified via laboratory analysis of samples from the site's monitoring wells. Conversely, 1,4-dioxane has been identified at the site, but the analytical data for this constituent were omitted from the figures.

15. Figure 1-8 - Layer 3 was not populated for TCE; please correct the figure.

16. Figure 2-4 Alternative 5 - Please remove the OU2 ISCO alignment along Daimler street.

17. Figure Series 7 – We recommend adding a satellite view base map, which will help reviewers visualize nearby facilities and features with respect to particle tracks.

18. Appendix B: Potential Federal and State of California Applicable or Relevant and Appropriate Requirements (ARARs) - This section did not address the comments provide in our July 25, 2018 letter titled "*Comments on Remedial Investigation/Feasibility Study Deliverable…*".
    a. Please include a response to comments table addressing our July 25, 2018 comments.
    b. Page 3 indicates, "*potentially relevant and appropriate.*" We recommend changing the category to "to be considered" (TBC).
    c. State Water Resources Control Board Notification Levels (NLs) California Health and Safety Code §116455 and §116271. NLs are advisory levels. not enforceable standards that potable water suppliers must comply with. If a chemical is detected above its notification level in a drinking water source, certain requirements and recommendations apply. We recommend that NLs be categorized as TBC.
    d. Order No. R8-2002-0033, as amended by Order Numbers R8-2003-0085 and R8-2013-0020. These Orders establish General Waste Discharge Requirements for the Reinjection/Percolation of Extracted and Treated Groundwater Resulting from the Cleanup of Groundwater Polluted by Petroleum Hydrocarbons, Solvents and/or Petroleum Hydrocarbons Mixed with Lead and/or Solvents for the Santa Ana Region. This State ARAR should be listed in Appendix B as relevant and appropriate.
    e. Please include General Waste Discharge Requirements for In-Situ Groundwater Remediation at Sites within the Santa Ana Region, Order No. R8-2018-0092. This Order applies to the discharge of chemical and biological amendments into the subsurface to perform cleanup of groundwater and soil contamination within defined "treatment zones." This State ARAR should be listed as relevant and appropriate.

19. Appendix D Detailed Cost Estimates for OU2 Interim Remedial Alternatives –
    a. General - Please provide more details for "*Southern California Unit Costs*" references.
    b. Please provide a reason for variations in rough order of magnitude (ROM) cost for testing: sampling, hydraulic testing and documentation for Alternatives 2-4. Alternative 2 (installation of 187 monitoring wells) has a cost of $1M while Alternative 3 (installation of 94 monitoring wells) has the same Cost of $1M. On the contrary Alternative 4 (installation of 84 monitoring wells) has a cost of

$1.5M. We recommend the explanation be added to the footnotes or in the Cost Estimate Source column.

c. Please describe how the estimated number of "*Permit/Access Well Easements*" were calculated.
d. For several Alternatives under Monitoring and Reporting "*sampling year 4*" there appear to be 4 years of annual sampling proposed at each monitoring well. Please explain why the quantity of sampling is doubled for years 5-8 when this covers the same 4-year time span. The quantity is also doubled for reporting; please correct and/or clarify.
e. Table D-6, Alternative 6 – This alternative contains the same number of 4" PVC extraction wells as Alternatives 3 and 4, although extraction alignment G-8 is not included. The number of extraction wells is expected to be lower when implementing partial injection alignments; please explain and/or correct this table.

20. Appendix E: Part I Model Construction Calibration Report –
    a. Figure 4.10 - Please explain the negative model layer thickness.
    b. Appendix A-1 Summary of Remedial Extraction wells and Appendix A-2 Calibration Targets – For each well we recommend including columns for upper bound and lower bound of each corresponding layer above mean sea level (amsl). This is intended to help visualize the vertical layer interval at individual wells.

21. Appendix E: Part II Model Simulation Results –
    a. The modeled residuals of Layer 1 are more positively skewed and indicate an underprediction of water level elevations. The text further states, "*Multiple factors could be affecting the quality of the calibration statistics of Layer 1 including: calibration targets from this layer may be from wells that are completed in perched systems that are not connected or continuous throughout the study area; may be from wells that are screened across multiple layers; or water levels at the wells used as calibration targets may be affected by localized remedial groundwater extraction systems.*" Please elaborate on how this calibration is "*still reasonable*" in terms of the level of detail necessary in the FSDE. In addition, please discuss whether the proposed PDI monitoring wells are intended to increase the calibration of Layer 1, or to focus on the more transmissive units in Layer 2.
    b. Figure 5.28, Locations for Assessing Horizontal and Vertical Hydraulic Gradients, SBGPP Model – Please explain the determination of "*Key wells*" (SAM-2, -6, -7, -8) used to qualitatively assess calibration in the fluctuations of potentiometric cycles and relative vertical gradients between Layers. As part of the remedial investigation, several other multi-completion monitoring wells were analyzed, including existing or newly installed wells (i.e. SAM-1, -3, -4, -5, -9, -10, -11, -13). Including additional wells is expected to improve calibration of the study area; please revise the figure to include the appropriate wells, or explain why these monitoring points were excluded.
    c. Section 4.0 Sensitivity Analysis – The text states, "*Hydraulic containment is assessed through capture zone analysis that incorporates reverse particle tracking to each* [Feasibility Study Groundwater Extraction Site] *FSES extraction well for a simulated period of 10 years.*" (1) Please explain why forward particle tracking was not performed and if it will be performed in the future when PDI data are available. After forward particle tracking is performed, reverse particle tracking simulations are usually performed to validate the forward run. (2)

Forward particle tracking results are generally considered a better way to assess the three-dimensional (3D) capture zone and are more representative than reverse particle tracking. In addition, the 2008 U.S. EPA guidance document, "*A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems*" states the following: "*Tracking particles in reverse from initial locations around the extraction wells, to define the capture zone, is a commonly used approach. However, it can lead to erroneous interpretations in two and three dimensions*..." The guidance further states that with reverse particle tracking, the capture is highly dependent on the number of particles released and their location (horizontal/vertical). In addition, the results may not show contributions to the well from aquifers above and/or below the screened interval. As such, in Section 3.3 Hydraulic Containment Assessment, please explain item (1) and provide justification for item (2) since forward particle tracking results are generally considered a better tool for assessing 3D capture zone.

d. Table 3-1 and 3-3 – This appendix defines flux as cubic feet per day or gallons per minute (gpm), a flow rate. Flux is defined as a volume per area per unit of time. Please revise and explain that the flux is the flow rate per unit cross-sectional area of the cell or alignment of cells.

We appreciate the opportunity to review this deliverable. If you have any questions, please contact Chad Nishida at (951) 782-3252, or by e-mail at chad.nishida@waterboards.ca.gov, or you may contact me at (951) 782-7958, or by email at nick.amini@waterboards.ca.gov.

Sincerely,

A. Nick Amini, Ph.D., P.E.
Chief, Site Cleanup Section

cc: Roy Herndon – OCWD (rherndon@ocwd.com)
Chris Ross – Engineering Analytics (CRoss@enganalytics.com)
Ken Puentes – Engineering Analytics (KPuentes@enganalytics.com)
Julie Macedo – SWRCB, OE (julie.macedo@waterboards.ca.gov)
Alex Huang – SWRCB, DFA (alex.huang@waterboards.ca.gov)
Aparjeet Rangi – SWRCB, DFA (aparjeet.rangi@waterboards.ca.gov)
Nicholas Ta – DTSC (Nicholas.ta@dtsc.ca.gov)
Yolanda Garza – DTSC (yolanda.garza@dtsc.ca.gov)
Emad Yemut – DTSC (emad.yemut@dtsc.ca.gov)

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APPENDIX Q
12/01/21 OCWD SOUTH BASIN TECHNICAL ADVISORY COMMITTEE MEETING MINUTES (D1712505)

MINUTES

OCWD South Basin Technical Advisory Committee Meeting (D1712505)

December 1, 2021
9:00 am – 11:00 am

MS Teams Link click here
Phone only: +1 (916) 535-3094, Phone Conference ID: 526 187 225#

Attendees:

X	Alex Huang	DFA	Prop 1 Program Manager	Alex.Hwang@waterboards.ca.gov
X	Aparjeet Rangi	DFA	Project Manager	Aparjeet.Rangi@Waterboards.ca.gov
	Jessica Law	RWQCB	Site Cleanup Program	Jessica.Law@Waterboards.ca.gov
X	Chad Nishida	RWQCB	Site Cleanup Program (Prop 1)	Chad.Nishida@Waterboards.ca.gov
X	Mehrnoosh Behrooz	RWQCB	Site Cleanup Program	Mehrnoosh.Behrooz@Waterboards.ca.gov
X	Carl Bernhardt	RWQCB	Site Cleanup Program	Carl.Bernhardt@Waterboards.ca.gov
X	Kayla Kawamura	RWQCB	Site Cleanup Program	Kayla.Kawamura@Waterboards.ca.gov
X	Nick Amini	RWQCB	Chief, Site Cleanup Program	Nick.Amini@waterboards.ca.gov
	Ann Sturdivant	RWQCB	Supervising Engineering Geologist	Ann.Sturdivant@waterboards.ca.gov
X	Nick Ta	DTSC	Project Manager	Nicholas.Ta@dtsc.ca.gov
X	Paul Pongetti	DTSC	GSU	PPongett@dtsc.ca.gov
X	Bill Leever	OCWD	Project Manager	wleever@ocwd.com
X	Roy Herndon	OCWD	Chief Hydrogeologist	rherndon@ocwd.com
X	Chris Ross	EA	Project Manager	CRoss@enganalytics.com
X	Ken Puentes	EA	Project Hydrogeologist	KPuentes@enganalytics.com

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9:00-9:05 **Roll Call/Introduction** Bill Leever

Bill Leever conducted roll call and introductions

9:05-10:45 **Discussion – TAC FSDE Review Comments and FSDE/PDI data cut-off date** All

Chris Ross provided a summary of the Feasibility Study (FS) document compilation process. The draft Feasibility Study Initial Screening Evaluation (FSISE), including redline-strikeout (RLSO) revisions associated with Technical Advisory Committee (TAC) review comments, were incorporated into the draft Feasibility Study Detailed Evaluation (FSDE) that was circulated for TAC review and comment. Now that TAC comments have been received on the draft FSDE, the plan is to: 1) accept previously circulated RLSO changes and 2) make new RLSO revisions in response to the recent TAC comments on the draft FSDE. The resultant document will become the draft FS and will include a table summarizing TAC review comments and responses to comments received on the draft FSDE. As such, final versions of the FSISE and FSDE tech memos are unnecessary and will not be prepared. The draft FS will be submitted to the TAC for review and comment, and when all TAC comments have been addressed a draft final FS will be submitted for Stakeholder Advisory Group (SAG) review and comment. Upon incorporation of SAG comments into the draft final FS, the post-SAG review FS will be submitted for final TAC review.

The TAC then reviewed comments from TAC members in the order they were received by the Orange County Water District (OCWD), including the Department of Toxic Substances Control (DTSC) Engineering and Special Projects Office (ESPO), DTSC Geologic Services Branch (GSB), the Regional Water Quality Control Board (RB), and the State Water Resources Control Board (SWRCB) Division of Financial Assistance (DFA).

DTSC ESPO 1 - Chris noted the comment.

DTSC ESPO 2 - Chris Ross stated that a professional civil engineer or geologist with at least 5-yrs experience in RI/FS type work will sign and stamp the FS.

DTSC ESPO 3 - Chris Ross stated that 1,4-dioxane requires an aggressive oxidizer for effective remediation and that is why sodium persulfate was specified in the FSDE. He also expects some bench and/or pilot testing of various oxidizers during the preliminary design investigation (PDI) phase, depending on the interim remedy selected.

DTSC ESPO 4 - Chris Ross stated the locations of abandoned wells are unknown and therefore the District cannot accurately front-load the costs of sealing legacy supply wells. The $50,000/year estimate is conservative in that it is unlikely that a legacy supply well will be discovered and properly destroyed/sealed every year for the next 30 years.

DTSC ESPO 5 - Roy Herndon stated the revised figure was sent to the TAC on 10/13/2021. The revised figure will be incorporated into the FS.

DTSC ESPO 6 - Roy Herndon stated the District uses a net present value (NPV) of 2.5%. The District will clarify the selection of the NPV used in the FSDE in the response to TAC FSDE comments.

DTSC GSU 1 - Chris Ross stated that the FSDE evaluated interim remedies and that the 30-year operating period used for cost comparison is an estimate and that extending the time period would not change the perspective. Paul Pongetti commented that the question was raised to show the relative differences between the alternatives. Chris stated that groundwater extraction and ISCO would require about the same remediation time. MNA would be longer. Chris stated the FS can incorporate these items in the text, but the 30-year remediation period used for costing would remain the same.

DTSC GSU 2 - Chris Ross stated the remedial action objectives (RAOs) were for the interim remedy not the final remedy. Paul Pongetti stated the RAOs would help support the justification for the remedy and the RAOs typical of a final remedy should be described in the FS. Chris indicated that the text will be revised to indicate that the final RAOs will likely incorporate restoration of the groundwater to the designated beneficial use to the extent practical.

DTSC GSU 3 - Chris Ross stated DNAPL is not a component of the OU2 contamination and is not expected to be encountered during the PDI or remedial system installation. Paul Pongetti asked that the FS explicitly state that DNAPL is not expected in OU2.

DTSC GSU 4 - Chris Ross stated that he agreed with the comment. Paul Pongetti asked if it was worth including advisory RAOs in the FS, which establish some standard of cleanup at the source sites that are needed to successfully implement the OU2 remedy. Roy Herndon responded that it may not be appropriate to list RAOs for source sites in this FS. Chris stated that the same objectives as to the status of source site remediation can be achieved through the 5-year remedy review process, with integrated OU1 and OU2 remedy reviews.

DTSC GSU 5 - Chris Ross stated there are low concentrations of PFAS in groundwater, but there is no basis for it to be a chemical of concern (COC). Chad Nishida asked if PFAS testing will be conducted during the PDI. Chris responded it would and that the waste discharge requirements would also require PFAS testing of groundwater, depending on the interim remedy selected. Paul Pongetti asked if the Orange County Sanitation District would require sampling for PFAS. Chris responded there are no such requirements at present and added that the Groundwater Replenishment System treats for PFAS.

DTSC GSU 6 - Chris Ross stated that upgradient monitoring would be conducted by the source site(s).

DTSC GSU 7 - This was addressed in a previous comment

DTSC GSU 8 - Chris Ross stated that the principal perchlorate groundwater contamination area is carved out of the FS as it is being addressed by others (i.e., source sites) and indicated that hexavalent chromium was not widespread within OU2. Ion exchange was not included in the FSDE for targeted inorganic constituent treatment because the membrane technology outlined in Alternative 4 was used to reduce a broader suite of inorganic constituents (total dissolved solids). Paul Pongetti asked that this be addressed in the FS text.

DTSC GSU 9 - Noted

RB 1 - Chris Ross stated that the Environmental Protection Agency (U.S. EPA) likes to include a sustainability assessment (SA) in the alternatives analysis. A SA may have more benefit if the remedial alternatives were ranked more closely based on evaluation criteria or during the remedy design phase, but it is still useful in the FS stage as a secondary (i.e., non-regulatory) comparison metric. Chad Nishida asked that the FS elaborate on the need for the SA and explicitly state that it is a secondary consideration, as the draft FSDE provided more detail in the SA sections than some of the other required evaluation criteria which is based upon applicable U.S. EPA guidance.

RB 2 - Noted

RB 3 - Chris Ross stated that a cost sensitivity analysis would likely have little impact on how the alternatives are ranked based on the large range in costs and similar uncertainties between alternatives. Chad Nishida asked that this be explained in the FS text considering the long remediation durations for each alternative.

RB 4 - Chris Ross indicated the Data Gap Analysis was meant to address the data gaps identified by the RB that may be, in part or whole, addressed during the PDI and through ongoing monitoring associated with each alternative, where applicable. The RB requested that all the data gaps be maintained and revisited during the PDI for the selected alternative. The data gaps will be included in an appendix of the FS and will be retained for further consideration during the PDI.

RB 5 - Chris Ross acknowledged the RB's comment on biodegradation and indicated the statement was a generalized statement that was not specific to OU2. This will be revised in the FS to clarify this and incorporate appropriate references.

RB 6 - Chris Ross stated that the average 12-foot radius of influence used for ISCO wells in the draft FSDE was based on literature review of source sites and that it would need to be refined during PDI work, depending on the interim remedy. After discussion, and as indicated in the comment, it was agreed that given the large cost differences between Alternative 5 and other alternatives a sensitivity analysis was not required for Alternative 5. The RB indicated that a sensitivity analysis for Alternative 6 - combined ISCO and pump and treat - would be beneficial. Injection may be proposed in specific areas for the interim remedy or future full-scale remedies. A sensitivity analysis for Alternative 6 will be conducted using a varied radius of influence dependent on and supported by subsurface geology of specific layers near the proposed alignments (radius of influence increases in more transmissive zones).

RB 7 - Chris Ross stated there is no published standard for a 1.5x change in groundwater flux as a metric for significant groundwater change. Further explanation and justification of the 1.5x value will be provided in the FS.

RB 8 through RB 11 - Noted

RB 12 - Chris Ross stated this will be addressed in the PDI water quality assessment as discussed in DTSC GSU comment 5. Roy Herndon indicated that PFAS sampling would be conducted to identify current conditions, but the sampling frequency may be reduced in subsequent events.

Nick Amini raised a question about the cut-off date for incorporating new information into the FS/PDI. Specifically, he wanted to know at what point in the District's efforts to implement OU2 remediation would the District revise its remedial plan if a source site remedy has been implemented by the responsible party in an area that may have a conflict with the District's plan.

Roy Herndon responded that the District intends to use the same data cut-off date for the RI and FS. The District will consider new information including issues raised by the Regional Board through the design phase of the interim remedy.

RB 13 - Chris Ross indicated that the table can include information/ranking on the level of control and adequacy/reliability of the technologies. Nick Amini stated the interim remedy must have the flexibility for modifications (i.e., reducing pumping rates of extraction wells or halting the remedy if adverse conditions are observed). Chad Nishida noted that some water treatment systems require a certain volume of influent to operate which may limit the ability to halt extraction entirely. Therefore, these variables and contingencies should be thoroughly explained and should not rely solely on a ranking level (Please see comment for requested details).

RB 14 - Chris Ross stated the figures will be updated.

RB 15 - See DTSC EPSO comment 6.

RB 16 - Chris stated the OU2 ISCO alignment along Daimler street has been removed (Complete).

RB 17 - Chris Ross stated the figures were developed using images of existing published source site figures and the images would obscure an underlying aerial photo. Chad Nishida asked for the aerial photos to be added even though they would be obscured by the source site images. Chad stated the intent of this comment is to capture existing features near the site being analyzed to help identify particle tracking paths relative to adjacent sites.

RB 18 - Roy Herndon said he'd check with legal to address using "relevant and appropriate" vs. "TBC."

RB 19 - Chris Ross stated the unit costs in the FSDE are based on experience at other sites in Southern California and professional experience and are consistent across alternatives.

DFA Comments

Due to the lack of time remaining, the TAC just addressed critical DFA comments. The response to comments (RTC) will be included in a separate RTC document, which will be circulated to the TAC by December 17, and following TAC review will be incorporated into the FS.

DFA 10 - Chris Ross stated that reverse particle tracking is best suited for the screening analysis presented in the FS and forward particle tracking is appropriate when the exact locations of groundwater extraction wells are known. Chad Nishida indicated that U.S. EPA guidance documents specify forward particle tracking be used in this type of analysis and verified with reverse particle tracking. Chris responded that forward particle tracking would be used during the design phase. Aparjeet stated that DFA still recommends adding forward particle tracking in addition to the reverse particle tracking in the FS. Additional discussion regarding Appendix E was requested.

9:45-9:55 Schedule Update Bill Leever

Bill Leever provided a schedule update that includes moving back the submittal of the FS and public outreach documents to February 2020. Bill with work with Aparjeet on processing a submittal schedule modification.

9:55-10:00 Walk-in Items, Action Item Recap, Adjourn

None

Action Items

1. **Bill Leever to send all TAC review comments to all TAC members**
2. **RB and District to discuss the need for a sensitivity analysis on the ROI of ISCO wells**
3. **RB and DFA to further discuss the particle tracking analysis**
4. **Roy Herndon to check with legal about using "relevant and appropriate" vs. "TBC"**
5. **Bill to prepare a document submittal schedule extension request and send to Aparjeet**
6. **District to provide RTCs to the TAC by December 17, 2021**
7. **Bill to send South Basin Geotracker link to Nick Ta**

APPENDIX R
12/15/21 OCWD SOUTH BASIN TECHNICAL ADVISORY COMMITTEE MEETING MINUTES
(D1712505)

MINUTES

OCWD South Basin Technical Advisory Committee Meeting (D1712505)

December 15, 2021
3:00 pm – 4:00 pm

MS Teams Link click here
Phone only: +1 (916) 535-3094, Phone Conference ID: 718 087 500#

Attendees:

___	Alex Huang	DFA	Prop 1 Program Manager	Alex.Hwang@waterboards.ca.gov
X	Aparjeet Rangi	DFA	Project Manager	Aparjeet.Rangi@Waterboards.ca.gov
___	Jessica Law	RWQCB	Site Cleanup Program	Jessica.Law@Waterboards.ca.gov
X	Chad Nishida	RWQCB	Site Cleanup Program (Prop 1)	Chad.Nishida@Waterboards.ca.gov
___	Mehrnoosh Behrooz	RWQCB	Site Cleanup Program	Mehrnoosh.Behrooz@Waterboards.ca.gov
___	Carl Bernhardt	RWQCB	Site Cleanup Program	Carl.Bernhardt@Waterboards.ca.gov
___	Kayla Kawamura	RWQCB	Site Cleanup Program	Kayla.Kawamura@Waterboards.ca.gov
X	Nick Amini	RWQCB	Chief, Site Cleanup Program	Nick.Amini@waterboards.ca.gov
___	Ann Sturdivant	RWQCB	Supervising Engineering Geologist	Ann.Sturdivant@waterboards.ca.gov
X	Nick Ta	DTSC	Project Manager	Nicholas.Ta@dtsc.ca.gov
___	Paul Pongetti	DTSC	GSU	PPongett@dtsc.ca.gov
X	Bill Leever	OCWD	Project Manager	wleever@ocwd.com
X	Roy Herndon	OCWD	Chief Hydrogeologist	rherndon@ocwd.com
X	Chris Ross	EA	Project Manager	CRoss@enganalytics.com
X	Ken Puentes	EA	Project Hydrogeologist	KPuentes@enganalytics.com

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3:00-3:05 **Roll Call/Introduction** Bill Leever

Bill Leever conducted roll call and introductions

3:05-4:00 **Discussion – Continuation from 12/1/2021 TAC Meeting** All

This meeting was held to address the below action items from the 12/1/2021 TAC meeting:

- **RB and District to discuss the need for a sensitivity analysis on the ROI of ISCO wells**
  The District will include, in the FS, a sensitivity analysis by increasing the ROI for ISCO injections for Alternative 6. A ROI of 25 feet (the maximum used at any source site in OU2) will be used and the associated costs will be developed and presented in the FS.

- **RB and DFA to further discuss the particle tracking analysis**
  The District will run forward particle tracking at a single alignment and compare the results with previously completed reverse particle tracking. The District and TAC will then meet to discuss the results and determine the most appropriate particle tracking approach for the FS.

Action Items

1. **Bill Leever to set meeting in mid-January 2022 to review forward particle tracking results.**

APPENDIX S
12/16/21 RESPONSES TO THE TECHNICAL ADVISORY COMMITTEE REVIEW COMMENTS ON THE DRAFT FEASIBILITY STUDY DETAILED EVALUATION, SOUTH BASIN GROUNDWATER PROTECTION PROJECT, OPERABLE UNIT 2 (PROP. 1 GRANT AGREEMENT NO. D1712505).
REVISED JANUARY 2022

Responses to the Technical Advisory Committee Review Comments on the
Draft Feasibility Study Detailed Evaluation, South Basin Groundwater Protection Project, Operable Unit 2 (Prop. 1 Grant Agreement No. D1712505)

Agency	Comment Number	Comment	Document Revision? (Y/N)	Proposed Response to Comment
RWQCB	1	General – The U.S. EPA Guidance on Feasibility Studies under [Comprehensive Environmental Response, Compensation, and Liability Act] CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 Code of Federal Regulations [CFR], Part 300) do not reference a sustainability assessment. Please explain how this assessment impacts the remedy selection.	**Y**	The sustainability assessment ranked each potential remedial alternative numerically from “0” (least sustainable) to “5” (most sustainable). **The sustainability assessment was performed to maintain consistency with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 Code of Federal Regulations [CFR], Part 300), commonly referred to as the National Contingency Plan or NCP. Specifically, the USEPA Office of Solid Waste and Emergency Response (OSWER) Principles for Greener Cleanups was referenced, which states “OSWER cleanup programs should consider these Principals for Greener Cleanups during any phase of work, including site investigation, evaluation of cleanup options, and optimization of the design, implementation, and operation of new or existing cleanups.” The text was revised to indicate that the sustainability assessment, like the Threshold and Balancing Criteria, should be used in the remedy selection process, although it may be considered in some instances to be a secondary consideration relative to the Threshold and Balancing Criteria. More detailed sustainability assessment will be conducted during the design phase to integrate green principals into the overall processes.**
RWQCB	2	Section 2.2 Screening Levels – The text states, “The US Environmental Protection Agency (EPA) adopted the same 50 [micrograms per liter] µg/L standard for total chromium, but in 1991 raised the federal [maximum contaminant level] MCL to 100 µg/L. California did not follow US EPA's change and stayed with its 50 µg/L standard.” We recommend using the hexavalent chromium MCL as soon as it is established. Please note, at the time of this letter the State Water Resources Control Board, Division of Drinking Water (DDW) proposed adopting and implementing a regulation that establishes an MCL for hexavalent chromium in drinking water provided by public water systems in California. The State Water Board is considering adopting and implementing 1 of 17 proposed MCLs ranging from 1 to 15, 20, and 25 µg/L.	N	Comment noted
RWQCB	3	Section 5.3 Relative Cost – A sensitivity analysis should be conducted to assess the variations in specific assumptions associated with design, implementation, operation, discount rate and the effective life an alternative can have on the costs estimated. The results of the analysis can be used to identify upper and lower limits of cost estimates and will allow for more accurate contingencies or reserve funds. For projects with high operations and maintenance costs extending over a 30-year lifecycle or more, it is encouraged to include a sensitivity analysis with different discount rates.	**Y**	**The text was revised to indicate that, based on the large spread in costs and similar uncertainties between and among the Remedial Alternatives, a sensitivity analysis would not add substantial value and that the relative cost estimates and comparisons in the FS are not intended to develop or support reserve estimates. The cost estimate(s) for selected Alternative(s) will be refined after PDI data collection and at different stages of the design process.**

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RWQCB	4	Section 7.2.2 Incorporation of RWQCB Data Gap Analysis – This comment and associated sub-sections (a-k) reiterate areas where data is missing downgradient (or off-site) from sources of contamination, as stated in our November 21, 2019 letter titled, "Summary of Data Gaps for The Supplemental Remedial Investigation Report – Orange County South Basin Groundwater Protection Project, Operable Unit 2 (Grant Agreement No. D1712505)". The following were either not mentioned or not fully addressed in the FSDE.	**Y**	The FS currently states that the Data Gap Analysis was meant to address the data gaps identified by the RWQCB that may be, in part or whole, addressed during the PDI and through ongoing monitoring associated with each alternative, where applicable. **The text was revised to indicate that the level of effort to select specific locations and depths of data gap monitor wells can be high and is reserved for the selected alternative during the Remedial Design phase of work. The level of effort to develop and present detailed evaluation in the FS for each alternative does not add commensurate value or influence comparison and selection of an alternative. All of the alternatives included a substantial number of monitor wells as outlined in Table 7-1. For groundwater extraction alternatives, extraction well monitoring data will also be collected, which substantially increases the monitoring data for these alternatives. The data gaps identified by the RWQCB that were not incorporated into the FSDE text will be reviewed prior to conducting PDI to assess relevancy to the selected alternative. The information developed during the PDI will inform and close many data gaps for the selected alternative, and there may be data gaps that become more apparent during implementation of the remedy which will be addressed during 5 year remedy reviews.** **Additionally, all of the Data gaps in the RWQCB November 21, 2019 letter titled, "Summary of Data Gaps for The Supplemental Remedial Investigation Report – Orange County South Basin Groundwater Protection Project, Operable Unit 2 (Grant Agreement No. D1712505)" were added to Appendix G of the FS.**
RWQCB	4.a	Alternative 2 Monitored Natural Attenuation (MNA): a. Bell Industries Off-Site (2) – We do not believe that the data gaps identified apply only to Alternative 2. The same consideration of data gaps should also apply to Alternatives 3-6. The Area 2 G/I-1 alignment near Warner Avenue and the 55-freeway (55FWY) is located downgradient of MW-24, -24C, cone penetrometer test (CPT)-15, -114, -17, and -111. Additional sampling in this area is necessary for determining the lateral and vertical extent of contamination, since the existing CPT data (collected in approximately 2012) are outdated and are not representative of current conditions. In addition, this information will be useful in defining the extent of migration of contaminants of concern (COCs) across the 55FWY and the adjacent alignment length (G/I-1). This information will be beneficial to the development and effective implementation of an interim remedy.	**Y**	See above

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RWQCB	4.b	Alternative 2 Monitored Natural Attenuation (MNA): b. Holchem and Circuit One (5) - We do not believe that the data gaps identified apply only to Alternative 2.and the same consideration of data gaps should also apply to Alternatives 3-6 below. The data gaps are directly related to Area 1 G/I-2. Specifically, CPT-100, -206, -104, and -180 were referenced, since the plume has comingled with historical discharges from other facilities in this area (bounded to the west by Holchem and Embee Plating sites, to the south by East Warner Avenue, to the east by Circuit One, and to the north by Barlen Enterprises). Investigation of this area will establish baseline conditions with respect to OU2, and provide vertical characterization of the subsurface zones that may benefit most from an interim remedy. Please note, Circuit One will be performing CPT/membrane interface probe (MIP) profiling, and will be collecting groundwater grab samples. The data from these efforts may contribute to the pre-design investigation (PDI) (e.g. used in the monitoring well installation and design).	Y	See above
RWQCB	4.c	Alternative 2 Monitored Natural Attenuation (MNA): c. Cherry Aerospace Off-Site (8) - For Alternative 2, we recommend this area encompass drinking water production well IRWD-3, since COCs were detected in nearby monitoring well, SAM-4. IRWD-3 was previously identified as the impaired drinking water source and is one reason for implementing interim remedial measures.	**Y**	See above
RWQCB	4.d	Alternative 3-6 Proposed Interim Remedial Measures: d. Steelcase off-Site (4) – Our comments indicated the need for additional delineation adjacent to the 55 FWY between Bell Avenue and Valencia Avenue, since comingling of 1,1-dichloroethylene (1,1-DCE) and 1,4-dioxane have been detected upgradient of Steelcase (MW-29B). More recent data that have been obtained since our issuance of that letter further support the need for the additional delineation. Results of additional groundwater investigation upgradient of the on-site source are available in the Second Half 2020 report prepared by Environmental Resources Management. Information in the report may be useful in your efforts to determine the extent of contaminant migration across the 55 FWY and the adjacent alignment length (Area 2 G/I-1).	**Y**	See above
RWQCB	4.e	Alternative 3-6 Proposed Interim Remedial Measures: e. Area Bounded by South Grand Avenue, East Warner Avenue and the 5 FWY (7) - This area extends south and downgradient of Area 2 G/I-1 and the eastern edge of Area 1 G/I-2. Please revise the associated Areas in the figures.	**Y**	See above

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RWQCB	4.f	Alternative 3-6 Proposed Interim Remedial Measures: f. Cherry Aerospace (8) – Our comments (8.a) also discussed the area southwest of Cherry Aerospace and west of drinking water production well IRWD-3; please include the area as per our request, or provide justification as to why this area was not included. Data from this area may be beneficial for designing the western edge of alignment Area 4 G/I-5. Similarly, comment (8.b) suggested future impacts to IRWD-3 and the possibility that pumping from IRWD-3 could cause vertical downward migration in monitoring well SAM-4. We recommend this area be further investigated if impacts to drinking water production well IRWD-3 remain a concern.	**Y**	See above
RWQCB	4.g	Alternative 3-6 Proposed Interim Remedial Measures: g. Not included as a data gap within the FSDE: ITT Cannon (9) – This comment was included for Alternative 2 only; however, we recommend this also be included for Alternatives 3-6. Our comment discussed the data gaps between SAM-5 and SAM-6 and CPT-123, -124, and -190. These data gaps are near Dyer Road and will apply to design and implementation of Alternatives 3-6, more specifically Area 1 G-8/I-10&11 and Area 4 G/I-5.	**Y**	See above
RWQCB	4.h	Alternative 3-6 Proposed Interim Remedial Measures: h. Not included as a data gap within the FSDE: Dyer Business Park off-site (10) – One of our comments was not included for both Alternative 2 and Alternatives 3-6, with respect to Area 7 G/I-6. The omitted comment states, "a. Since 2012, no data has been collected southwest of Dyer Business Park and north of SAM-7, therefore, the extent of the comingled COC plume may have migrated beyond the contour boundary since the time the groundwater grab samples were obtained. b. In addition, data gaps exist in the vicinity of SAM-7. [trichloroethylene] TCE concentrations in SAM-7A (39.5-49.5 [feet below ground surface] ft bgs) have fluctuated from approximately 32. 1µg/I to 49 µg/L. No data exists from 0-39.5 ft bgs and step-out borings in all directions have not delineated nor identified an upgradient source/potential downgradient impacts." Data from the Dyer Business Park would be relevant to help design G/I-6 near SAM-7. Without additional monitoring points in the area, SAM-7 will be the only monitoring well north of the intersection of West MacArthur Blvd and the 55 FWY. Please include the omitted comment in the discussions for Alternative 2 and Alternatives 3-6.	**Y**	See above

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RWQCB	4.i	Alternative 3-6 Proposed Interim Remedial Measures: i. South of the intersection of Redhill Avenue and Gillette Avenue (14) - Please explain why Area 6 and Area 8 for Alternative 2 (MNA alternative) have more extensive coverage when compared to Area 6 and Area 8 of Alternatives 3-6. We recommend that Area 6 and Area 8 be consistent for both Alternative 2 and Alternatives 3-6. Data from Areas 6 and 8 will aid in the design of Area 8 G/I-7, since those areas are upgradient of the proposed remedial action.	**Y**	See above
RWQCB	4.j	Alternative 3-6 Proposed Interim Remedial Measures: j. South of the 55 FWY and MacArthur Blvd (15) – The data gap analysis did not address our comment (15.b), which states, "In addition, SAM-8A is screened from 33-43 ft bgs and does not address shallow contamination from 0-33 ft bgs." Shallow groundwater grab samples ranged from 25-30 ft bgs, and monitoring wells near MacArthur Blvd. are screened from ~10-20 ft bgs with depth to water of approximately 10 ft. Please include/address this data gap. k. Baxter Healthcare and Edwards Lifesciences off-site (16) – The data gap analysis did not address our comment (16.a), which states, "Further delineation of the leading edge of the plume is needed vertically and laterally located to the west of MacArthur Blvd, bounded by Redhill Avenue and Main Street, and in the general vicinity of CPT-174." Contaminants may have migrated beyond the locations where groundwater grab samples were collected in approximately 2012. The extent of contamination is not delineated. Updated and complete information and clear delineation of the extent of contamination will benefit the design and optimization of G/I-7 alignment, which may need to be extended westward across MacArthur Blvd.	**Y**	See above
RWQCB	5	Section 7.2.3.2 Alternative 2 - Monitored Natural Attenuation - The text states, "Biodegradation of 1,4-dioxane has been observed to occur under aerobic conditions at many other sites but not all. Although slightly aerobic conditions exist in the shallow aquifer, the length of the 1,4-dioxane plumes (greater than several thousand feet) indicates the 1,4-dioxane plumes are not being controlled by natural biodegradation or any other destructive process…". The statement is inaccurate, since anaerobic conditions are typically observed in the subsurface of the South Basin; however, it is true that appropriate microorganisms that degrade 1,4-dioxane are neither native nor dominant in the South Basin. Aerobic conditions have been seen at some, but not the majority of sites. Similarly, other prevalent COCs in the South Basin (such as 1,1-dichloroethene at concentrations as low as 5 µg/L) are shown to inhibit the destruction of 1,4-dioxane. Please remove, or provide justification for, the statement that biodegradation of 1,4-dioxane has been observed to occur under aerobic conditions at many sites.	**Y**	**The text was revised to add references and clarify that the discussion was not specific to OU2 but rather a generalization.**

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RWQCB	6	Section 7.2.3.5 Alternative 5 – The text states, "Based on an average injection [radius of influence] (ROI) of 12 feet, injection wells would be installed on 24-foot spacings." There is a large variation in hydraulic conductivity with depth and location within the study area; therefore, it is unlikely that an "average" ROI can be realistically applied to the entire study area. The summary table of source site injection spacing should be dependent on its location within the study area and the targeted vertical intervals, which may be significantly more or less transmissive. We recommend proposing appropriate values for ROI in the different and varying hydrogeologic conditions that exist in the study area. Alternatively, please provide sufficient technical details to justify the selection of the average 12 ft ROI and its application to Layers 1, 2, and 3. a. Please note, this generalized ROI assumption is likely to influence costs associated with Alternative 6 and its overall ranking, not the overall ranking of Alternative 5. Alternative 6 incorporates fewer injection wells compared to Alternative 5 (In-situ Chemical Oxidation [ISCO] only), but still assumes an average 12 ft ROI, even though the injections are located within Area 1 as opposed to spanning the entire study area. A more careful assessment of realistic ROI values, based on local lithology and horizontal and vertical extent of COCs, may identify portions of the study area that would benefit from targeted injection instead of implementing a full injection alignment.	**Y**	**The document was revised to include a sensitivity analysis of increasing the ROI for ISCO injections for Alternative 6. A ROI of 25-feet (the maximum used at any source site in OU2), was assumed consistent with our discussion on December 15, 2021 and the associated costs were developed and presented.**
RWQCB	7	Section 7.3.3. Alternatives 3 through 6 - The text states, "For the purposes of this evaluation, simulated groundwater flux increases of less than a factor of 1.5 from ambient (non-IRM pumping conditions) are considered negligible and are not further discussed below." Please provide justification for determining that a flux factor of 1.5 from ambient conditions is negligible.	**Y**	**The text was revised to indicate that changes in groundwater flux are dictated by changes in horizontal hydraulic gradients. It is not uncommon to have changes in horizontal hydraulic gradients under ambient conditions. For example, water level elevation contours for the upper and lower portions of the Shallow Aquifer System within the Study Area published in the July 2020 South Basin Supplemental Remedial Investigation Report indicated that horizontal hydraulic gradients under ambient conditions ranged from a high of 0.0028 to low of 0.002 and 0.0017 to 0.001, respectively. These variable ambient groundwater gradients represent changes in groundwater flux values ranging between a factor of 1.4 to 1.7. Thus, use of a factor of 1.5 appears reasonable and technically supported.**
RWQCB	8	Section 7.3.3.7: Steelcase Incorporated – Please note that the RP has recently informed us about their plan to submit a work plan proposing mass removal for impacted soil and in-situ remediation of contaminated groundwater at this source site.	**Y**	**The FS was updated with this information**

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RWQCB	9	Section 7.3.3.8: Troy Computer – The responsible party for this site is no longer planning to perform groundwater remediation; please update this section and associated sections. Please refer to our September 20, 2021 comment letter, which discusses source zone impacts. The potential selection and implementation of a groundwater remedy is on hold, pending further groundwater investigation and a feasibility study.	**Y**	**The FS was updated with this information**
RWQCB	10	Section 7.3.3.9: GE Plastics – The downgradient in-situ bioremediation of perchlorate has been conducted through the use of biobarriers installed along Deere Avenue in both the first and second water-bearing zones, and in Alton Parkway in the second water-bearing zone. Please refer to the "off-site biobarrier" Waste Discharge Requirements (WDRs) monitoring reports from 2018 to the present for details.	**Y**	**The FS was updated with this information**
RWQCB	11	Section 7.3.3.12: Baxter Healthcare – The text states that the site "is planning to perform additional ISCO using activated persulfate into the intervals 28 to 38 feet bgs (Layer 1) and 40 to 50 feet bgs (Layer 2) on the property." The Site has already implemented pilot scale remediation using persulfate activated with sodium hydroxide. Please refer to the WDRs monitoring reports from February 2020 to the present for details.	**Y**	**The FS was updated with this information**
RWQCB	12	Tables 7-1 and 7-2 – Operations, maintenance and monitoring (OM&M). We recommend the addition of per- and polyfluoroalkyl substances (PFAS) as monitoring parameters, using U.S. EPA Method 537.1 for chemical analysis. This information will benefit the PDI by determining the current extent of PFAS. In addition, this information will be required in the monitoring and reporting plan established by the WDRs.	**Y**	**The text was revised to indicate that some PFAS monitoring would be required for alternatives that rely on Waste Discharge Requirements (WDR) Orders and that it is expected that some PFAS sampling will be conducted as part of PDI and part of groundwater extraction discharge monitoring.**

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RWQCB	13	Table 8-2 – This table indicates the degree to which the treatment process is irreversible and states, "Once COCs are removed from groundwater, the process is irreversible." It should be expected that treatment processes are irreversible; however, the analysis should be done with respect to the remedial action (i.e. extraction and injection [E&I]). Please identify and evaluate any expected adverse effects of remedial construction and operation to the groundwater basin and state whether the effects are reversible or irreversible (i.e. modification to extraction frequency and rates; response to inducing unfavorable gradients; contingencies if higher than expected contaminant concentrations must be treated; conflicts with implementation of a final remedy, and the potential for back-diffusion to occur). a. If any alternative appears to have significant irreversible effects, the user should state the mitigative measures (i.e. reduction in E&I flow rates, halt E&I in all or portions of the alignments) to be taken in conjunction with the alternative. If success of the remedial alternative may be compromised by the mitigative measures, this should also be explained. b. Please explain to what extent the operation of extraction and injection alternatives can be modified (extraction/injection rates reduced or halted in the event that unfavorable gradients may be induced). c. The footnotes for Criteria Ranking do not match Alternatives 1-6; please revise.	**Y**	**Table 8-2 has been supplemented with Table 8-2A, which includes analysis of adequacy, reliability and reversibility of the remedial technologies included in each alternative.**
RWQCB	14	Figure Series 1 – Figures depicting the Former Standard Screw products site are inaccurate. The figures inconsistently identify well screens in either Layer 2, Layer 3, or the wells are omitted when they should have been included. In addition, hexavalent chromium data were included, yet it has not been identified as a COC for the site, nor has it been quantified via laboratory analysis of samples from the site's monitoring wells. Conversely, 1,4-dioxane has been identified at the site, but the analytical data for this constituent were omitted from the figures.	**Y**	**The Former Standard Screw Products well designations were reviewed and figures 1-08 and 1-38 were revised. Hexavalent chromium is a COC and was identified as such in Section 1.6 of the FS. Figures 1-18 through 1-21 of the FS illustrate 1,4-D in Layers 1 through 4.**
RWQCB	15	Figure 1-8 - Layer 3 was not populated for TCE; please correct the figure.	**Y**	**The referenced table and figure were revised.**
RWQCB	16	Figure 2-4 Alternative 5 - Please remove the OU2 ISCO alignment along Daimler street.	**Y**	**This alignment was removed from the figures**

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RWQCB	17	Figure Series 7 – We recommend adding a satellite view base map, which will help reviewers visualize nearby facilities and features with respect to particle tracks.	Y	**These figures were developed using existing published source site figures, so that there would be no loss in accuracy or fidelity in transposing remediation areas, wells, or groundwater level elevation contours to another base map, such as a "satellite view base map". We have used the figures from each source site to ensure that the original interpretations provided from each source site were utilized. The figures were revised to include an larger-scale aerial photo to provide additional context.**
RWQCB	18	Appendix B: Potential Federal and State of California Applicable or Relevant and Appropriate Requirements (ARARs) - This section did not address the comments provide in our July 25, 2018 letter titled "Comments on Remedial Investigation/Feasibility Study Deliverable…". a. Please include a response to comments table addressing our July 25, 2018 comments. b. Page 3 indicates, "potentially relevant and appropriate." We recommend changing the category to "to be considered" (TBC). c. State Water Resources Control Board Notification Levels (NLs) California Health and Safety Code §116455 and §116271. NLs are advisory levels. not enforceable standards that potable water suppliers must comply with. If a chemical is detected above its notification level in a drinking water source, certain requirements and recommendations apply. We recommend that NLs be categorized as TBC. d. Order No. R8-2002-0033, as amended by Order Numbers R8-2003-0085 and R8-2013-0020. These Orders establish General Waste Discharge Requirements for the Reinjection/Percolation of Extracted and Treated Groundwater Resulting from the Cleanup of Groundwater Polluted by Petroleum Hydrocarbons, Solvents and/or Petroleum Hydrocarbons Mixed with Lead and/or Solvents for the Santa Ana Region. This State ARAR should be listed in Appendix B as relevant and appropriate. e. Please include General Waste Discharge Requirements for In-Situ Groundwater Remediation at Sites within the Santa Ana Region, Order No. R8-2018-0092. This Order applies to the discharge of chemical and biological amendments into the subsurface to perform cleanup of groundwater and soil contamination within defined "treatment zones." This State ARAR should be listed as relevant and appropriate.	**Y**	**Table 1 summarizes how the ARARs were updated based on RWQCB comments.** **Use of "Potentially Applicable" were removed and replaced with "Applicable", "Relevant and Appropriate", or "TBC"** **Notification Levels are identified as TBCs in current table 8-2. WDR permits would be required for injection, if selected, and potential inclusion of WDR permit requirements in the ARARs will be evaluated and discussed.** **The orders noted in the comment were included as ARARs, as applicable.**

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RWQCB	19	Appendix D Detailed Cost Estimates for OU2 Interim Remedial Alternatives – a. General - Please provide more details for "Southern California Unit Costs" references. b. Please provide a reason for variations in rough order of magnitude (ROM) cost for testing: sampling, hydraulic testing and documentation for Alternatives 2-4. Alternative 2 (installation of 187 monitoring wells) has a cost of $1M while Alternative 3 (installation of 94 monitoring wells) has the same Cost of $1M. On the contrary Alternative 4 (installation of 84 monitoring wells) has a cost of $1.5M. We recommend the explanation be added to the footnotes or in the Cost Estimate Source column. c. Please describe how the estimated number of "Permit/Access Well Easements" were calculated. d. For several Alternatives under Monitoring and Reporting "sampling year 4" there appear to be 4 years of annual sampling proposed at each monitoring well. Please explain why the quantity of sampling is doubled for years 5-8 when this covers the same 4-year time span. The quantity is also doubled for reporting; please correct and/or clarify. e. Table D-6, Alternative 6 – This alternative contains the same number of 4" PVC extraction wells as Alternatives 3 and 4, although extraction alignment G-8 is not included. The number of extraction wells is expected to be lower when implementing partial injection alignments; please explain and/or correct this table.	**Y**	**The text and table footnotes were revised to indicate that the cost reference to Southern California Unit Costs reflect actual contracted costs for similar work items at other Southern California environmental investigation/remediation sites.** **The ROM cost is essentially a place holder estimate as the name implies. The placeholder cost does not include the installation of monitor wells, but is a general cost for studies/testing associated with each alternative. Alternatives 2 and 3 do not need treatability/bench studies; however, injection technologies (ISCO and re-injection) do, so there is an increased cost for Alternatives 4 through 6.** **The estimated permit/access fees for wells is based on costs obtained from similar work in Fullerton California and is used as a surrogate for OU2 work that may be performed in the public right of ways.** **The main reasons for the difference in sampling volume and sampling/reporting costs between and within alternatives are: 1) the sampling frequencies vary by year (they are not static); and, 2) the difference in laboratory analyses between and within alternatives (for example MNA Alt 2 has small analyte list years 1-4, then larger list every 5 years, which is repeated every 5-years).** Table D-6, Alternative 6 correctly identifies 74 extraction wells for this alternative, versus 75 extraction wells (one additional extraction well for Alignment G-8) that are specified for Alternatives 3 and 4.
RWQCB	20	Appendix E: Part I Model Construction Calibration Report – a. Figure 4.10 - Please explain the negative model layer thickness. b. Appendix A-1 Summary of Remedial Extraction wells and Appendix A-2 Calibration Targets – For each well we recommend including columns for upper bound and lower bound of each corresponding layer above mean sea level (amsl). This is intended to help visualize the vertical layer interval at individual wells.	**Y**	**The referenced table and figure were revised.**
RWQCB	21.a	Appendix E: Part II Model Simulation Results – a. The modeled residuals of Layer 1 are more positively skewed and indicate an underprediction of water level elevations. The text further states, "Multiple factors could be affecting the quality of the calibration statistics of Layer 1 including: calibration targets from this layer may be from wells that are completed in perched systems that are not connected or continuous throughout the study area; may be from wells that are screened across multiple layers; or water levels at the wells used as calibration targets may be affected by localized remedial groundwater extraction systems." Please elaborate on how this calibration is "still reasonable" in terms of the level of detail necessary in the FSDE. In addition, please discuss whether the proposed PDI monitoring wells are intended to increase the calibration of Layer 1, or to focus on the more transmissive units in Layer 2.	N	a. Section 5.3 addresses the observed bias in Layer 1 and potential causes, however, the simulated directions of groundwater flow and hydraulic gradients are close to those that were observed. Given the low hydraulic conductivity of this layer, it is not considered an important OU2 contaminant migration pathway (lateral) and the model therefore was deemed adequate for the purposes of the FSDE/FS. However, future PDI well installation does include Layer 1 monitor wells, and data from these wells and other PDI data can be used to update the data analysis during Remedial Design process.

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RWQCB	21.b	b. Figure 5.28, Locations for Assessing Horizontal and Vertical Hydraulic Gradients, SBGPP Model – Please explain the determination of "Key wells" (SAM-2, -6, -7, -8) used to qualitatively assess calibration in the fluctuations of potentiometric cycles and relative vertical gradients between Layers. As part of the remedial investigation, several other multi-completion monitoring wells were analyzed, including existing or newly installed wells (i.e. SAM-1, -3, -4, -5, -9, -10, -11, -13). Including additional wells is expected to improve calibration of the study area; please revise the figure to include the appropriate wells, or explain why these monitoring points were excluded.	N	b. All SAM wells were used as a calibration targets in model calibration as indicated in Table A-2. A subset of SAM wells were used to illustrate vertical hydraulic gradients.
RWQCB	21.c	c. Section 4.0 Sensitivity Analysis – The text states, "Hydraulic containment is assessed through capture zone analysis that incorporates reverse particle tracking to each [Feasibility Study Groundwater Extraction Site] FSES extraction well for a simulated period of 10 years." (1) Please explain why forward particle tracking was not performed and if it will be performed in the future when PDI data are available. After forward particle tracking is performed, reverse particle tracking simulations are usually performed to validate the forward run. (2) Forward particle tracking results are generally considered a better way to assess the three-dimensional (3D) capture zone and are more representative than reverse particle tracking. In addition, the 2008 U.S. EPA guidance document, "A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems" states the following: "Tracking particles in reverse from initial locations around the extraction wells, to define the capture zone, is a commonly used approach. However, it can lead to erroneous interpretations in two and three dimensions..." The guidance further states that with reverse particle tracking, the capture is highly dependent on the number of particles released and their location (horizontal/vertical). In addition, the results may not show contributions to the well from aquifers above and/or below the screened interval. As such, in Section 3.3 Hydraulic Containment Assessment, please explain item (1) and provide justification for item (2) since forward particle tracking results are generally considered a better tool for assessing 3D capture zone.	**Y**	**Based on the 12/15/2021 meeting with the RWQCB and DFA, the District ran forward particle tracking at all of the extraction alignments and compared the results with previously completed reverse particle tracking. The District and TAC then discussed the results on 01/10/22. Hydraulic containment was evaluating using forward particle tracking wherein particles were placed upgradient of the groundwater extraction alignments in each layer that requires hydraulic containment (based on water quality data). Consistent with the reverse particle tracking, the code MODPATH Version 3 (Pollack 1994) was used to simulate the forward particle tracking. Lines of particles were placed approximately 250 and 500 feet upgradient of the groundwater extraction alignments. Layer 1 and 2 particles were initialized in the midpoint of the respective layers. Layer 3 particles were initialized in the upper quarter of this layer. The particles were tracked to steady-state conditions. The forward particle tracking was applied using the same remediation modeling framework and parpameter assumptions as the reverse particle tracking and there were no changes in the simulated potentiometric surfaces or flow fields. The modeling results from the forward particle tracking are consistent with those of the reverse particle tracking, in that most groundwater immediately upgradient of the groundwater extraction alignments is captured under the simulated extraction rates (Figures 1 through 3).**
RWQCB	22	Table 3-1 and 3-3 – This appendix defines flux as cubic feet per day or gallons per minute (gpm), a flow rate. Flux is defined as a volume per area per unit of time. Please revise and explain that the flux is the flow rate per unit cross-sectional area of the cell or alignment of cells.	**Y**	**The table was revised to include explanation of the groundwater flow rate/flux values.**
DTSC ESPO	1	General Comment 1. The document does not contain conclusions or recommendations for the remedial alternatives and should be clearly marked "Draft".	N	The document will be labeled draft final until public review is complete.

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DTSC ESPO	2	General Comment 2. The FSDE includes cost estimates associated with civil infrastructure and should thereby be signed and stamped by a California licensed civil engineer with current registration, in accordance with the California Business and Professional Code Section 6735.	N	The document will be signed by a California Professional Geologist or Professional Civil Engineer with relevant experience.
DTSC ESPO	3	Section 54.4.73, Chemical Processes, Screening Determination. It's not clear why the FSDE identifies activated sodium persulfate as the recommended in-situ chemical oxidation (ISCO) oxidant at this stage of the evaluation process, beyond the observation that is has been used with some success for groundwater treatment at source areas located within OU-2. It may be more appropriate to include costs for a more comprehensive bench-scale study to evaluate multiple oxidants, and perhaps a pilot test, to identify the most suitable oxidant(s) and oxidant delivery methods for the conditions present across OU-2.	N	If a remedial alternative that includes ISCO as a treatment technology is selected, then additional evaluations and/or bench-scale studies of additional oxidants may be considered as part of the PDI. The use of activated sodium persulfate provides a reasonable surrogate for the scope and costs of ISCO application for the purposes of the FS.
DTSC ESPO	4	Section 7.2 Scope of Alternatives and Common Elements. The FSDE allocates $50,000 per year to address activities associated with sealing legacy water supply wells within the OU. The basis for annual allocated sum is not clear, and it is not apparent that it is appropriate for the money allocated for this work to be distributed equally across each year of work included in the cost estimate. Given that these legacy wells may serve as continuing vertical conduits for contaminant transfer within OU-2, it may be of value to frontload the estimate with the money for this work to identify and seal these wells on a more expeditious schedule.	N	Since it is not known when, where, or how many of these wells may be discovered, the cost estimate allocation for Sealing Legacy Water Supply Wells is a rough order-of-magnitude estimate. The actual schedule and cost expenditures will be based on the discovery of the Legacy Water Supply Wells , which is expected to occur on a relatively low frequency, since most of the OU2 area has been redeveloped.
DTSC ESPO	5	Figure 1-8, Trichloroethylene in Layer 3 Groundwater. This figure doesn't show any TCE data on it. It is unclear if TCE data is not available for Layer 3, or if the data was simply not shown on the figure. Please revise as necessary.	**Y**	**The figure was revised**
DTSC ESPO	6	Appendix D, Detailed Cost Estimates for OU2 Interim Remedial Alternatives. a. Table D-1 indicates that a discount rate of 2.5% was used for the net present value (NPV) evaluation. The NPV should be based on the applicable Real Discount Rate from the most current White House Office of Management and Budget Circular for 2020 A-94 Appendix C. b. The cost estimate incorporates varying contingency factors across different elements of the remedial alternatives, with a maximum contingency of 35%. We consider this to be too low of a contingency for this FSDE and recommend that it is increased to align more closely with the US EPA and US Army Corps of Engineers guidance for developing and documenting cost estimates during the feasibility study (EPA 540-R-00-002, July 2000). c. The remedial alternative cost estimates include costs for investigation activities that range between $1,000,000 and $1,500,000 with the note that they are rough-order-of-magnitude estimates. The estimated investigation costs should be further substantiated for each individual remedial alternative.	**Y**	**For item a., the document was revised to indicate that the 2.5% discount rate is based on OCWD's financial personnel input and is the typical current discount rate used by OCWD for assessing longer-term projects.** For Items b., and c., the document was not revised

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DTSC GSU	1	Executive Summary: "In response to DFA comments on the FSISE, it is noted that Interim Remedial Actions do not include numeric cleanup goals as part of RAOs, nor do they provide an estimate for cleanup times." 30 year project lifetime costs were presented for all alternatives. GSB understands there is significant uncertainty with cleanup time estimates given the unspecific numeric cleanup goals and variable source site remedial efforts; however, GSB recommends relative cleanup timeframes for remedial alternatives be provided in the FS to evaluate alternatives and associated cost more accurately.	**Y**	**This text actually exists in Section 1.1. The text was revised to indicate that, comparing the anticipated relative durations of remedial operations, groundwater extraction and treatment (GET) and ISCO would be similar, and that MNA would be longer than either GET or ISCO. For Alternatives 2 through 6, it is expected that the IRMs will operate for at least several decades, so 30 years was used as a basis of the comparisons and cost estimates.**
DTSC GSU	2	Executive Summary: "Consistent with the preceding USEPA guidance, OCWD intends to implement IRMs that will be consistent with any final remedy, if required." GSB recommends the FSDE include a discussion of possible final remedy RAOs to evaluate consistency of the IRMs with a future final remedy. For example, it would be useful to understand if the final remedy RAOs are expected to include restoration of groundwater to its designated beneficial use.	**Y**	This text actually exists in Section 1.1. The final remedy is expected to be a combination of OU2 and source site remediation, and both components will be evaluated periodically, including 5 year remedy reviews. The OU2 final remedy RAOs will consider restoration of groundwater to the designated beneficial use, to the extent practical. **The text was revised to indicate that RAOs for a final remedy will likely incorporate restoration of groundwater to the designated beneficial use, to the extent practical, which would be advanced by the selected alternative.**
DTSC GSU	3	Section 1.5, Conceptual Site Model: "There are numerous contaminant source areas within the Study Area. Some of the VOC source areas contain dense nonaqueous phase liquid (DNAPL) or residual DNAPL (Aquilogic, 2015) that will continue to act as long-term sources of contamination to off-property groundwater if not contained or removed." GSB agrees that DNAPL is a long-term source for dissolved-phase groundwater contamination and identifying DNAPL source zones is an important component of the conceptual site model and critical to the selection of IRMs. GSB recommends that boundaries of suspected DNAPL source zones be identified in the FS and investigated further, if necessary. Additionally, GSB recommends phasing the construction of monitoring wells in these areas so information obtained from initial drilling and well installation informs the Conceptual Site Model (CSM) and decisions about siting subsequent monitoring, extraction and/or injection wells.	**Y**	**The text was revised to indicate that there is no known or suspected DNAPL in OU2, as OU2 is defined in the document and identification of DNAPL boundaries are part of the source site remedies.**
DTSC GSU	4	Section 1.5, Conceptual Site Model: "Remediation of source areas is expected to be conducted by potential responsible parties in tandem with the interim remedy resulting from this RI/FS." Source removal is the most effective way to prevent further degradation of groundwater resources (RAO 1) and source removal is relevant to the effectiveness, reliability, and cost of the interim and final remedies selected for OU2. For the interim and final remedies to be successful, groundwater upgradient of the treatment areas must make progress towards consistent RAOs. GSB recommends the remedial design include standardized advisory RAOs and performance goals for source site remedial efforts to ensure compatibility with the selected IRMs for OU2.	N	Comment noted. We believe that DTSC and RWQCB will be instrumental in ensuring that source remedial actions are effective.

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DTSC GSU	5	Section 1.6.1, Potential Human Health Risk. This Section explains that Per- and polyfluoroalkyl substances (PFAS) did not appear to be related to sites and were not retained as COCs. GSB is concerned about the representativeness of PFAS sampling results used for this evaluation and GSB recommends OCWD provide more explanation as to how their evaluation was completed. It's not clear how many source sites were sampled for PFAS and GSB recommends PFAS be retained as a COC until more sites are sampled. GSB notes that Embee Plating is located within OU2 and completed a preliminary investigation for PFAS in 2021. The PFAS investigation included collection of 15 soil samples from five soil borings and groundwater samples from 13 wells. PFAS was detected in both soil and groundwater. Perfluorooctanesulfonic acid (PFOS) was detected in 10 of the 13 groundwater samples with the highest concentration of 15,200 ng/L reported at EP-16C. Perfluorobutanesulfonic acid (PFBS) PFBS was also detected. DTSC has requested a workplan for additional PFAS investigation. Details can be found on Envirostor: https://www.envirostor.dtsc.ca.gov/public/final_documents2?global_id=30340013&doc_id=60484984.	**Y**	**The text was revised to indicate that some PFAS monitoring would be required for alternatives that rely on Waste Discharge Requirements (WDR) Orders and that it is expected that some PFAS sampling will be conducted as part of PDI and part of groundwater extraction discharge monitoring.**
DTSC GSU	6	Section 5.4.3, Monitoring: This Section describes long-term groundwater monitoring as a component of containment and in-situ response actions and explains how monitoring data will be used. GSB recommends groundwater monitoring data also be used to demonstrate continued IRM compatibility with ongoing and planned remediation at source sites. GSB recommends the groundwater monitoring objectives be better aligned to the RAOs as follows: a. GSB recommends monitoring data be used to provide an interpretation of upgradient groundwater conditions and trends in contaminant concentrations (RAO1, RAO4). For example, identify rebounding concentrations from a previous source site remedial effort. b. GSB recommends monitoring include surface water sampling results, if needed, to determine exceedance of ecological risk-based concentrations or other ARARs (RAO 5). c. Groundwater monitoring should include a discussion of the any water supply well COC concentrations exceeding drinking water MCLs or other ARARs (RAO 6). d. For in-situ technologies, GSB recommends that groundwater monitoring data be used to evaluate treatment byproducts detrimental to source site remedial efforts (RAO 4). e. For groundwater extraction and treatment (GET), GSB recommends that groundwater monitoring data be used to evaluate changes in groundwater fluxes and directions of flow near source sites that may affect their remedial efforts (RAO 4).	N	a. This type of evaluation is the responsibility of the individual source site responsible parties. b., c., and e. Comment noted d. The ISCO treatment cost estimates include the costs of analyzing groundwater samples for treatment byproducts on a routine basis

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DTSC GSU	7	Discharge to the Orange County Sanitation District (OCSD) publicly owned treatment works (POTW) Reclamation Plant No. 1 in Fountain Valley was retained in the FSDE as a discharge option for groundwater extraction and treatment (GET), and included in Remedial Alternatives 3 and 6. GSB recommends the discharge standards be included in the FSDE and compared to the expected GET effluent concentrations. In the event that discharge standards are modified or exceeded, or unanticipated concentrations of COCs are encountered in extracted groundwater, contingency groundwater treatment costs should be provided and discussed.	N	The extracted water will meet current POTW requirements. It is agreed that there could be changes to these standards, detection of emergent compounds, and other uncertainties. The FS is not meant to address potential costs associated with contingencies for alternatives. The 5-year remedy reviews are normally the means of addressing changing conditions and ability of lack thereof to achieve RAOs.
DTSC GSU	8	The screening of remedial technologies and process options in Section 5 indicates that perchlorate and Cr6 have not been identified as significant contaminants in the areas that may be considered for OU2 IRMs, although they were designated as OU2 groundwater COCs. Membrane processes were retained as a response action related to the injection of treated groundwater for Remedial Alternative 4, while ion exchange was not. GSB recommends retaining these two technologies and comparing the costs. Additionally, GSB recommends including the costs for perchlorate and Cr6 analysis in the cost estimates due to their designation as OU2 groundwater COCs.	**Y**	**The text was revised to indicate that the main perchlorate source and associated plume are outside the scope of the OU2 FS and IRMs. Hexavalent chromium is found at several source sites, but is not wide spread within OU2. Alternative 4 uses reverse osmosis to reduce non-compounds of concern (COC) inorganic constituents to concentrations similar to those existing in the receiving layer (Basal Sand). Ion exchange is not warranted for this type of application.**
DTSC GSU	9	Groundwater extraction and in situ chemical oxidation (ISCO) transects located south of East Warner Avenue, north of Dyer Road and east of Cherry Aerospace are presented as alternatives (e.g., Remedial Alternative 5). On October 12, 2021 DTSC participated in a meeting with SOCO West consultants (Geosyntec) to discuss potential locations for a replacement monitoring well which was installed in 2016 at 1312 East Warner Avenue. The general location of the well is south of East Warner Avenue and east of Cherry Aerospace and Geosyntec reported difficulty in obtaining site access for a replacement well. This property is currently owned by Calpine Corporation (Calpine) and used as a battery energy storage project. Southern California Edison (SCE) operates an electrical substation to the South. Access for well installation purposes may be challenging at these two properties and GSB recommends OCWD explore accessibility with Calpine and SCE as soon as possible and incorporate the findings into the FSDE.	N	We appreciate the information and understand that access is a challenge with any alternative.

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SWRCB DFA	1	Appendix A, Data and Methods Used to Prepare COC Plan View Figures - Please provide detailed methodology of how the plume maps of Chemicals of Concern (COC) were created. Specifically, which software and methods were used to create the COC maps. Please include detail information similar to Model Development and Model codes section in Appendix E. Include references used to create heat maps, and spatial interpolation of contamination. Indicate the various interpolation methods such as kriging, inverse direct weighted, moving averages, etc. that were used to create the COC plan view figures.	N	The COC plan view contours are from the SRI and the data and detailed methods and presentation of interpretations were presented in the appendices. The method of interpreting large data sets usually starts with kriging data as a starting point, followed by adjustments based on professional judgement.
SWRCB DFA	2	Appendix E, Model Domain, Grid and Layering, Section 4.2 - Paragraph states that the model domain was extended over a distance of one mile in all direction from the Study area boundaries to minimize impacts of exterior boundary conditions on the model solution in the area of interest. Please clarify if additional area is included in the 31,000 feet by 31,000 feet model grid size.	N	The extended area is included in the model domain.
SWRCB DFA	3	Geologic and Hydrogeologic Framework, Section 1.2.1 – Paragraph describes four layers of the groundwater model in the Shallow Aquifer System. However, Appendix E, Model Domain, Grid and Layering section indicates that the overall model consists of six layers. Please correct the discrepancy or provide details of layers 5 and 6 in the Principal Aquifer System in Section 1.2.1.	N	Appendix E states that Layers 1 to 4 are part of the Shallow Aquifer system. Layer 5 is the aquitard at the base of the SAS and Layer 6 is the upper portion of the Principal Aquifer System.
SWRCB DFA	4	Potential Human Health Risk, Section 1.6.1 – Paragraphs identifies Operable Unit2 groundwater chemical of concerns (COCs) as identified in the Preliminary Aquilogic Report (Aquilogic 2015). These groundwater COCs are further evaluated in the FSDE. Based on the review, none of the COCs within the study area includes evaluation of Perfluorooctanoic acid (PFOA) and Perfluorooctanesulfonic acid (PFOS). Based on the publicly available data, several of the City of Santa Ana production wells have been impacted with PFOA/PFOS. It is DFA understanding that the OCWD has performed several pilot tests outside of the project to determine best available technology for treatment of PFOA/PFOS in the Basin based on cost and effectiveness. Therefore, include a paragraph that details OCWD holistic approach to address PFOA/PFOS contamination in the Basin that aligns with the objectives of this project.	N	See responses to DTSC GSU comment 5 and RWQCB comment 12.
SWRCB DFA	5	Treated Water Discharge or End Use Process Options, Section 5.4.6 - Remedial Alternatives, Section 6.2 – Section provides explanation of the six Remedial Alternatives for the project area. Please explain why the end use option to treat water and provide it for drinking water purposes were not considered. It is understood that the evaluation might not have been retained for review in the Initial Screening Evaluation Memo, please explain/confirm.	N	Drinking water end use was not considered for multiple reasons. Two of the primary considerations are the relatively small quantity of water generated and the substantial Division of Drinking Water (DDW) permitting requirements. No revisions recommended.
SWRCB DFA	6	Treated Water Discharge or End Use Process Options, Section 5.4.6.1 – Please explain the text that states the following: “using extraction rate at the source area sites cannot be applied to the injection rate at Principal Aquifer.”	N	No response required, as this comment was on another document

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SWRCB DFA	7	Appendix E, Boundary Conditions, Section 4.4 – Text indicates approximately 70 source site remedial extraction wells were used in the groundwater model. However, model did not take into account any production wells in the principal aquifer system. Please explain.	N	The hydraulic influence of production wells was incorporated into the model through variable heads in Layer 6 which are correlated to pumping in the area and recharge to the basin.
SWRCB DFA	8	Appendix E, Figures – Please include a figure similar to Figure 4.17 that shows all the monitoring and extraction wells used in the development of the groundwater model. Separate the wells according to the layer designation. If possible, indicate the fifty-six (56) wells (46 wells inside the study area) used for calibrating the model.	**Y**	**Figures were prepared illustrating all of the monitoring and extraction wells used in the model simulations for each Layer**
SWRCB DFA	9	Calibration Statistics, Table 5.2 – Residual mean square error (RMSE) in all the layers and individual layers are approximately the same, except in Layer 1 which has a RMSE of 4.08. Please explain the statistical model calibration fit in Layer 1.	N	See RWQCB comment 21a
SWRCB DFA	10	Figures 7s, Model Simulated Groundwater Particle Tracks – Please explain the justification to only use reverse particle tracking for groundwater flow analysis. Include pros and cons of difference between the reverse and forward modeling simulations. Include the results of both the forward as well as reverse particle tracking. It is DFA understanding that the data input values for the both the simulations in the USGS ModPath package are almost the same. Include methodology paragraph of reverse particle tracking in Appendix E, provide references. Include forward particle tracking to show extraction wells alignment (for ex: G2 and G3) are adequate for hydraulically capturing/containing the COCs.	N	See RWQCB comment 21c
SWRCB DFA	11	Appendix E, Table 5-2 – Thank you for providing model's statistical residual values to indicate that the model is calibrated adequately.	N	Comment noted.
SWRCB DFA	12	Inactive Potable Water Supply Wells, Page 7, Section 1.2.5.1– Freon 113 and other contaminants were detected in production well IRWD – 51. Confirm the well designation, there is a reference to IRWD – 51 in Table 1-2, however no further discussion on IWRD-51. Please revise if necessary.	N	the DFA clarified the question as to whether IRWD-51 existed. It does exist as indicated in Table 1-2 and the text and currently is inactive.
SWRCB DFA	13	Appendix A, Screening Levels, Section 2.2: Trichloroethylene and Tetrachlorethylene screening levels are listed as Federal Primary Maximum Contaminant Level (MCL) in the table. Please also list the CA Primary MCLs screening levels for these two contaminants.	N	The screening levels were the lower of Federal or State MCLs, and if both of these were the same, which is the case for TCE and PCE, the Federal MCL was identified, since the Federal MCL is a broader reference.

TABLES

TABLE 1
RESPONSE TO RWQCB COMMENTS ON APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
SOUTH BASIN GROUNDWATER PROTECTION PROJECT
ORANGE COUNTY, CALIFORNIA

Agency	Comment Number	Comment	Revision Y/N	Response to Comment
RWQCB	18 a.	**Please include a response to comments table addressing our July 25, 2018 comments.**		
		Comment 25 (RWQCB July 25, 2018) Table A-1, Page 1 of 11: The 1995 Water Quality Control Plan for the Santa Ana River Basin (Region 8) was updated in February 2008, June 2011, February 2016 and February 2018. Please refer to the current version in the ARARs.	*Y*	Added list of updates as listed in comment
		Comment 26 (RWQCB July 25, 2018) Table A-1, Page 4 of 11: Seems to be a duplication of the ARAR mentioned on Page 1. Also, the date (1/28/95) should be updated.	*Y and N*	Added list of dates (per Comment 25), but the Water Quality Control Plan for Santa Ana River Basin ARAR has both chemical-specific (WQOs for gw) and action-specific sections (relevant to treated gw reinjection and/or surface water discharge), thus the duplication. So remains in both sections.
		Comment 27 (RWQCB July 25, 2018) Table A-1, Page 4 of 11: The status for SWRCB Resolutions 68-16 and 92-49 should be changed to ‘Applicable’	*N*	OCWD does not agree that the State Water Resources Control Board (SWRCB) Resolutions are “Applicable”. The remedies that will be recommended in the Feasibility Study are interim measures to prevent further vertical and horizontal plume migration and will not be implemented for plume cleanup. Remediation to background levels is not an objective and is not appropriate for interim measures.
		Comment 28 (RWQCB July 25, 2018) Table A-1, Page 7 of 11: In the description listed for SWRCB Resolution No. 86-63, please mention that the listed exceptions are overruled by designations for each body of water in the Santa Ana Region's Basin Plan. Also, the status of this requirement should be revised to ‘Appropriate and Relevant’	*Y*	(Note, RWQCB typo, meant "88-63" in comment). Comment Noted: "Listed exceptions are overruled…" statement was added to end of description and status changed to Relevant and Appropriate.
		Comment 29 (RWQCB July 25, 2018) Table A-2: California notification levels for drinking water (NLs) should be considered ‘Relevant’	*N*	No Change. NLs are not ARARs (advisory levels and no formal regulatory standards) and are therefore TBCs. Also, see Comment 18c, below.
		Comment 30 (RWQCB July 25, 2018) Table A-2: California Well Standards should be considered ‘Applicable’	*N*	The ARARs for this item have been changed to applicable

TABLE 1
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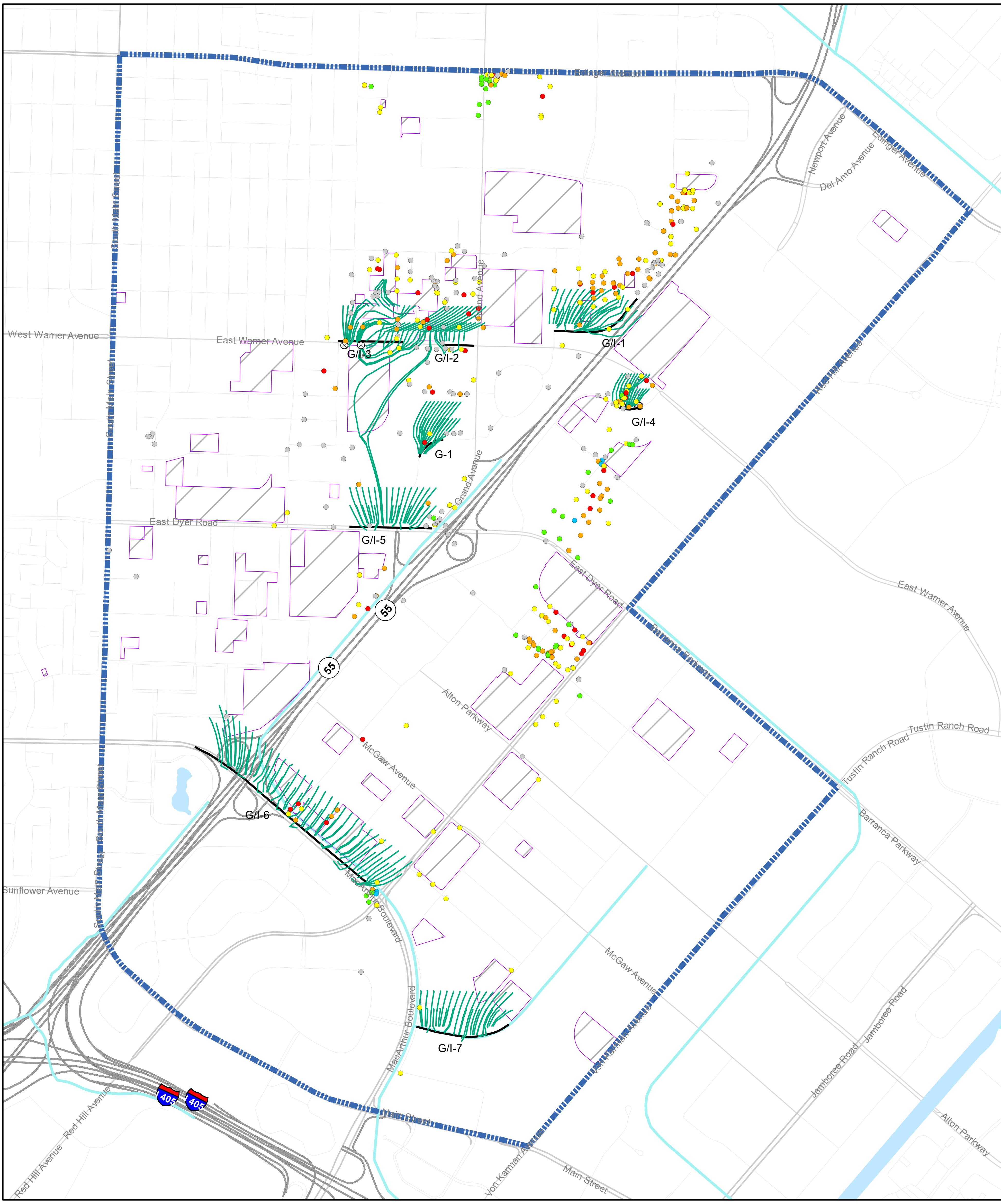
RWQCB	18 a.	**Comment 31 (RWQCB July 25, 2018)** Table A-2: SWRCB Division of Drinking Water Policy 97-005 should be considered 'Relevant'	*N*	This policy establishes a process, including permitting, that must be followed before using an extremely impaired water source as a drinking water supply. This policy is not a promulgated requirement and is included as a TBC for drinking water end use to the extent this is considered.
	18 b.	**Page 3 indicates, "potentially relevant and appropriate." We recommend changing the category to "to be considered" (TBC).**	*Y*	This applies to Secondary Drinking Water Standards, which were moved from ARARs (Table B-1) to TBCs (Table B-2)
	18 c.	**State Water Resources Control Board Notification Levels (NLs) California Health and Safety Code §116455 and §116271. NLs are advisory levels. not enforceable standards that potable water suppliers must comply with. If a chemical is detected above its notification level in a drinking water source, certain requirements and recommendations apply. We recommend that NLs be categorized as TBC.**	*Y*	Agree. NLs are included in TBCs (Table B-2).
	18 d.	**Order No. R8-2002-0033, as amended by Order Numbers R8-2003-0085 and R8-2013-0020. These Orders establish General Waste Discharge Requirements for the Reinjection/Percolation of Extracted and Treated Groundwater Resulting from the Cleanup of Groundwater Polluted by Petroleum Hydrocarbons, Solvents and/or Petroleum Hydrocarbons Mixed with Lead and/or Solvents for the Santa Ana Region. This State ARAR should be listed in Appendix B as relevant and appropriate.**	*Y*	New entry for California Water Code §13260 Report of Waste Discharge (ROWD)/Waste Discharge Requirements (WDR) was added under under Porter Cologne WQA (see action-specific ARARs section), including citation for R8-2002-0033.
RWQCB	18 e.	**Please include General Waste Discharge Requirements for In-Situ Groundwater Remediation at Sites within the Santa Ana Region, Order No. R8-2018-0092. This Order applies to the discharge of chemical and biological amendments into the subsurface to perform cleanup of groundwater and soil contamination within defined "treatment zones." This State ARAR should be listed as relevant and appropriate.**	*Y*	New entry for California Water Code §13260 Report of Waste Discharge (ROWD)/Waste Discharge Requirements (WDR) was added under under Porter Cologne WQA (see action-specific ARARs section), including citation for R8-2018-0092.

FIGURES



Groundwater Sample Point

- Non-Detect less than MCL/NL
- Detect less than MCL/NL
- Non-Detect greater than or equal to MCL/NL
- MCL/NL to 10x MCL/NL
- >10x MCL/NL to 100x MCL/NL
- >100x MCL/NL

- Forward Particle Track Layer 1
- Groundwater Extraction Transect
- OU2 Extraction Well Screened within Layer
- Study Area
- Source Sites

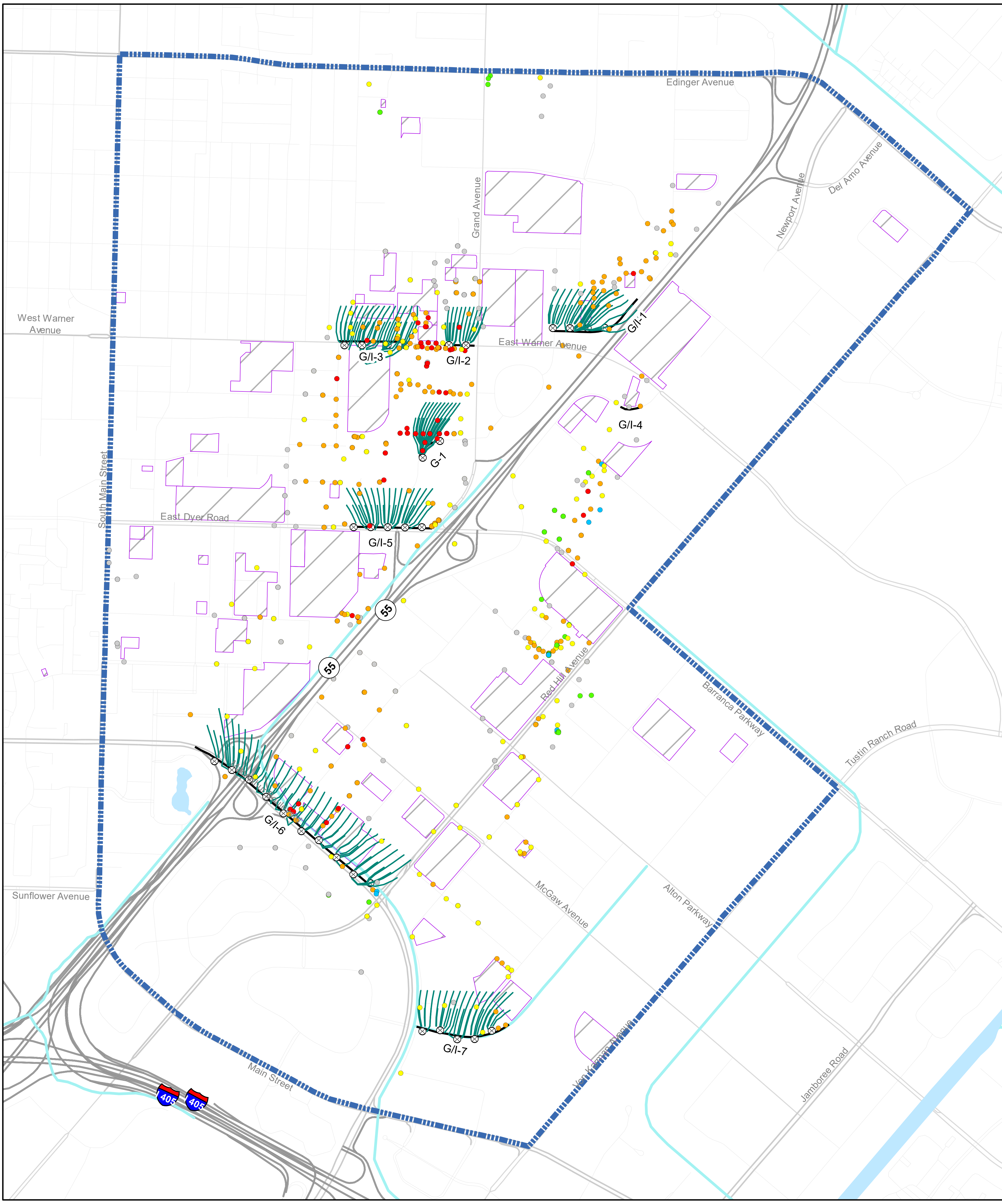
NOTES:
MCL = Maximum Contaminant Level
NL = Notification Limit
> = greater than
x = times
Groundwater sample points represent the maximum result relative to MCLs of any compound of concern at that location and depth
Particle paths are only illustrated for this layer of model, in some cases the particle path migrates vertically into other layer(s), in these instances, the particle path is illustrated on other layer figures. For example, the particle paths that appear to be a single point illustrate vertical migration into Layer 2.

N

0 750 1,500 3,000
Feet

Engineering Analytics, Inc.

FIGURE 1
Layer 1 Forward Particle Tracks and Groundwater Sample Results
Orange County Water District South Basin



Groundwater Sample Point

- Non-Detect less than MCL/NL
- Detect less than MCL/NL
- Non-Detect greater than or equal to MCL/NL
- MCL/NL to 10x MCL/NL
- >10x MCL/NL to 100x MCL/NL
- >100x MCL/NL

- Forward Particle Track Layer 2
- OU2 Extraction Well Screened within Layer
- Groundwater Extraction Transect
- Study Area
- Source Sites

NOTES:
MCL = Maximum Contaminant Level
NL = Notification Level
> = greater than
x = times
Groundwater sample points represent the maximum result relative to MCLs of any compound of concern at that location and depth
Particle paths are only illustrated for this layer of model, in some cases the particle path migrates vertically into other layer(s), in these instances, the particle path is illustrated on other layer figures.

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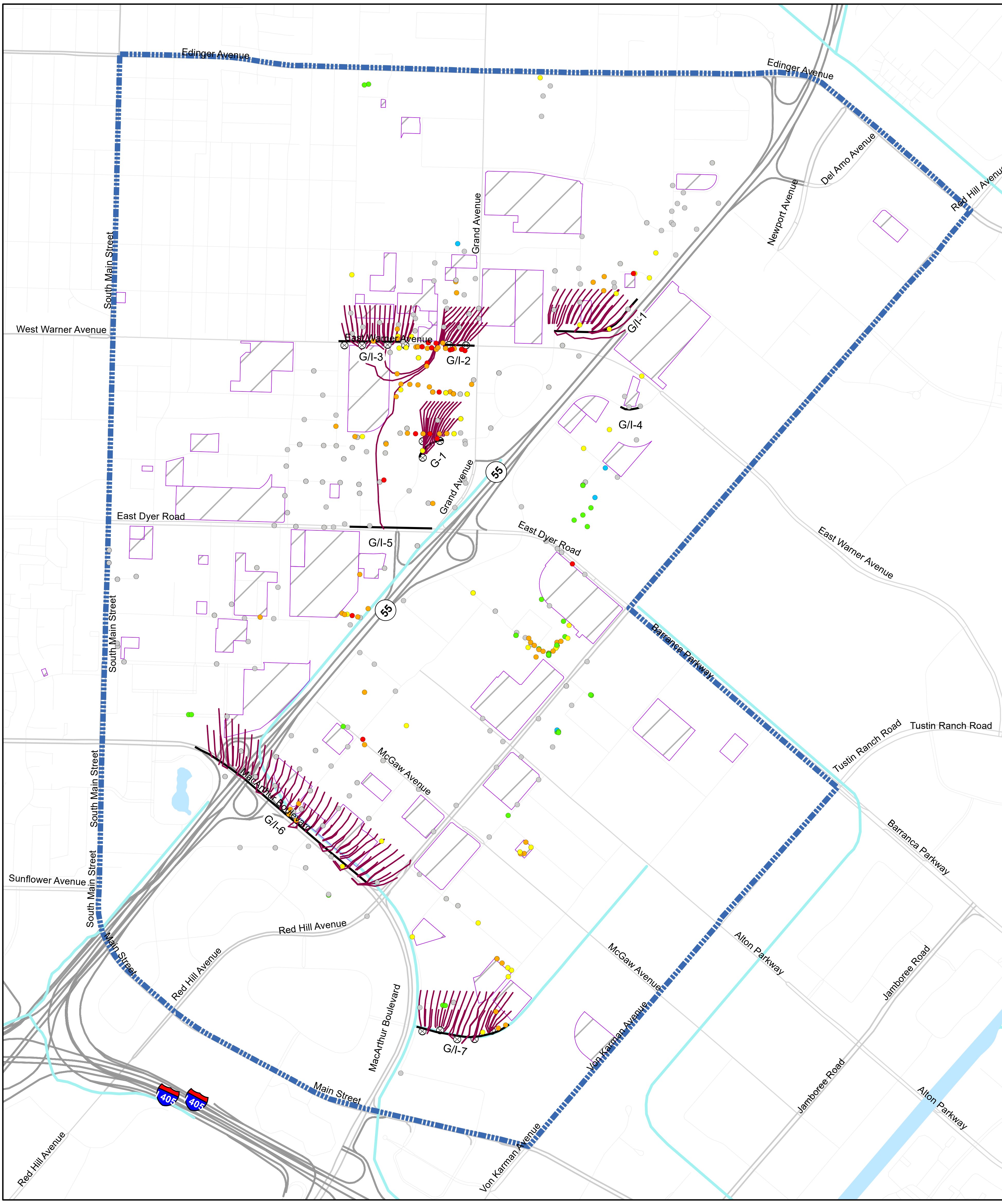
Engineering Analytics, Inc.

FIGURE 2
Layer 2 Forward Particle Tracks and Groundwater Sample Results
Orange County Water District South Basin



Groundwater Sample Point

- Non-Detect less than MCL/NL
- Detect less than MCL/NL
- Non-Detect greater than or equal to MCL/NL
- MCL/NL to 10x MCL/NL
- >10x MCL/NL to 100x MCL/NL
- >100x MCL/NL

- Forward Particle Track Layer 3
- Groundwater Extraction Transect
- OU2 Extraction Well Screened within Layer
- Study Area
- Source Sites

NOTES:
MCL = Maximum Contaminant Level
NL = Notification Level
> = greater than
x = times
Groundwater sample points represent the maximum result relative to MCLs of any compound of concern at that location and depth
Particle paths are only illustrated for this layer of model, in some cases the particle path migrates vertically into other layer(s), in these instances, the particle path is illustrated on other layer figures.

N

0 750 1,500 3,000
Feet

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Engineering Analytics, Inc.

FIGURE 3
Layer 3 Forward Particle Tracks and Groundwater Sample Results
Orange County Water District South Basin

APPENDIX T
01/10/22 OCWD SOUTH BASIN TECHNICAL ADVISORY COMMITTEE MEETING MINUTES
(D1712505)

MINUTES

OCWD South Basin Technical Advisory Committee Meeting (D1712505)

January 10, 2022
11:00 pm – 12:00 pm

MS Teams Link click here
Phone only: +1 (916) 535-3094, Phone Conference ID: 122 807 879#

Attendees:

	Name	Agency	Role	Email
X	Alex Huang	DFA	Prop 1 Program Manager	Alex.Hwang@waterboards.ca.gov
X	Aparjeet Rangi	DFA	Project Manager	Aparjeet.Rangi@Waterboards.ca.gov
	Jessica Law	RWQCB	Site Cleanup Program	Jessica.Law@Waterboards.ca.gov
X	Chad Nishida	RWQCB	Site Cleanup Program (Prop 1)	Chad.Nishida@Waterboards.ca.gov
	Mehrnoosh Behrooz	RWQCB	Site Cleanup Program	Mehrnoosh.Behrooz@Waterboards.ca.gov
	Carl Bernhardt	RWQCB	Site Cleanup Program	Carl.Bernhardt@Waterboards.ca.gov
	Kayla Kawamura	RWQCB	Site Cleanup Program	Kayla.Kawamura@Waterboards.ca.gov
	Nick Amini	RWQCB	Chief, Site Cleanup Program	Nick.Amini@waterboards.ca.gov
	Ann Sturdivant	RWQCB	Supervising Engineering Geologist	Ann.Sturdivant@waterboards.ca.gov
	Nick Ta	DTSC	Project Manager	Nicholas.Ta@dtsc.ca.gov
	Paul Pongetti	DTSC	GSU	PPongett@dtsc.ca.gov
X	Bill Leever	OCWD	Project Manager	wleever@ocwd.com
X	Roy Herndon	OCWD	Chief Hydrogeologist	rherndon@ocwd.com
X	Chris Ross	EA	Project Manager	CRoss@enganalytics.com
X	Ken Puentes	EA	Project Hydrogeologist	KPuentes@enganalytics.com
X	Errol Lawrence	EA	Groundwater Modeler	ELawrence@enganalytics.com

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11:00-11:05 Roll Call/Introduction Bill Leever

Bill Leever conducted roll call and introductions

11:05-12:00 Discussion – Comparison of Forward Particle Tracking to Reverse Particle Tracking All

This meeting was held to address the below action items from the 12/1/2021 TAC meeting and 12/15/2021 meeting of a sub-group of the TAC:

- **RB and DFA to further discuss the particle tracking analysis**
  Engineering Analytics (EA) performed forward particle tracking at each groundwater extraction alignment and compared the results with previously completed reverse particle tracking (10-year period). Particle tracks were placed 250-500ft upgradient of each proposed extraction well alignments with approximately 100ft of horizontal spacing, which is intended to demonstrate containment of a certain amount of groundwater. Vertically, particles were placed in the middle of Layers 1 and 2, and the upper one-third of layer 3 The following summarizes the results of the analysis:

Alignment G-1: The draft FSDE included extraction in Layers 2 and 3. Extraction in Layer 2 captures groundwater in both Layers 1 and 2, and extraction in Layer 3 captures groundwater from this layer. Layer 3 extraction was erroneously omitted from the forward particle tracking analysis and the District will add extraction from Layer 3 in this analysis to be consistent with the simulations included in the draft FS. The forward particle tracking analysis in Layers 1 and 2 shows containment of particles and confirmed the results of the reverse particle tracking.

Alignments G-2 and G-3: Extraction in Layers 2 and 3 in G-2, and in Layers 1, 2, and 3 in G-3. It was noted that particles released in Layer 1, upgradient of alignment G-2 accounted for groundwater extraction at the Gallade site. For G-2, extraction in Layer 2 captures groundwater in both Layers 1 and 2. Some particles between the two alignments G-2 and G-3 escape capture, but they are captured by alignment G-5 to the south. It was noted the gap between these two alignments was to not influence the SOCO West remedy. The forward particle tracking analysis shows containment of particles and confirmed the results of the reverse particle tracking.

Alignment G-4: Extraction in Layer 1 only. The forward particle tracking analysis shows containment of particles and confirmed the results of the reverse particle tracking.

Alignment G-5: Extraction in Layer 2 only. Layer 2 extraction captures groundwater in both Layers 1 and 2. The forward particle tracking analysis shows containment of particles and confirmed the results of the reverse particle tracking.

Alignment G-6: Extraction in Layer 2 only. Layer 2 extraction captures groundwater in Layers 1, 2 and 3. The forward particle tracking analysis shows containment of particles and confirmed the results of the reverse particle tracking.

Alignment G-7: Extraction in Layers 2 and 3. Layer 2 and 3 extraction captures groundwater in Layers 1, 2 and 3. The forward particle tracking analysis shows containment of particles and confirmed the results of the reverse particle tracking.

Alignment G-8: Extraction in Layers 2 and 3. Layer 2 and 3 extraction captures groundwater in Layers 1, 2 and 3. The forward particle tracking analysis shows containment of particles and confirmed the results of the reverse particle tracking.

Aparjeet requested the forward particle tracking analysis be included in the FSDE response to comments and that it includes the methods and assumptions used in the analysis.

Chad asked if the results of the analysis changed any of the FSDE conclusions and Chris responded they did not change any of their conclusions. Chad also said he had sent a few comments on the draft response to comments to the TAC in an email and would resend to the group today.

Action Items

1. **District to include forward particle tracking analysis in the response to comments on the FSDE, including the methods and assumptions used in the analysis.**
2. **District will include the Layer 3 extraction in Alignment G-1 (erroneously omitted) in the modeling analysis and in the draft FS.**

APPENDIX U
11/08/22 OCWD SOUTH BASIN TECHNICAL ADVISORY COMMITTEE MEETING MINUTES (D1712505)

MINUTES

OCWD South Basin Technical Advisory Committee Meeting (D1712505)

November 8, 2022
2:00 pm – 3:00 pm

MS Teams Link click here
Phone only: +1 (916) 535-3094, Phone Conference ID: 667 284 882#

Attendees:

X	Alex Huang	DFA	Prop 1 Program Manager	Alex.Huang@waterboards.ca.gov
X	Aparjeet Rangi	DFA	Project Manager	Aparjeet.Rangi@Waterboards.ca.gov
	Jessica Law	RWQCB	Site Cleanup Program	Jessica.Law@Waterboards.ca.gov
X	Chad Nishida	RWQCB	Site Cleanup Program (Prop 1)	Chad.Nishida@Waterboards.ca.gov
X	Mehrnoosh Behrooz	RWQCB	Site Cleanup Program Supervisor	Mehrnoosh.Behrooz@Waterboards.ca.gov
	Kayla Kawamura	RWQCB	Site Cleanup Program	Kayla.Kawamura@Waterboards.ca.gov
X	Nick Amini	RWQCB	Manager Surface Water and Ag	Nick.Amini@waterboards.ca.gov
X	Eric Lindberg	RWQCB	Manager Groundwater Protection	Eric.Lindberg@waterboards.ca.gov
X	Nick Ta	DTSC	Project Manager	Nicholas.Ta@dtsc.ca.gov
	Paul Pongetti	DTSC	GSU	PPongett@dtsc.ca.gov
X	Bill Leever	OCWD	Project Manager	wleever@ocwd.com
	Roy Herndon	OCWD	Chief Hydrogeologist	rherndon@ocwd.com
X	Chris Ross	EA	Project Manager	CRoss@enganalytics.com
X	Ken Puentes	EA	Project Hydrogeologist	KPuentes@enganalytics.com
X	Errol Lawrence	EA	Project Hydrogeologist	ELawrence@enganalytics.com

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2:00-2:05 Introduction Bill and Chad

Bill welcomed the group and provided an overview of the agenda. Chad introduced Eric Lindberg who is taking over for Ann Sturdivant, and Mona Behrooz who is taking over for Nick Amini.

2:05-2:25 Review of Feasibility Study SAG Comments and RTCs All

Bill opened the discussion to the TAC to address any specific comments and/or RTCs of concern. Chad started the discussion with RWQCB comments on the RTCs, including:

1) SOCO Comment 8-02 (Page 33 of 112): There is duplicate wording in the referenced comment that should be removed.
2) DRSS Comment 1-01 (Page 91 of 112): Chad stated that the two DRSS remediation alignments have not been implemented at full scale. Mona indicated that only ~20 feet of the ~100-foot onsite DRSS remediation alignment had been implemented as a pilot test, pending a proposal at full scale. Additionally, the offsite pilot test alignment was not fully successful and that a new pilot test has been implemented in the offsite injection wells. No changes to the RTC were suggested.
3) All other RTCs on the DRSS comments were satisfactory to the RWQCB.
4) Chad stated all RTCs on the SOCO comments were satisfactory to the RWQCB, but wanted to solicit input from Nick Ta, as SOCO is under DTSC oversight.

Nick Ta stated all RTCs on the SOCO comments were satisfactory to the DTSC. Nick also stated that SOCO concerns on the impacts of OCWD remedies on the SOCO remedy should be addressed during the remedial design phase.

There were no additional discussion items from the TAC on the RTCs.

2:25-2:35 Schedule Update and Walk-in Items TAC

Bill suggested the following FS finalization process and tentative schedule, to which the TAC agreed was appropriate:

1) The District will issue a RLSO of the FS to the TAC for review
2) TAC will have approximately 2 weeks to review the RLSO FS
3) TAC will meet in early to mid-December to discuss issues related to the RLSO FS, and, pending no additional changes to the FS, District will issue to the public a Final FS with RTCs attached.

Action Items:

1. **District/EA to incorporate changes identified in the RTCs into a RLSO FS and submit for TAC review by 11/22**
2. **District to schedule next TAC meeting for early to mid-December**

APPENDIX V
11/28/22 RESPONSE TO COMMENTS ON DRAFT FEASIBILITY STUDY REPORT, SOUTH BASIN GROUNDWATER PROTECTION PROJECT, OPERABLE UNIT 2

Technical Memorandum

To:	Mr. Bill Leever, Orange County Water District	From:	Christopher G.A. Ross
Cc:	Mr. Roy Herndon, Orange County Water District	Date:	November 28, 2022
EA No.:	151099		PROFESSIONAL GEOLOGIST CHRISTOPHER G.A. ROSS No. 4594 STATE OF CALIFORNIA
Re:	Response to Comments on Draft Feasibility Study Report, South Basin Groundwater Protection Project, Operable Unit 2		

1.0 INTRODUCTION

This response to comments document has been prepared by Engineering Analytics, Inc. (EA) on behalf of the Orange County Water District (OCWD) in support of the South Basin Groundwater Protection Project (SBGPP).

The purpose of this document is to provide responses to comments received from the Stakeholder Advisory Group (SAG) on the Draft Operable Unit 2 (OU2) Feasibility Study (FS) report for the SBGPP prepared by EA dated April 5, 2022. Comments made on the Draft OU2 FS Report were received from five entities during the comment period (April 8, 2022 to July 6, 2022). Comments were also received from an additional entity after the public comment period had closed.

During the comment period, OCWD received comments from the following: a letter from the Irvine Ranch Water District dated June 27, 2022; a letter from Geosyntec Consultants on behalf of Soco West, Inc. (SOCO) dated June 30, 2022 with supplement provided by Geosyntec Consultants on July 5, 2022; a letter from Newmeyer Dillion on behalf of DRSS-I, LCC (DRSS) dated July 5, 2022; an e-mail from CDM Smith on behalf of Textron dated July 5, 2022; an e-mail from Carl Benninger dated July 6, 2022. In addition, the California Environmental Protection Agency, Department of Toxic Substances Control (DTSC) transmitted comments prepared on June 16, 2022 within an e-mail to OCWD on July 11, 2022. All of the comment documents will be included in the Administrative Record.

2.0 RESPONSE TO COMMENTS

There were numerous comments received from two of the six entities, many of these comments had common topics and/or were repetitive and do not require revision of the Draft OU2 FS Report. The comments, associated response and need to revise Draft OU2 FS Report are presented in the Attachments to this Technical Memorandum (Attachments 1 to 6).

The Draft OU2 FS Report will be revised in response to several comments as well as additional considerations as outlined in the following.

2.1 Updated Cost Estimate for Alternatives

The cost estimates presented in Appendix D in the Draft OU2 FS Report are being revised to incorporate: a response to comment; include a pre-treatment process for selected Alternatives; and correct several errors identified in the Draft OU2 FS Report cost estimates as described below.

As indicated in response to SOCO comment 11 (Attachment 1), the Replenishment Assessment (RA) and Basin Equity Assessment (BEA) costs have been removed from the cost estimates for Alternatives 3, 4 and 6. This revision reduces the estimated cost for Alternatives 3, 4 and 6/6a by approximately $9.6, $1.9 and $9.4 million dollars (not accounting for net-present value [NPV]), respectively.

The Orange County Sanitation District (OCSD) has ordinances with respect to industrial discharges to sanitary sewers. In the past, OCSD had allowable concentrations of total toxic organic (TTO)[1] compounds in water discharged to the sewer system. TTO includes many of the volatile organic compound chemicals of concern (COC) for OU2. The current OCSD standard does not include a reference to TTO[2]. Since TTO are no longer referenced in OCSD ordinance, the Draft OU2 FS Report has been updated to include use of liquid phase granular activated carbon (LGAC) as a pre-treatment for Alternatives 3 and 6 prior to sewer discharge. This revision increases the estimated cost for Alternatives 3 and 6/6a by approximately $3.8 and $3.5 million dollars (not accounting for NPV), respectively.

The equations in the Draft OU2 FS cost estimate spreadsheet were incorrectly linked with respect to permitting costs for operations and maintenance (O&M) for Alternatives 3 and 6. This correction increased the cost estimate for Alternative 3 by approximately $2.8 million dollars, decreased the estimated cost Alternative 6 by approximately $4.9 million dollars and decreased the estimated cost of Alternative 6a by approximately $4.3 million dollars (not accounting for NPV).

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[1] OCSD Ordinance OCSD-39 https://records.ocsan.gov/WebLink/Browse.aspx?id=89699&dbid=0&repo=OrangeCountySanitationDistrict&cr=1
[2] OCSD Ordinance OCSD-53 https://records.ocsan.gov/WebLink/Browse.aspx?id=89699&dbid=0&repo=OrangeCountySanitationDistrict&cr=1

The above revisions change the estimated cost for Alternatives 3, 4 and 6; however, individually and collectively they do not change the cost ranking presented in the Draft OU2 FS Report. The following table provides a revised summary of the estimated cost of each Alternative.

Alter-native	Alternative Description		Non-NPV Total Cost		NPV (2.5%) Total Cost[a]	
	Approach	End Use	April 2022	Current	April 2022	Current
1	No Action	No Action	$ -	$ -	$ -	$ -
2	MNA	N/A	$31,600,000	$31,600,000	$24,600,000	$24,600,000
3	GET	POTW	$48,700,000	$45,700,000	$37,300,000	$35,800,000
4	GET	Injection	$80,400,000	$78,500,000	$65,400,000	$64,000,000
5	ISCO	N/A	$482,600,000	$482,600,000	$348,600,000	$348,600,000
6	GET/ISCO	POTW	$148,900,000	$138,100,000	$110,300,000	$103,400,000
6a	GET/ISCO	POTW	$153,469,961	$143,300,000	$111,213,701	$104,700,000

[a] The 2.5% discount rate is based on OCWD's financial personnel input and is the typical current discount rate used by OCWD for assessing longer-term projects.

MNA = monitored natural attenuation
GET = groundwater extraction and treatment
ISCO = In-situ chemical oxidation
POTW = Publicly owned treatment works
N/A = not applicable

The above revised cost estimates will be reflected in the next revision to the Draft OU2 FS Report, which will be referred to as the Final Draft OU2 FS Report. The Final Draft OU2 FS Report will also be revised to incorporate the LGAC as a pre-treatment process for Alternatives 3 and 6/6a.

2.2 Evaluation of OU2 Groundwater Extraction Influence on SOCO Source Remedy

As indicated in response to SOCO comment 2, the OU2 groundwater flow model grid spacing was refined to incorporate the approved SOCO source area remedy which has yet to be installed (refer to response 2-03 in Attachment 1). The Draft OU2 FS Report evaluated change in groundwater flow direction and change in hydraulic gradient at the SOCO property to assess the influence of OU2 groundwater extraction in the vicinity of the SOCO source control remedy. The evaluation presented in the Draft OU2 FS Report did not include the SOCO source control remedy in the model due to practical limitations described below. The results of the additional evaluation are also summarized below.

The groundwater flow model presented in the Draft OU2 FS Report did not incorporate the design of the SOCO source control remedy because the SOCO remedy has low permeability slurry walls that are much thinner than the OU2 model grid spacing (refer to response 2-03 in Attachment 1). As indicated in the Draft OU2 FS Report, refinement of the yet to be selected OU2 remedial alternative will occur during the design process. However, in response to SOCOs comment, the OU2 FS groundwater flow model grid spacing has been refined to further evaluate the potential effects of OU2 groundwater extraction on SOCO’s approved source control remedy by reducing the grid spacing across the SOCO site.

The revised OU2 groundwater flow model was modified by incorporating the slurry walls, flow gates and permeable reactive barriers (PRB[s]) into the model using the available SOCO design parameters (*Feasibility Study/Remedial Action Plan, Former Service Chemical Facility, 1341 East Maywood Avenue, Santa Ana, California*, prepared by Geosyntec Consultants, dated July 14, 2015 and *Remedial Design and Implementation Plan, Former Service Chemical Facility 1341 E. Maywood Avenue, Santa Ana, California*, prepared by Geosyntec Consultants, dated November 2016) in order to simulate OU2 FS pumping with the SOCO remedy in place (refer to response 2-03 in Attachment 1). The model simulations indicated that the direction of groundwater flow within the SOCO treatment area was relatively unaffected by OU2 FS pumping. This indicates that OU2 FS pumping has a lesser effect on the change in groundwater flow direction through the SOCO source area than presented in the Draft OU2 FS Report. The hydraulic gradient within the SOCO treatment area was then calculated with and without OU2 FS pumping. Given the refinement of the OU2 groundwater flow model grid and incorporation of the SOCO source area remedy into the model, a more direct comparison of change in groundwater flux (amount of groundwater flow) through the SOCO source area remedy could be evaluated. The groundwater flux through the SOCO treatment area was assessed using the revised OU2 groundwater flow model with and without OU2 FS pumping. The amount of water flowing through the SOCO treatment zone increased by approximately 1.7 with OU2 pumping as compared to the non-OU2 pumping condition. This change in flux through the SOCO source area remedy is smaller than was inferred based on the change in hydraulic gradient, indicating a lesser influence than was presented in the Draft OU2 FS Report.

The Final Draft OU2 FS Report will be revised to include a brief description of the additional groundwater flow modeling as summarized above and described in more detail in response 2-03 in Attachment 1. The associated tables and alternatives compatibility relative to the SOCO site will also be revised.

2.3 Typographical and Minor Editorial Revisions

In addition to the revisions described in Sections 2.1 and 2.2, typographical and/or minor editorial revisions to the Draft OU2 FS Report are being implemented in response to comments and additional review as described below.

In response to SOCO comment 5 (Attachment 1), the term Land Use Covenants (LUC) will be removed from tables to be consistent with the Draft OU2 FS Report text which explicitly states that LUC's will not be part of institutional controls.

In response to DRSS comment 1 (Attachment 2), in-situ treatment areas associated with the DRSS property will be labeled on associated figures in the Final Draft of OU2 FS Report.

The definition for "OU2" has been revised to be consistent with the definition presented in the Supplemental Remedial Investigation Report (*Supplemental Remedial Investigation Report, Orange County Water District South Basin Groundwater Protection Project, Operable Unit 2*, prepared by Hargis + Associates, Inc., dated May 6, 2020).

2.4 Signature

As indicated in the DTSC response to comments (Attachment 4), the Final Draft OU2 FS Report will be signed by a California Professional Geologist or Professional Civil Engineer with relevant experience.

If you have any questions, please contact me at (858) 883-3710.

Respectfully Submitted,

Christopher G. A. Ross. P.G. 4594, CHG 221
Senior Professional Hydrogeologist

LIST OF ATTACHMENTS

Attachment 1	DRAFT Response to SOCO West, Inc Comments, Draft Feasibility Study Report, South Basin Groundwater Protection Project, Operable Unit 2
Attachment 2	DRAFT Response to DRSSS-I, LCC Comments, Draft Feasibility Study Report, South Basin Groundwater Protection Project, Operable Unit 2
Attachment 3	DRAFT Response to Carl Benniger Comments, Draft Feasibility Study Report, South Basin Groundwater Protection Project, Operable Unit 2
Attachment 4	DRAFT Response to DTSC Comments, Draft Feasibility Study Report, South Basin Groundwater Protection Project, Operable Unit 2
Attachment 5	DRAFT Response to Textron Comments, Draft Feasibility Study Report, South Basin Groundwater Protection Project, Operable Unit 2
Attachment 6	DRAFT Response to IRWD Comments, Draft Feasibility Study Report, South Basin Groundwater Protection Project, Operable Unit 2

ATTACHMENT 1
RESPONSE TO SOCO WEST, INC COMMENTS, DRAFT FEASIBILITY STUDY REPORT, SOUTH BASIN GROUNDWATER PROTECTION PROJECT, OPERABLE UNIT 2

ATTACHMENT 1

RESPONSE TO SOCO WEST, INC COMMENTS, DRAFT FEASIBILITY STUDY REPORT, SOUTH BASIN GROUNDWATER PROTECTION PROJECT, OPERABLE UNIT 2

This response to comments document has been prepared by Engineering Analytics, Inc. (EA) on behalf of the Orange County Water District (OCWD) in support of the South Basin Groundwater Protection Project (SBGPP).

This attachment is in response to Geosyntec Consultants' June 30, 2022 comments and July 5, 2022 supplement (Subject Comment Document) regarding the April 5, 2022 SBGPP OU2 Feasibility Study report (Draft OU2 FS Report) prepared by EA. Geosyntec Consultants provided these comments on behalf of the Stakeholder Advisory Group (SAG) member Soco West, Inc. (SOCO).

ORGANIZATION

Comments in the Subject Comment Document were divided into selected categories developed by the author. These categories included comment topics, some of which were repeated between the selected categories. Given the number of comment topics within the individual selected categories, this Attachment organizes the responses to comment topics as follows:

- The selected category developed by the author of the Subject Comment Document is used as major sections in this attachment
- The text from the Subject Comment Document is presented under the "Comment" subsection to the respective major section of this attachment. Each "Comment" heading incorporates the major section information (Subject Comment Document Comment ID, e.g., 1,2,3, etc.) and the sequence of the respective comment within the major section (1 to n). For example, the resultant "Comment" identifier for the second major section (e.g., Subject Comment Document comment 2) and the third comment topic would be "Comment 2-03".
- A response is presented to each comment immediately following the "Comment" subsection; and
- A statement as to whether the Draft OU2 FS Report is being revised with respect to the subject comment.

COMMENTS PRESENTED IN INTRODUCTION

There was an introductory section presented in the June 30, 2022 document, portions of which are restated in following comment subsections.

Comment 0-01:

> *"Soco developed a Feasibility Study and Remedial Action Plan (RAP) for the Holchem property in compliance with the NCP, which was approved as a final remedy by the Department of Toxic Substances Control (DTSC). Soco's RAP was prepared and submitted to DTSC in accordance with a Corrective Action Order (CAO) issued by DTSC to Soco on April 1, 2014.[2] Soco's RAP addresses contamination at Holchem (identified in OCWD's Draft FS as part of its Operable Unit [OU] 1) and the groundwater plume south of Warner Avenue (identified in OCWD's Draft FS as part of Area 1 within OU2, as shown on Figure 7-2 of the Draft FS). Soco's RAP consists of a permeable reactive barrier to treat chlorinated solvents in groundwater, enhanced in-situ biodegradation (EISB) for 1,4-dioxane in groundwater, and contingency injection wells along Warner Avenue in case the OU-1 remedy does not meet remedial goals (collectively referred to as the "Soco remedy"). Soco's RAP for the commingled plume downgradient from Holchem consists of groundwater management, which is comprised of monitored natural attenuation (MNA) and engineering and/or land use controls to manage any potential exposure risks posed by contaminants in hydrostratigraphic unit (HSU) 3, as defined in Soco's RAP, which corresponds with Layer 2 as defined by OCWD.*
>
> *DTSC also approved a November 2015 Remedial Design and Implementation Plan (RDIP) for the Holchem Site. As noted in both the FS/RAP and the RDIP, the Soco remedy was designed to reduce concentrations of chlorinated solvents to California Maximum Contaminant Levels (MCLs) at OU1. Similarly, the EISB remedy for 1,4-dioxane will be optimized through bench-scale and field-scale pilot testing to reduce concentrations to the notification level. Implementation of the DTSC-approved Soco remedy was simulated with a groundwater flow and solute fate and transport model. Geosyntec's modeling results indicate that: (1) the existing plume in OU2 would begin to shrink in fewer than 20 years; and (2) in 50 years from implementation of the OU1 remedy, the leading edge of the plume of trichloroethene (TCE) in OU2 groundwater with concentrations above 200 micrograms per liter (µg/L) would travel approximately 3,000 feet downgradient from the Holchem property, or approximately to Dyer Road. Thus, following implementation of OU1 remedies at the Holchem property and other source sites associated with the plume, natural attenuation would be a dominant process in OU2 that would reduce contaminant concentration and migration."*

Response 0-01A:

SOCO states that their remedy relies on applied remedial technologies at and immediately downgradient of their property (north of Warner Avenue) and monitored natural attenuation (MNA) in a downgradient area (south of Warner Avenue). For the purposes of this document, the applied remedial technologies near the SOCO property will be referred to as the SOCO source control remedy. They also state that should their remedy (the combined source control and downgradient MNA) not meet remediation goals they have a "contingency" plan to address this failure. As stated in their comment, the contingency plan would be applied at Warner Avenue approximately 150 feet downgradient of their source control remedy, while their furthest downgradient monitor well[1] is over 2,100 feet downgradient of Warner Avenue. In essence, SOCO's contingency plan is focused on failure of their source control remedy and, if implemented as described, would not address the majority of SOCO's plume area which extends well south of Warner Avenue. In addition, SOCO's contingency plan will not address the large volume of downgradient groundwater contamination originating from their source site if MNA does not perform as they forecast, and they are proposing a contingency action which is the same as the original source control action that will have failed if the contingency action is required[2].

Response 0-01B:

SOCO claims that MNA will result in a shrinking trichloroethylene (TCE) 200 microgram per liter (ug/l) plume emanating from their property in about 17 years after they construct their source control remedy. In their comment, they clearly stated that the SOCO source control remedy was designed to achieve California Maximum Contaminant Levels (MCL) in groundwater for chlorinated solvents. The California MCL for trichloroethylene (TCE), one of SOCOs chlorinated solvents, is 5 ug/l. There are multiple issues with the assumption that their source control remedy will effectively meet the California MCL remediation goal, some of which are highlighted in the following:

- The SOCO FS model and associated assumptions indicate that without effective source remediation at the SOCO site the TCE 200 ug/l plume will continue to expand. As of the date of this document, almost seven years have elapsed since DTSC approved the Remedial Action Plan (RAP) and SOCO has not implemented the remedy, allowing for continued expansion of the SOCO plume. The SOCO FS model and associated assumptions also indicate that, even with effective source remediation at the SOCO site, the TCE 200 ug/l plume will continue to expand for approximately 17 years. Expansion of the TCE 200 ug/l plume is not consistent with the OU2 FS Remedial Action Objectives (RAO[s]) 1 or 2.
- The SOCO FS model and associated assumptions did not evaluate expansion of the leading edge of the SOCO plume. SOCO used the term "leading edge" when referencing the 200 ug/l TCE plume. This concentration is 40 times higher than the MCL for TCE and clearly does not address the "leading edge". As such, the SOCO FS/RAP does not address the OU2 FS RAO 3.
- The starting conditions for the TCE 200 ug/l plume in the SOCO FS model were less extensive than observed field conditions. The location of the 200 ug/l plume boundary is shown near SOCO monitor well MW-45B; however, the concentration of TCE in this

[1] SOCO monitor well MW-45B is the furthest downgradient monitor well based on the direction of groundwater flow in SOCO hydrostratigraphic unit (HSU) HSU3, which is generally consistent with the direction of groundwater flow in OU2 Layer 2.
[2] SOCO's source area remedy is relying on Enhanced In Situ Biodegradation (EISB) for treatment of 1,4-dioxane. It is a bit of circular logic that the contingency technology used to "remedy the failure" is the same technology that could have resulted in the failure.

monitor well was 1,300 ug/l[3] indicating that the TCE 200 ug/l plume was more extensive than initial conditions presented in the SOCO FS.

- The SOCO FS Model, like any groundwater flow model, is a simplified version of real-world systems[4]. Appropriately constructed groundwater flow models provide estimated flow; however, there is always some degree of uncertainty. Solute transport models rely on the groundwater flow model and the underlying input assumptions and factors, including advection, dispersion and chemical reactions (including but not limited to. contaminant degradation), with each having their own set of uncertainties. The SOCO FS/RAP model incorporated a single SOCO contaminant, TCE, and a single degradation half-life for this contaminant based on treatability study results[5]. The soil and groundwater samples collected to support the microcosm studies presented in the referenced treatability study report were collected from locations north of Warner Avenue[6] and as such are not representative of conditions within the MNA area downgradient (south) of Warner Avenue. Furthermore, the treatability study report concluded that one of the SOCO contaminants of potential concern, 1,4-dioxane[7], did not exhibit any degradation[8]. The concentration of 1,4-dioxane in the furthest downgradient SOCO monitor well was over 50 times[9] greater than California's drinking water Notification Level and over 100 times[10] greater than the USEPA Regional Screening Level for tap water. Matrix diffusion is another factor adding to uncertainties in solute transport simulations. Predictive sensitivity analysis is normally done to quantify the effect of uncertainty in parameter values on model simulation results[11]. Given the number and complexity of parameters used in the SOCO FS Model, predictive sensitivity analysis should have been conducted on the flow and transport parameters including but not limited to reduction or elimination of the TCE/degradation product half-lives and incorporation of 1,4-dioxane into model simulations.

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[3] From a sample collected in October 2017, Geosyntec Consultants Fourth Quarter 2017 Groundwater Monitoring Report for SOCO.

[4] Jacob Bear, Milovan S. Beljin and Randall R. Ross (EPA/540/S-92/005) indicated that "no model is unique to a given ground-water system".

[5] Section 1.3 of Appendix A to the SOCO FS/RAP dated July 14, 2015 prepared by Geosyntec Consultants.

[6] Section 5.2 of the Remedial Action Plan prepared by Geosyntec Consultants dated October 12, 2012 indicates microcosm samples were collected from MW-27 and MW-22. Sirem Treatability Study indicated groundwater microcosm sample was also obtained from MW 11 as indicated in Section 1 of Sirem Treatability Study dated September 21, 2012.

[7] Section 5.2 of SOCOs FS/RAP states that 1,4-dioxane is a SOCO COPC, Geosyntec Consultants, July 14, 2015.

[8] Conclusion point number 4 presented in Sirem Treatability Study dated September 21, 2012, stated "As expected, the anerobic degradation of 1,4-dioxane was not observed in any of the control or treatment microcosms",

[9] As stated previously in this attachment, monitor well MW-45B is the furthest downgradient of SOCOs monitoring wells which is located approximately 2,100 feet south of Warner Avenue. 1,4-dioxane was detected at a concentration of 55 ug/l in a groundwater sample collected on October 9, 2017 as indicated in Table 2 of the Fourth Quarter 2017 Groundwater Monitoring Report prepared by Geosyntec Consultants dated December 29, 2017. The California drinking water Notification Level is 1ug/l (https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/14-Dioxane.html#:~:text=The%20drinking%20water%20notification%20level,greater%20than%20its%20notification%20level.)

[10] The USEPA Tap Water Regional Screening Level for 1,4-dioxane is 0.46 ug/ (USEPA Regional Screening Level (RSL) Residential Table (TR=10E-06; HQ=1) May 2022)

[11] Applied Groundwater Modeling, Simulation of Flow and Advective Transport, Mary P. Anderson and William W. Woessner 1992.

Revision to Draft OU2 FS Report:

As indicated in above responses (0-01A and 0-01B), the SOCO FS does not meet OU2 FS RAO 1 or 2 and does not evaluate RAO 3. The Draft OU2 FS Report addresses these RAOs, and revisions to the Draft OU2 FS Report are not necessary.

Comment 0-02

> *"Geosyntec reviewed OCWD' s Draft FS and below is the summary of the Geosyntec comments identifying the errors, inconsistencies, and/or deviations from the NCP, followed by a detailed discussion of the comments .... "*

Response 0-02:

See detailed responses to comments presented in the remaining portions of this attachment. Note that comments 10 and 11 were presented in attachments to the SOCO comment letter.

Revision to Draft OU2 FS Report:

See revisions to Draft OU2 FS Report following the respective response to comments presented in the remaining portions of this attachment.

<u>COMMENT 1: INADEQUATE EVALUATION OF ALTERNATIVE 1, "NO ACTION"</u>

Comment 1-01

> *"The Draft FS inaccurately defines the "No Action" alternative and does not evaluate this alternative sufficiently. This flawed evaluation of the "No Action" alternative stems from the Draft FS' inaccurate definitions of OU1 and OU2. Specifically, the Draft FS assumes that remedies being implemented by the source site responsible parties "under the oversight of the State of California" only address "vadose zone and groundwater contamination in the Shallow Aquifer System directly beneath source properties," which the Draft FS defines as OU-1 (Draft FS, page 1). Likewise, the Draft FS states in Section 6.2.1 that "the lateral and vertical remediation or containment of the OU2 groundwater plumes downgradient of the source sites are not objectives of these source site remedial actions". Both of those assumptions and statements are incorrect. For Soco, the CAO issued by DTSC applies to the Property located at 1341 East Maywood Avenue in Santa Ana "and the areal extent of contamination that resulted from activities on the Property." DTSC also listed the site on the Cortese List, which is the California Superfund List. The remedy approved by DTSC pursuant to the NCP, in turn, also applies to the Property "and the areal extent of contamination that resulted from activities on the Property. This off-property area-which OCWD includes within its definition of OU2-is therefore covered by the DTSC order and DTSC-approved remedy for Soco. In order to approve Soco's remedy in the off-property, downgradient area, the DTSC determined that the remedy was the appropriate remedy for the entire plume emanating from the Holchem property. "*

Response 1-01:

The SOCO comment states that the SOCO remedy (the combined source control and downgradient MNA) "applies to the… 'areal extent of contamination that resulted from activities on the Property'". However, the SOCO FS/RAP did not define the extent of contamination from SOCO property, but only evaluated the 40x MCL (TCE at 200 ug/l) concentration area (refer to response 0-01B). In addition, the RAP only provided a contingency plan that includes an EISB within 150 feet of SOCO's source control remedy, located north of Warner Avenue (refer to response 0-01A). This contingency did not address the remaining portion of the plume to the south of Warner Avenue, which extends over well over 10 times[12] this distance. Moreover, TCE was detected in the most downgradient SOCO monitoring well MW-45B at a concentration of 1,300 ug/l (over 250 times the MCL), which was outside of the 40x MCL (200 ug/l) concentration plume delineated in the SOCO FS Model (refer to response 0-01B).

Revision to Draft OU2 FS Report:

SOCO has not defined the extent of the contamination that resulted from releases on their property, so they cannot reasonably claim that their remedy will address it. As indicated in above responses 0-01A and 0-01B, the SOCO FS does not meet the OU2 FS RAO 1 or 2 and does not evaluate RAO 3. The Draft OU2 FS Report addresses these RAOs, and revisions to the Draft OU2 FS Report are not necessary.

Comment 1-02:

> *"For this off-property area, the groundwater modeling presented in Soco's FS/RAP shows that MNA coupled with effective source site remediation will shrink the plume with time."*

Response 1-02:

Refer to response 0-01B.

Revision to Draft OU2 FS Report:

As indicated in responses 0-01A/0-01B, the SOCO FS does not meet the OU2 FS RAO 1 or 2 and does not evaluate RAO 3. The Draft OU2 FS Report addresses these RAOs, and revisions to the Draft OU2 FS Report are not necessary.

[12] As stated previously in this attachment, SOCO monitor well MW-45B had concentrations of TCE over 250 times the MCL at a location approximately 2,100 feet south of Warner Avenue, based on sample collected on October 9, 2017 as indicated in Table 2 of the Fourth Quarter 2017 Groundwater Monitoring Report prepared by Geosyntec Consultants dated December 29, 2017.

Comment 01-03:

> *"Further, in the evaluation of the "No Action" alternative in Section 7.2.3.1, the Draft FS states that "The No Action Alternative does not include any Institutional Controls to prevent exposure to the contaminated site groundwater, and there is no way to monitor migration of the OU2 contaminant plumes." Again, that is incorrect. The Draft FS fails to evaluate Soco's DTSC approved remedy for the area within OU 2 south of the Holchem property, which includes a monitoring program, institutional controls, and coordination with well permitting agencies"*

Response 1-03:

SOCO's FS/RAP includes institutional controls (ICs), monitoring program and coordination with well permitting agencies in a portion of OU2; a portion that does not cover the full extent of the SOCO plume[13]. These measures would not achieve the OU2 RAO 1 or 2 and did not address RAO 3 for reasons stated in responses 01-01A, 01-01B, and 1-01.

In addition, the SOCO FS/RAP does not address potential for discovery of former water wells within the footprint of their plume and whether they would properly destroy the wells should they be discovered in the future, which would help address OU2 FS RAO 2.

Revision to Draft OU2 FS Report:

For the reasons stated in responses 01-01A, 01-01B, 1-01, and 1-02, revisions to the Draft OU2 FS Report are not necessary.

Comment 1-04:

> *"Thus, the Soco remedy, which was approved by DTSC, addresses both impacts at the source property as well as contaminants in the Shallow Aquifer System that have migrated from the Holchem property (i.e., south of Warner Avenue). In this area, OCWD's remedy is duplicative, redundant, and unnecessary. By virtue of already being subject to oversight by DTSC and a remedy approved pursuant to the HSAA, this area should be excluded from OCWD's interim remedy."*

Response 1-04:

OU2 FS Alternatives 3 to 6 have application of active remedial technologies in transects along Warner Avenue with a gap near SOCO to avoid duplication of the proposed SOCO source control remedy should SOCO install it. These same OU2 FS Alternatives address high concentration groundwater south of Warner Avenue which SOCO's own analysis indicates will continue to expand without a SOCO source remedy and will also expand for almost two decades following

[13] The institutional controls referenced in the SOCO FS/RAP are limited to the SOCO and Diesel Logistics properties. The area of monitoring was indicated in Figure 5 of the FS/RAP. It does not encompass the SOCO MW-45B to the west nor does it extend to the south of Dyer Road.

initiation of SOCO's source remedy. Also refer to responses 01-01A, 0-01B, 1-01, 1-02, and 1-03).

Revision to Draft OU2 FS Report:

As indicated above, the OU2 FS Alternatives are not duplicative of SOCO's remedy. Revisions to the Draft OU2 FS Report are not necessary.

Comment 1-05:

> *"The "No Action" alternative evaluation should acknowledge the planned remedial activities outlined in the NCP-compliant and DTSC-approved Soco RAP, which would result in a more accurate and realistic evaluation. When properly evaluated, the "No Action" alternative is the appropriate alternative for the area off of the Holchem Property to which contaminants from the property have migrated."*

Response 1-05:

The Draft OU2 FS Report assumes that SOCO will implement their proposed source control remedy and further assumes that the source control will be effective. Also, refer to responses 01-01A, 0-01B, 1-01, 1-02, and 1-03.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

<u>COMMENT 2: ALTERNATIVES 3 AND 4 ARE NOT COMPATIBLE WITH SOURCE SITE REMEDIES AND, THEREFORE, DO NOT SATISFY RAOS</u>

Comment 2-01:

> *"RAO #4 (Draft FS, page 16) is "Implement a reliable interim groundwater remedy(s) that is compatible with ongoing and planned remediation at source sites and associated off-property locations, as appropriate. The Draft FS quantified the allowable magnitude of groundwater flux increase that was considered to be within the range of natural (i.e., without pumping) variability and, therefore, negligible (page ES-8): "For the purposes of this evaluation, simulated groundwater flux increases less than a factor of 0.5 ... are considered negligible."*

Response 2-01:

The Draft OU2 FS Report defined negligible with respect to changes in groundwater gradient and/or flow direction but did not indicate that these conditions were "not allowable". For context, the entire sentence and following sentence from the above referenced portion of the Draft OU2 FS Report have been provided as follows:

> "For the purposes of this evaluation, simulated groundwater flux increases less than a factor of 0.5 and changes in groundwater flow directions less than 20 degrees from ambient (non-IRM pumping conditions) are considered negligible. As further described in Section 7, there are several source sites where the simulated changes in groundwater flux and/or the direction of groundwater flow in Layers 1 and/or 2 resulting from IRM pumping were higher than these screening criteria over limited areas."

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 2-02:

> *"However, per OCWD's modeling summarized in Appendix E of the Draft FS, the implementation of the IRM will result in "an increase of the groundwater flux near this source site by a factor of approximately 2.4" (i.e., 240% of the natural groundwater flux) in HSU 3 (Model Layer 2) at the Holchem property (page 95).[6] OCWD considers this impact to be "moderate" (Table 8-2) and concludes, without providing rationale in the Draft FS, that its proposed IRM is compatible with source site remedies, which includes the DTSC-approved Soco remedy (e.g., page 104)"*

Response 2-02:

The Draft OU2 FS Report is a means of comparing different remedial alternatives and thus provides conceptual aspects for the implementation of the various alternatives, but is by no means a remedy design. As such, the OU2 FS groundwater flow model (OU2 FS Model) is a tool used only for the evaluation of the listed alternatives. For Alternatives 3, 4, and 6, the potential effects of well field operation in the vicinity of active or planned remedies will be further assessed during the pre-design investigation to minimize potential negative effects on source area remedies. This additional evaluation would be used to refine the design of the alternatives prior to their implementation.

The Draft OU2 FS Report outlined potential negative effects to SOCO planned remediation in Table 8-2. The table indicated that the "Adjacent extraction alignment, affects groundwater flow direction and moderate influence on groundwater flux". The Draft OU2 FS Report also identifies potential steps that can be taken to mitigate the negative effects on the SOCO planned remediation during wellfield operation. These potential contingency actions include "reducing/relocating extraction locations and/or reducing extraction rates can mitigate this condition". As stated previously, potential negative effects and corresponding mitigation measures will be evaluated during the pre-design evaluation, prior to implementation.

The Draft OU2 FS Report groundwater flow model is not intended for remedy design and did not incorporate the design of the SOCO source control remedy because the SOCO remedy has low permeability slurry walls that are much thinner than the OU2 model grid spacing. The condition made it difficult to simulate the design of the SOCO source control remedy with the OU2 groundwater flow model. As such, the change in the direction of groundwater flow and gradient in the SOCO planned treatment area is based on the coarser model grid that does not include the low permeability slurry walls. In practice, these low permeability walls would help control the groundwater flow direction within the SOCO treatment area, so the Draft OU2 FS Report overstates the actual groundwater flow changes should SOCO implement their source area remedy. In response to this comment and in order to further evaluate the potential groundwater flow changes within the SOCO treatment area from the OU2 groundwater extraction alternatives, the OU2 FS Model was modified to fine up the grid spacing in the vicinity of SOCO and incorporate the slurry walls (refer to response 2-03 below).

Revision to Draft OU2 FS Report:

The Draft OU2 FS Report was revised by including documentation of model grid refinement, additional simulations, and results, as explained in response to comment 2-03.

Comment 2-03:

> *"The increased groundwater flux at the Holchem property that would be caused by the IRM corresponds to a reduced hydraulic residence time (HRT) within the PRB and within the active treatment zone of the in-situ biodegradation remedy for 1,4-dioxane at the Holchem property. HRT is a critical parameter in the design of both remedies and increasing the groundwater flux by a factor of 2.4 is significant. The PRB guidance published by the Interstate Technology and Regulatory Council (ITRC) notes (emphasis added) "the primary physical function of the PRB is to capture the targeted groundwater (and plume) and provide it with sufficient residence time in the reactive media to achieve the desired cleanup goals."*
>
> *The change in flow direction will also impact Soco's remedy. To optimize the HRT in the PRB, the design includes flow control gates at the upgradient (north) boundary of the Holchem property. The gates were designed based on natural groundwater conditions and altering the groundwater flow direction by pumping will impact the groundwater flux across the flow control gates with implications for the performance of the Soco remedy. Soco's network of groundwater monitoring wells was also designed and constructed based on natural groundwater conditions. If the groundwater flow directions are altered as predicted following implementation of one of OCWD's pump and treat alternatives, Soco's existing network of monitoring wells, which was designed with DTSC's input and approval, would become obsolete."*

Response 2-03:

As indicated in response 2-02, the Draft OU2 FS Report groundwater flow model is not intended for remedy design and did not incorporate the design of the SOCO source control remedy because the SOCO remedy has low permeability slurry walls that are much thinner than the OU2 model grid spacing (Figure 1). As indicated in the Draft OU2 FS Report, refinement of the yet to be selected OU2 remedial alternative will occur during the design process. However, in response to SOCO's comment, the OU2 FS groundwater flow model grid spacing was refined to further evaluate the potential effects OU2 groundwater extraction on SOCO's approved source control remedy. This additional evaluation incorporated the modification of the OU2 FS model to reduce the grid spacing across the SOCO site (Figures 2 and 3). The extent of the model was reduced to encompass the OU2 Study Area (Figure 4) using the Telescoping Mesh Refinement (TMR) option available in Groundwater Vistas. Following refinement to the model, the simulated water level elevations across Layer 1 and Layer 2 were compared to the original calibrated model (Figures 5a/5b and 6a/6b). Additionally, the refined grid model was used to simulate OU2 FS Alternative 3 groundwater extraction wells (Figures 7a/7b and 8a/8b). The direction of groundwater flow and elevations in both Layers 1 and 2 matched well with the previous larger OU2 FS model grid indicating the model revisions did not substantially affect the hydraulic properties throughout the model domain.

The revised OU2 groundwater flow model was then modified by emplacing the slurry walls, flow gates and permeable reactive barriers (PRB[s]) for the configuration presented in the SOCO FS[14] and the configuration presented in SOCO remedial design (RD) and implementation plan[15] into the OU2 groundwater flow model using the available SOCO design parameters (Figures 9a/9b). The resulting model simulations indicated that the installation of the SOCO FS Alternative 2 and the SOCO RD would significantly affect and change the direction of groundwater flow in the vicinity of the PRB (Figures 10a/10b and 11a/11b). The revised OU2 groundwater flow model then was used to simulate OU2 FS pumping with the SOCO PRB in place. The direction of groundwater flow within the SOCO treatment area, which consists of the area within the slurry wall from the upgradient flow control gates to the downgradient PRB for the SOCO FS and RD configurations was relatively unaffected by OU FS pumping under the given conditions (Figures 12a/12b and 13a/13b). As part of the OU2 FS, changes in hydraulic gradient near source site remedies caused by operation of OU2 groundwater extraction systems was used as a simple surrogate to evaluate potential increases in groundwater flux due to operation of the OU2 groundwater extraction alternatives. The hydraulic gradient from the monitoring point for the SOCO site selected in the OU2 FS Model, which is within the SOCO treatment area to the south end of the SOCO treatment area was then calculated with and without OU2 FS pumping for the SOCO FS and RD configurations (Figures 14a/14b and 15a/15b). The hydraulic gradient for Layer 1 under non-OU2 FS pumping and OU2 FS pumping for the SOCO FS configuration was 0.00043 and 0.00078, respectively and the hydraulic gradient for Layer 2 under non-OU2 pumping and OU2 pumping was 0.00020 and 0.00067, respectively (Figures 14a and 15a). The hydraulic gradient for Layer-1 under non-OU2 FS pumping and OU2 FS pumping for the SOCO RD configuration was 0.00027 and 0.00067, respectively and the hydraulic gradient for Layer 2 under non-OU2 pumping and OU2 pumping was 0.00021 and 0.00065, respectively (Figures 14b and 15b). Given the refinement to the OU2 groundwater flow model grid and incorporation of the SOCO source area remedy into the model, a more direct comparison of change in groundwater flux (amount of groundwater flow) through the SOCO source area remedy was evaluated. The groundwater flux through the SOCO treatment area was evaluated using the model with and without OU2 FS pumping for the SOCO FS and RD configurations (Tables 1a/1b). The amount of water flowing through the SOCO treatment zone for both the FS and RD configurations increased by approximately 1.7 with OU2-pumping as compared to the non-OU2 pumping condition. This change in flux through the SOCO source area remedy is smaller than was inferred based on the change in hydraulic gradient presented in the OU2 FS, indicating a lesser influence

[14] Appendix A to the SOCO FS and RAP prepared by Geosyntec on July 14, 2015 provided model simulations for Alternative 2 which included two rows of PRBs

[15] Remedial Design and Implementation Plan prepared by Geosyntec on November 28, 2016 provided designs for Alternative 5 which included one row of PRBs coupled with EISB injection.

than was presented in the Draft OU2 FS Report. The Draft OU2 FS Report will be updated to reflect this refined estimate in change in groundwater flux.

It is acknowledged that there is uncertainty in the OU2 FS model simulations as it is not meant for design purposes; however, the model shows that the OU2 FS pump and treat has less impact to direction of groundwater flow and hydraulic gradient within the SOCO treatment area given the general design of the SOCO source area remedy. In addition, the placement of the SOCO slurry walls appears to have a more pronounced effect in the change in direction of groundwater flow in the vicinity of the SOCO property as compared to the OU2 FS groundwater pump and treat options. This indicates that any future required changes to monitor well placement for the SOCO remedy would more likely be a result of the installation of the PRB slurry walls rather than hydraulic changes associated with OU2 FS pumping.

In addition to the above considerations, the Interstate Technology and Regulatory Council (ITRC) reference cited by SOCO also explicitly states that flow problems may arise with PRB despite detailed site characterization and a thorough design process due to uncertainties in subsurface installations[16]. The uncertainties exist with and without the OU2 FS pump and treat system. Some of these uncertainties can be mitigated through minor PRB design modifications.

Revision to Draft OU2 FS Report:

The Draft OU2 FS Report will be revised to include a description of the additional groundwater flow modeling described above. The associated tables and compatibility for the SOCO site will also be revised.

Comment 2-04:

> *"DTSC also communicated to OCWD its concern over OCWD's pump and treat remedy impacting Soco's remedy in a letter dated October 21, 2015; refer to Comment 8 for details."*

Response 2-04:

Comment noted. DTSC is part of the South Basin Technical Advisory Committee (TAC), which reviewed and provided comments to the Draft OU2 FS Report. The TAC approved distribution of the Draft OU2 FS Report to the Stakeholder Advisory Group.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report will be made per responses 2-02 and 2-03.

Comment 2-05:

> *"The Draft FS did not include a sensitivity analysis to evaluate the effect of this increased groundwater flux and change in flow direction on the DTSC-approved Soco remedy, nor was Soco*

[10] From page 39 of ITRC reference.

> *contacted by OCWD to perform such an evaluation. The Draft FS acknowledges that the preferred alternatives Nos. 3 & 4 will impact the Soco remedy, but it characterizes that impact as "moderate" without providing any basis for doing so or even defining "moderate impact." Moreover, there is no basis for OCWD's conclusion that the proposed IRM is compatible with the Soco remedy."*

Response 2-05:

Refer to responses 2-02 and 2-03 regarding modifications to and additional simulations using the groundwater model, as well as additions to the Draft OU2 FS Report.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report will be made per responses 2-02 and 2-03.

Comment 2-06:

> *"In addition, the Draft FS contradicts itself as to the compatibility of various Alternatives with remedies at source sites. Table 8-2 states that Alternatives 1, 2, and 5 are compatible with the Soco remedy, but Alternatives 3, 4, and 6 have "moderate influence on groundwater flux." Notably, Table 8-2 does not state that preferred Alternatives 3 and 4, or Alternative 6, are compatible with the Soco remedy. However, the Draft FS states in the Executive Summary (page ES-11) and in Section 8 .1.4 (page 104) that Alternatives 3 and 4 are compatible with source sites, presumably including the Holchem property:*
>
> > *"Alternatives 3 and 4 are compatible with source site remediation and with Armstrong Channel, given the flexibility and reversibility of these remedial alternatives."*
>
> *In both sections, the preceding statement is contradicted by the sentences that follow:*
>
> > *"In instances where these alternatives may not have negligible effects, the IRM containment alignments are located relatively close to the subject source site remedial areas. At these containment alignments, options for IRM implementation include not installing extraction wells or balancing extraction rates during implementation to moderate and minimize the effects that OU2 extraction may have on selected source site remedial efforts. "*
>
> *The Draft FS concluded that the proposed IRM is compatible with source sites despite acknowledging that its analysis suggests some source sites will experience non-negligible effects (e.g., the Holchem property, where the groundwater flux impact will be "moderate" per Table 8-2).*

Response 2-06:

Refer to Responses 2-01, 2-02, and 2-03. As indicated in response 2-03, the estimated groundwater flux through the SOCO treatment area increased by a factor 1.7 which is less than the factor of 2.4

estimated in the Draft OU2 FS Report based on the hydraulic gradient change without the SOCO source area remedy in place. The Draft OU2 FS Report and associated tables will be updated to reflect this lesser impact by changing "moderate" impact for the Holchem property to "low" impact.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report will be made per responses 2-02 and 2-03 including the revision to relative change in groundwater flux at the Holchem Property in Table 8-2.

Comment 2-07:

> *"The Draft FS is thus inconsistent and incomplete, and the RAO of compatibility with remedies at source sites (page 16) is not met."*

Response 2-07:

Refer to Responses 2-01, 2-02, and 2-03.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report will be made per responses 2-02 and 2-03.

COMMENT 3: THE EVALUATION OF IMPLEMENTABILITY OF ALTERNATIVES 3 AND 4 IS FLAWED

Comment 3-01:

> *"The implementability evaluations of Alternative 3 in Section 7.2.3.3 (Draft FS, page 69) and of Alternative 4 in Section 7.2.3.4 (page 74) fail to actually evaluate technical feasibility (i.e., the relative ease of undertaking the remedial action under consideration) at the proposed extraction locations. For both alternatives, the Draft FS notes that containment has been implemented elsewhere in California and at several source sites, and concludes without any support that implementability is moderate to high (Alternative 3) or moderate (Alternative 4)."*

Response 3-01:

Table 8-2 in the Draft OU2 FS Report summarizes the threshold and balancing criteria, which include the technical and administrative feasibility as well as the availability of services and materials for each alternative.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 3-02:

"Implementability The evaluation does not consider technical feasibility, such as each alternative's expected impact on remedies at source sites like the Holchem property, which is documented in the Draft FS (see Comment 1 above for details). In fact, the proposed IRM as described in the Draft FS is not implementable given that it is predicated on effective remedy implementation at source sites (Table 8-2), yet OCWD's own analysis shows its proposed IRM will negatively impact some source site remedies."

Response 3-02:

Refer to responses 2-01, 2-02, and 2-03.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report will be made per responses 2-02 and 2-03.

COMMENT 4: ALTERNATIVE 3 FAILS TO EVALUATE THE OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Comment 4-01:

"The selected Alternative 3 fails to meet the NCP's threshold criterion of Overall Protectiveness of Human Health and Environment. The alternatives evaluation did not consider the vapor intrusion pathway as a result of discharging groundwater containing volatile contaminants into the public sewer system. The vapor intrusion (VI) into the buildings via the sewer lines is an established pathway, as noted by DTSC and the California Water Resources Control Boards in their Draft Supplemental VI Guidance: "A growing body of evidence is highlighting the importance of sewer lines as potentially significant preferential pathways for VF' (Attachment 3). The Draft Supplemental VI Guidance recommends sampling inside sewers and other vapor conduits concurrently with indoor air and sub-slab sampling to determine if such preferential pathways are increasing exposure to VI. These recommendations are being considered by the State Water Board for inclusion in its overall policies (Attachment 2).

Alternative #3 in the Draft FS proposes to extract 344 gallons per minute (GPM) of groundwater from wells screened in Layers 1 through 3 (page 70). The extracted groundwater would be filtered to reduce sediment loads-but not treated for volatile organic compounds (VOCs)-and then discharged into sanitary sewer pipes set in shallow soils. The contaminated groundwater would then be conveyed several miles to the Orange County Sanitation District's (OCSD's) POTW and from there to OCWD's Ground Water Replenishment System (GWRS).

When water containing chemicals of concern (COCs) is inside sewer lines, volatile COCs in the water will partition to the vapor phase and the sewer gas containing volatile COCs traveling in the sewer system can subsequently impact indoor air. Specific pathways into buildings can *include cracked or punctured pipes, loose fittings, degraded toilet gaskets (e.g., wax rings), and dry plumbing traps (e.g., p-traps). Not considering the dilution effect, tetrachloroethene (PCE), TCE, and vinyl chloride (VC) concentrations of 20 microgram per liter (µg/L) each in groundwater could produce concentrations of 11,580 micrograms per cubic meter (ug/m3), 6,700 ug/m3, and 19,620 ug/m3 in sewer gas, respectively." These concentrations are significantly higher than the regulatory indoor air environmental screening levels published by DTSC for protection of the residents, which are 0.46 µg/m3, 0.48 g/m', and 0.0095 g/m' for PCE, TCE, and VC, respectively. Because VOC-impacted groundwater would be conveyed in sewer pipes for several miles through a densely populated area, many buildings would be at risk for vapor intrusion. Buildings at risk would include residential buildings and businesses, as well as sensitive receptors such as day care facilities, schools, healthcare centers, and retirement communities. Figure 1 (Attachment 3) shows the potential sewer line routes to the POTW, identifying the large area that may potentially experience VI and the sensitive receptors along the sewer trunk line.*

Additionally, because sewer pipes commonly leak, discharge of contaminants into soil and groundwater would likely occur, resulting in a widespread environmental contamination problem. Shallow soil contamination would be an additional potential source for vapor intrusion. Additionally, workers could be exposed to volatilized contaminants at the treatment facilities, as well as when conducting sewer repair and maintenance along the several miles of sewer piping used for contaminated groundwater conveyance."

Response 4-01:

The Draft OU2 FS Report did not "select" an alternative, rather it provided a comparison and ranking of alternatives, for which Alternatives 3 and 4 ranked highest (Section 8.2 of the Draft OU2 FS).

The documents referenced in SOCO's comment more precisely consider the pathway for vapor forming chemicals (VFCs), also referred to volatile organic compounds (VOCs) that "enter sewer pipes that intersect contaminated soil or groundwater".

The Orange County Sanitation District (OCSD) has ordinances with respect to discharges to industrial sewers. In the past, OCSD had allowable concentrations of total toxic organic (TTO)[17] compounds in water discharged to the sewer system. TTO includes many of the VOC chemicals of concern (COC) for OU2. Subsequent to preparation of the Draft OU2 FS Report, it was found that the current OCSD standard does not include a reference to TTO[18]. Since TTO are no longer referenced in OCSD ordinance, the Draft OU2 FS Report has been revised to include use of liquid phase granular activated carbon (LGAC) as a pre-treatment for Alternatives 3 and 6 prior to sewer discharge. The addition of LGAC to these alternatives addresses the comment regarding vapor intrusion from extracted groundwater that is not treated for VOCs.

[17] OCSD Ordinance OCSD-39 https://records.ocsan.gov/WebLink/Browse.aspx ?id=89699&dbid=0&repo=OrangeCountySanitationDistrict&cr=1 . .
[18] OCSD Ordinance OCSD-53 https://records.ocsan.gov/WebLink/Browse.aspx ?id=89699&dbid=0&repo=OrangeCountySanitationDistrict&cr=1 .

Revision to Draft OU2 FS Report

The Draft OU2 FS Report will be revised to include LGAC treatment for extracted groundwater for Alternatives 3 and 6.

Comment 4-02

> *"Also, as described in the Supplemental Remedial Investigation Report, the results of testing groundwater in the Shallow Aquifer System within the Study Area indicated the presence of multiple inorganic constituents, including chloride, sulfate, nitrate, and selenium. These constituents are included in OCWD's Producer/User Water Recycling Requirements and have maximum discharge concentrations. By extracting these constituents and conveying them to the OCSD's POTW and then ultimately to OCWD's GWRS facility, the proposed alternative will increase the influent load of these constituents. The POTW's ability to receive increased levels of inorganic constituents and meet discharge requirements was not discussed in the Draft FS."*

Response 4-02:

Selenium is the only constituent of those specified in the comment which is listed in Table 1 of Orange County Sanitation District (OCSD) discharge limits [19] . The estimated background concentration of selenium in the South Basin Groundwater Protection Project was approximately 0.0517 milligrams per liter[20] compared with the 3.9 milligrams per liter in OCSD discharge limits. Additionally, the referenced documents presented in SOCO's comment address standards for discharge of treated groundwater from the Groundwater Replenishment System (GWRS) into seawater intrusion barrier and recharge basins in Orange County, not the POTW which is applicable to OU2 remedial alternatives. The GWRS produces highly treated wastewater that meets the California Division of Drinking Water requirements. The GWRS treatment process includes reverse osmosis (RO) to reduce wastewater concentrations of constituents, including those referenced in SOCOs comment, to meet concentration thresholds specified in the permits referenced in the above comment and subsequent updates. The Draft OU2 FS Report clearly states that the extracted groundwater that would be pumped to the sewer would be treated by the GWRS prior to ultimate discharge in compliance with the discharge standards.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 4-03:

> *"The Draft FS describes the NCP criterion of Overall Protection of Human Health and the Environment as follows (page 53):*

[19] Table 1 of OCSD-53 https://www.ocsan.gov/home/showpublisheddocument/28457/637014653105430000
[20] Table 8-1 of the Supplemental Remedial Investigation Report, Hargis + Associates, Inc dated June 19, 2020

> *"This criterion assesses whether each alternative provides and maintains adequate protection of human health and the environment. Alternatives are assessed to determine whether they can adequately protect human health and the environment from unacceptable short- and long-term risks posed by OU2 COCs."*

As explained above, Alternative 3 is not protective of human health by potentially complete exposure pathways, including vapor intrusion, and thus does not comply with the threshold criterion of Overall Protectiveness of Human Health and Environment. The NCP states that "Overall protection of human health and the environment and compliance with ARARS ... are threshold requirements that each alternative must meet in order to be eligible for selection" (40 C.F.R. Section 300.430(f)(i)(A), which OCWD acknowledges (Draft FS, page 53). Thus, Alternative 3 is not eligible for selection as a remedy."

Response 4-04:

Refer to responses 4-01 and 4-02.

Revision to Draft OU2 FS Report:

As described in response 4-01, the Draft OU2 FS Report will be revised to include treatment of groundwater using LGAC prior to discharge to sewer for Alternatives 3 and 6.

COMMENT 5: ALTERNATIVE 3 FAILS TO SATISFY THE NCP REQUIREMENTS FOR SHORT-TERM EFFECTIVENESS

Comment 5-01:

"The selected Alternative 3 fails to meet the NCP's short-term effectiveness criteria. The effectiveness of the alternative in protecting human health and the environment during construction and implementation is assessed under the short-term effectiveness criterion. As explained in Comment 4, the implementation of the selected Alternative 3 could cause widespread vapor intrusion issues, spread COC contamination in shallow soil along the sewer lines, increase exposure by sewer maintenance workers to volatile contaminants in sewer gas, and increase the loading of inorganic constituents at the POTW and OCWD's treatment facilities. A relate to discharge of treated groundwater from the response Revisions to the draft FS Report are not necessary. The short-term effectiveness assessment for Alternative 3 (Draft FS, page 69) is incomplete, and the conclusion "Short-term effectiveness of Institutional Controls would be satisfactory to prevent human exposure to OU 2 groundwater COCs..." is incorrect and lacks proper evaluation."

Response 5-01:

Refer to responses 4-01 and 4-02.

Revision to Draft OU2 FS Report:

As described in response 4-01, the Draft OU2 FS Report will be revised to include treatment of groundwater using LGAC prior to discharge to sewer for Alternatives 3 and 6.

Comment 5-02:

> *"The Draft FS defines "Institutional Controls" as including "Land Use Covenants/Deed Restrictions/Water Well Permit, Notification, Design and Coordination Requirements." (Draft FS, page ES-5). The Draft FS does not discuss how OCWD, which is not a landowner in this area nor a regulatory agency, will negotiate and achieve "Land Use Covenants" or "Deed Restrictions" in order to achieve the claimed short-term effectiveness criteria."*

Response 5-02:

The Draft OU2 FS Report Table 5-1 and Section 5.4.2. indicate that Land Use Covenants (LUC) will not be part of the ICs.

Revision to Draft OU2 FS Report:

To minimize confusion, the Draft OU2 FS Report will be revised to modify tables that describe specific ICs for alternatives and remove the term "LUC".

COMMENT 6: THE MNA EVALUATION IS BASED ON UNREPRESENTATIVE CONDITIONS AND IS THEREFORE INVALID

Comment 6-01:

> *"Alternative 2, MNA, is evaluated in Section 7.2.3.2 of the Draft FS. This evaluation: (1) incorrectly characterizes MNA in OU 2 as a stand-alone remedy; (2) relies on historical and unrepresentative data to evaluate potential effectiveness following remedy implementation at the source sites; and (3) evaluates MNA throughout the entire OU 2 rather than smaller sub-areas, thus overlooking spatial heterogeneity in potential MNA effectiveness.*
>
> *First, the third paragraph states "MNA is often used as a follow up or combined remedy with other treatment technologies. MNA is seldom used as a stand-alone remedy for individual plumes, especially with the combination and concentrations of COCs in OU 2 groundwater."*
>
> *These statements suggest that MNA would be a stand-alone remedy if it were selected for OU 2, but this ignores source site remediation that is either in progress or planned for future implementation. The U.S. Environmental Protection Agency (USEPA) guidance document referenced in the Draft FS discusses the applicability of MNA and notes "Removal, treatment, or containment of [non-aqueous phase liquids] NAPLs may be necessary for MNA to be a viable remedial option or to decrease the time needed for natural processes to attain site-specific*

remediation objectives." The COC concentrations present in OU 2 are not indicative of NAPL, and elevated COC concentrations at source sites are being or will be addressed by source site remediation. It is, in fact, a rather common approach to treat the source areas and manage the exposure risk in the relatively lower concentration downgradient plume with MNA."

Response 6-01:

The OU2 FS Model does integrate and consider source area remediation[21] in the evaluation of the MNA Alternative (2). Section 5.4.7.1 of the Draft OU2 FS Report describes MNA and the lines of evidence typically used to evaluate MNA effectiveness and the summary presented in Section 7.2.3.2 indicates that the lines of evidence do not support use of MNA for OU2 groundwater. The SOCO comment references an EPA document and implies that if non-aqueous phase liquid (NAPL) is removed, MNA can work and then states that there is no NAPL in OU2 groundwater further implying MNA is effective[22]. However, EPA guidance also states that "the hydrologic and geochemical conditions favoring significant biodegradation of chlorinated solvents sufficient to achieve remediation objectives within a reasonable timeframe are anticipated to occur only in limited circumstances"[23]. As indicated in Section 8.1.1, Alternative 2 (MNA) does not meet the threshold criteria of protectiveness of human health and the environment with the exception of protection of human exposure to groundwater through institutional controls. MNA Alternative 2 would not achieve the Draft FS Report RAOs 1, 2, 3, and 5.

Revision to Draft OU2 FS Report

Revisions to the Draft OU2 FS Report are not necessary.

Comment 6-02:

"Second, the MNA evaluation is based on historical data that are reflective of contributions from source sites where remedies have not yet been implemented. The Draft FS states that the first and second lines of evidence (historical mass reduction and hydrogeologic/geochemical data, respectively) have not been met (page 64). This is a meaningless evaluation because not all source sites have finished implementing remedies, so OU 2 continues to be impacted by adjacent COC sources. "

Response 6-02:

The SOCO comment fails to account for the OU2 FS RAOs. The RAOs presented Section 2.0 of the Draft OU2 FS Report are meant to be protective of further degradation of groundwater which includes, but is not limited to, "preventing lateral and vertical migration of high concentration

[21] Section 1.5 of the draft FS, which is excerpted from the SRI states: remediation of source areas is expected to be conducted by potential responsible parties in tandem with the interim remedy; and given the extent and concentrations of TCE, PCE, 1,1-DCE and 1,4-dioxane detected in groundwater downgradient of source area properties, it is expected that intrinsic biodegradation (a process that is integral to MNA), is not a dominant process.

[22] EPA OSWER Directive 9200.4-17P dated April 1999 has the following statement on page 11: MNA should not be considered a default or presumptive remedy at any contaminated site.

[23] EPA OSWER Directive 9200.4-17P dated April 1999, page 7

COCs into zones with lower concentrations of COCs within OU2, to the extent practicable". SOCO's comment suggests that it is acceptable for COC concentrations to increase until all source sites have implemented remedies, regardless of the length of time it takes for implementation. Waiting for all source control remedies to be finalized, implemented and verified can be a very long process. Using the SOCO site and SOCOs assumptions regarding MNA as an example, the following provides an indication of the potential time elapsed between source area remedy selection and verification of source area remedy effectiveness. The SOCO groundwater remedy was approved by DTSC on July 23, 2015[24]. SOCO's FS indicates that their 200 ug/l plume will continue to expand for almost two decades after they implement their remedy (refer to response 0-01B), allowing for further plume expansion even after the source control remedy has been implemented. Optimistically, if SOCO were to implement their source remedy in 2023 and their FS model assumptions were correct, their 200 ug/l TCE groundwater plume would be stabilized in about 2040, which is 25 years after remedy selection. Thus, waiting until all source sites, including SOCO, to implement and complete their source control remedies only serves to allow OU2 groundwater contamination to further spread and migrate downgradient, which bolsters the need to implement the OU2 interim remedy well before all source site remedies have been completed.

Revision to Draft OU2 FS Report

Revisions to the Draft OU2 FS Report are not necessary.

Comment 6-03:

> *"Current groundwater conditions in OU 2 are not representative of conditions that will exist after implementation of source site remedies. For example, the Draft FS discusses evidence of dechlorination downgradient from the Holchem property but notes that concentrations of degradation products such as cis-DCE and vinyl chloride remain high. The dechlorination rates for cis-DCE and vinyl chloride are typically slower than for PCE and TCE, so as long as the sources of PCE and TCE are uncontrolled the concentrations of degradation products will remain elevated. Historical concentration trends are not indicative of the potential effectiveness of MNA following implementation of source site remedies."*

Response 6-03:

Refer to response 6-02.

Revision to Draft OU2 FS Report

Revisions to the Draft OU2 FS Report are not necessary.

[24] Section 1 of the Remedial Design and Implementation Plan, Former Service Chemical Facility prepared by Geosyntec dated November 28, 2016.

Comment 6-04:

> *"Third, the Draft FS evaluated the feasibility of MNA throughout OU 2, an area of approximately 5 square miles, rather than within the individual areas shown on Figure 7. Evidence of dechlorination of some chlorinated solvents downgradient from the Holchem property was noted in the Draft FS, which indicates appropriate conditions for dechlorination including the presence of the appropriate microorganisms. As documented in the DTSC-approved RAP for the Holchem property, MNA is a potentially effective technology for the commingled chlorinated solvent plume downgradient from the Holchem property (i.e., Area 1 on Figure 7). The assessment in the Draft FS that MNA is not appropriate for all of OU 2, and therefore not appropriate for any area within OU 2, is a flawed conclusion that overlooks spatial heterogeneity within OU 2 with respect to potential MNA effectiveness."*

Response 6-04:

The SOCO FS/RAP treatability study report[25] concluded the following regarding appropriateness of conditions for the SOCO Site: "*The rate and extent of intrinsic degradation of chlorinated ethenes and chlorinated ethanes in Site groundwater is limited by the lack of available nutrients (e.g., electron donors) and the absence of suitable strains of bacteria capable of promoting complete dechlorination of the chlorinated ethenes and chlorinated ethanes at the Site.*" In addition, refer to responses 0-01A, 0-01B, 6-01, and 6-02.

Revision to Draft OU2 FS Report

Revisions to the Draft OU2 FS Report are not necessary.

COMMENT 7: THE EVALUATION OF LONG-TERM EFFECTIVENESS IS INSUFFICIENT AND INCOMPLETE

Comment 7-01:

> *"The Draft FS contains several statements affirming the long-term effectiveness of the proposed IRM without providing any support. First, OCWD ranks Alternatives 3 and 4 high in long-term effectiveness (pages ES-10, 68, and 74; and Table 8-2), but its ranking is based on flawed premises. Section 5.4.4.1 and Table 8-2 explain that pump and treat is a proven technology, yet not a single example is provided of pump and treat reducing groundwater concentrations to state and federal MCLs (i.e., IRM RAO #6, pages ES-4 and 16), as OCWD claims its IRM will do (pages 68 and 72). Appendix F of the Draft FS lists six source sites that are implementing pump and treat, and none of them have yet reached cleanup levels. The National Research Council (1994, page viii) noted "Unfortunately, and some would say not surprisingly, the effectiveness of this technology [pump and treat] to restore contaminated aquifers seems quite limited." The*

[25] Conclusion point number 1 presented Sirem Treatability Study dated September 21, 2012, which is presented in Appendix B of the SOCO Remedial Action Plan prepared by Geosyntec Consultants dated October 12, 2012.

> *assertion in the Draft FS that pump and treat is an appropriate technology for treating groundwater to MCLs is not supported."*

Response 7-01:

As indicated in Section 1.1 of the Draft OU2 FS Report, the USEPA recommends performance standards for Interim Remedial Actions that focus on stabilizing the operable unit and/or preventing further migration of contaminants. As stated in response 6-02, the Draft OU2 FS Report RAOs address preventing further migration of contaminants, to the extent practical, as part of the IRM. SOCO's comment ignores the OU2 FS RAO (see response 6-02). However, Section 1.1 of the Draft OU2 FS Report provides a brief comparison on the duration of potential remedial operations for groundwater extraction and treatment (GET), in-situ chemical oxidation (ISCO), and MNA. This high-level comparison identified GET and ISCO as having similar durations and MNA as having the longest duration of the three.

As indicated in Table 8-2 of the Draft OU2 FS Report, RAO 6 is maintained through ICs for Alternatives 2 through 6.

Revision to Draft OU2 FS Report

Revisions to the Draft OU2 FS Report are not necessary.

Comment 7-02:

> *"The RWQCB previously commented that the effectiveness of the selected pump and treat technology was questionable due to matrix diffusion, stating: "P&T technologies must often operate for an extended period of time (decades) to meet aquifer cleanup goals, and in many cases may fail to achieve those goals. Limitations and concerns with this technology are evident when an assessment of remaining contaminant concentrations indicates an asymptotic curve, or when concentrations rebound after shutdown. The residual mass of volatile organic compounds (VOCs) in groundwater tends to adsorb to organic materials in less permeable soils, and may later migrate back into the groundwater via back-diffusion, thus acting as a long-term source of contamination." (Draft FS, Appendix H [RWQCB Comments on Draft Feasibility Study Initial Screening], Comment #14.)"*

Response 7-02:

The Draft OU2 FS Report indicates that matrix back diffusion is expected to prolong conditions that result in elevated COC concentrations in groundwater. This is true for GET Alternatives (3, 4 and 6), the MNA Alternative (2) and the ISCO Alternatives (5 and 6) as summarized in

Table 8-2a of the Draft OU2 FS Report. As indicated in response 7-01, the interim remedy focuses on stabilizing and/or preventing further migration of contaminants in OU2.

Revision to Draft OU2 FS Report

Revisions to the Draft OU2 FS Report are not necessary.

Comment 7-03:

Even without considering matrix diffusion, a pump and treat system will run for a long time. Extraction well transect G-8 (shown in Figure 3.14 of Draft FS Appendix E is south (downgradient) of Warner Avenue Transect G-2 and will capture groundwater downgradient from Transect G-2. The distance between those transects, along with the width and thickness of capture, define one pore volume for each layer. The particle tracks in Appendix A, Figure 3 .14 indicate that 10 years of pumping will capture groundwater in Layer 2 up to 1,000 feet upgradient from the extraction wells, which does not quite reach to Warner Avenue. Therefore, the pump rate is less than 0.1 pore volumes per year. A review of groundwater treatment technologies by the National Research Council noted the following:

(1) *"Attainment of cleanup criteria at most sites under the most favorable of circumstances can be expected to take decades with extraction rates of less than one pore volume per year."*

(2) *"The time required for a pump and treat system to extract one pore volume of ground water from the contaminated zone is a fundamental system parameter that should be documented for all pump and treat systems."*

(3) *"Assessments of ground water cleanup time should include estimates of the number of pore volumes that must be extracted to attain cleanup goals"*

The proposed extraction rate for transect G-8 is less than 10% of one pore volume, so the system should be expected to operate for many decades. A rough estimate using a batch flushing model that does not account for matrix back diffusion indicates a minimum operation period of more than 50 years, calculated as follows:

(1) *# pore volumes required to cleanup from initial concentration (CO) to final concentration (Cf)= Rx ln(C0/Cf), where R is assumed to be approximately 1.01 in Layer 2, CO is 1,000 ug/L, and Cf is 5 ug/L*

(2) *# pore volumes= 5.3*

(3) *At 0.1 pore volume per year, an optimistic estimate of the time required for cleanup by pump and treat is 53 years.*

GSI' s matrix diffusion tool, which provides a more realistic estimate of cleanup times as compared to the batch flush model, indicates cleanup to MCLs will not be achieved within 80 years. The Draft FS notes "in general, relatively lengthy operations are required," but does not

> *provide either cleanup goals or an estimate of operation duration. Similar to Alternatives 3 and 4, Alternative 2 (MNA) would require multiple decades to clean up OU 2. The Draft FS considered this to be unreasonable time, so it is unclear why the time for Alternatives 3 and 4 was scored differently and deemed "reasonable." The incomplete assessment of required times for operation makes it impossible to compare the likely duration of operation for Alternatives 3 and 4 versus Alternative 2.*

Response 7-03:

The IRM focus on stabilizing OU2 groundwater and/or preventing further migration of contaminants in OU2, without specifying numeric cleanup goals or estimating time for groundwater cleanup (refer to response 7-01). As indicated in response 7-01, the relative clean up times for pump and treat and ISCO are expected to be significantly faster than MNA.

Revision to Draft OU2 FS Report

Revisions to the Draft OU2 FS Report are not necessary.

COMMENT 8: THE REQUIREMENT FOR REGULATORY AGENCY ACCEPTANCE HAS NOT BEEN SATISFIED

Comment 8-01:

> *"Regulatory agencies provided comments on the proposed IRM during the Feasibility Study Initial Screening Evaluation (FSISE) and Feasibility Study Detailed Evaluation (FSDE) that remain unresolved. "*

Response 8-01:

The TAC consists of the State Water Resources Control Board Division of Financial Assistance (DFA), the California Regional Water Quality Control Board-Santa Ana Region (RWQCB) and DTSC. The TAC reviewed and commented on the FS Initial Screening Evaluation (FSISE) and FS Detailed Evaluation (FSDE). Comments received from the TAC and responses were incorporated in the Draft OU2 FS Report. The comments and responses were also included in appendices to the Draft OU2 FS Report (Appendices H to S). The TAC has reviewed the responses and associated revisions, did not indicate there were any unresolved issues [26] , and approved circulation of the Draft OU2 FS Report to the Stakeholder Advisory Group for review and comment. As such, SOCOs claim that Regulatory Agency Acceptance has not been met is an inaccurate statement, and SOCO's remaining comments need not be addressed; however, for the sake of completeness, SOCO's comments pertaining to comment 8 are presented in the following.

[26] email from DTSC to B. Leever, OCWD, dated July 11, 2022; email from Chad Nishida, RWQCB, to B. Leever, OCWD, dated March 29, 2022; and email from A. Rangi, DFA, to B. Leever, OCWD, dated March 28, 2022.

Revision to Draft OU2 FS Report

There are no revisions to the Draft OU2 FS Report as the TAC comments were resolved prior to preparation and submittal to SAG.

Comment 8-02:

> "First, as discussed above, the proposed IRM will impact the DTSC-approved remedy at the Holchem property. *RWQCB commented that "any substantial effect on groundwater quality or flow near the source sites could potentially complicate the ongoing or planned execution of remedial actions by responsible parties," to which OCWD responded "Comment noted" (Appendix K, page 5). DTSC also voiced concern about IRM impacts to residence times for remedial elements at the Holchem property (Appendix J). OCWD responded that the detailed remedial alternative evaluation would address these concerns, but the issue is not resolved in the Draft FS. In fact, OCWD's detailed evaluation shows that the proposed IRM will affect groundwater flux and residence times at the Holchem property, as discussed in Comment 2."*

Response 8-02:

Refer to Responses 2-01 through 2-06.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report will be made per responses 2-02 and 2-03.

Comment 8-03:

> *"DTSC has long been aware of and concerned about OCWD's plan to implement a pump and treat remedy that would compromise the Soco remedy. Years before OCWD prepared this Draft FS, it selected pump and treat as the preferred remedial alternative and proposed pilot studies to evaluate pump and treat. It proposed multiple pumping locations downgradient from and proximate to the Holchem property. A letter from DTSC to OCWD dated October 21, 2015 (Attachment 9), noted "DTSC is concerned that OCWD's proposed pilot study might interfere with the DTSC-approved remedial activities required for the Site, the areal extent of groundwater contamination from activities at the Site, and other adjacent properties. We hereby request that OCWD consult with DTSC regarding OCWD's proposed pilot study and any other proposal to ensure that they will not interfere with the DTSC-approved remedial activities. " OCWD's proposed remedial alternatives in the Draft FS do not satisfy requirements articulated by DTSC nearly seven years ago. "*

Response 8-03:

The remedial alternative for OU2 groundwater has not been selected. Further, the pilot study referenced in the SOCO comment was not and is not a remedy or an interim remedy. As previously stated, the Draft OU2 FS Report does not "select" an alternative, rather it provides a comparison and ranking of alternatives, for which Alternatives 3 and 4 (containment and treatment) rank highest (Section 8.2 of the Draft OU2 FS). DTSC is part of the South Basin TAC and has reviewed and provided comments to the Draft OU2 FS Report and approved circulating the Draft OU2 FS Report to the SAG for review and comment.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 8-04:

> *"Second, OCWD has not identified cleanup goals or a cleanup timeline. The California State Water Board Division of Financial Assistance commented "The RAOs should be updated to include groundwater cleanup goals, the area addressed by groundwater cleanup activities, and estimated timeframes for achieving the proposed groundwater cleanup goals" (Appendix I).*

Response 8-04:

Refer to responses 7-01 and 8-01.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 8-05:

> *OCWD responded that IRMs do not require numeric cleanup goals as part of RAOs, nor do they require an estimate for cleanup times. That may be consistent with EPA guidance, but the NCP requires an FS to include remediation goals that establish acceptable exposure levels that are protective of human health and the environment (40 CFR § 300.430(e)(2)(i))."*

Response 8-05:

The Draft OU2 FS Report provided information necessary to establish protection of human health and the environment for the IRMs. It does so through the identification of relevant COCs based on the Human Health and Ecological Risk Assessment and incorporation of Applicable or Relevant and Appropriate Requirements (ARARs). The Draft OU2 FS Report further indicated that ARARs in conjunction with the overall protection of human health and the environment criterion, form the threshold criteria to evaluate remedial alternatives when selecting a remedial action. The Draft OU2 FS Report also included RAOs that are protective of human health and the environment.

The Draft OU2 FS Report is for the IRM of the OU2, not the final remedy. Final remediation goals are determined with the final remedy selection[27].

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 8-06:

> *"Cleanup goals are also necessary for evaluating the progress of a remedial action. In addition, although cleanup goals were not labeled as such in the Draft FS, OCWD does state that the proposed IRM will satisfy ARARs, including state and federal MCLs: "In the context of transitioning the IRM to final remedy, this alternative also would meet chemical-specific ARARs associated with the state and federal MCLs for OU2 groundwater COCs by removing these COCs from OU2 groundwater.*
>
> *With these de facto cleanup goals, cleanup times should be estimated as requested by the agencies. RWQCB also commented that relative cleanup timeframes for remedial alternatives should be provided in the FS to more accurately evaluate alternatives and associated costs (Appendix 0)."*

Response 8-06:

Refer to response 7-01. IRMs have performance standards tied to RAOs which are evaluated to assess performance of the IRM.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

<u>COMMENT 9: THE SUSTAINABILITY ASSESSMENT IS INACCURATE AND INCOMPLETE</u>

Comment 9-01:

> *"The sustainability assessment in the Draft FS contains several notable errors and inconsistencies. First, Alternatives 3 requires "installing groundwater extraction and monitor wells and filtration systems at each alignment" (page 67), and Alternative 4 requires the same plus conveyance piping, treatment units and injection wells (page 72). However, the SiteWise summaries in Appendix C for Alternatives (Table C-2 for alternative 3 and Table C-3 for*

[27] "Final remediation goals will be determined when the remedy is selected" per 40 CFR § 300.430(e)(2)(i)).

> *alternative 4) show no greenhouse gas emissions and no energy consumption for the transportation of equipment during construction. This is not possible."*

Response 9-01:

As stated in Section 7.1.3 of the Draft OU2 FS Report, the sustainability assessment was conducted in addition to the seven NCP criteria. It is important to note that some FS reports have no evaluation of remedy sustainability, as is the case for SOCO's FS Report. The Draft OU2 FS Report sustainability assessment was performed as a preliminary assessment during the FS and development of remedial alternatives (as characterized in Section 7.1.3 of the Draft OU2 FS Report). As such, a semi-quantitative rank was produced for each alternative using a reduced version of SiteWise. Modules that had high levels of detail beyond what is practical to consider as part of a FS, such as the transportation of equipment during construction, were not incorporated as part of the preliminary assessment. A more detailed sustainability assessment will be conducted during the remedial design for the selected remedial alternative as mentioned in the Draft OU2 FS Report.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 9-02:

> *"Second, emissions and energy usage during construction for Alternative 2 (MNA) and Alternative 3 (pump and treat at POTW) are effectively the same. Both alternatives involve installing groundwater wells, but Alternative 3 also involves constructing underground conveyance piping. Insufficient information was provided in Appendix E to understand the scope of work evaluated in SiteWise, but the work scopes are summarized in the cost tables provided in Appendix D. Alternative 2 consists of a $5 million pre-design investigation that involves installing groundwater wells and no activities considered "construction ". In contrast, Alternative 3 consists of a $3 million pre-design investigation and nearly $10 million in capital costs associated with constructing extraction well and conveyance systems. It seems unlikely that the PDI and construction scope for Alternative 2 will result in similar emissions and energy usage as Alternative 3 despite being less than 40% the scope based on cost."*

Response 9-02:

Per response 9-01, a subset of SiteWise modules was used to evaluate and semi-quantitatively rank the sustainability of each of the remedial alternatives as part of a preliminary sustainability assessment. The SiteWise evaluation was limited to selected well and treatment system construction activities (i.e., piping installation, treatment system construction) and operations and maintenance (O&M) activities (i.e., groundwater monitoring and treatment system O&M). Alternative 2 had greenhouse gas (GHG) emissions that were relatively high during construction due to the large number of monitor wells compared to other alternatives, but the electrical use and GHG emissions for Alternative 2 during O&M were substantially lower than Alternative 3.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 9-03:

> *"Third, the ranges of values for the "low, "medium", and "high" designations (Draft FS, page 104) were not defined and are not logical. Greenhouse gas (GHG) emissions were classified low for Alternative 2 (MNA, 970 metric tons) and pump and treat Alternatives 3 and 4 (12,000 and 18,000 metric tons, respectively), despite emissions being 10 times lower for Alternative 2 than Alternatives 3 and 4. Emissions under alternative 6 (56,000 metric tons) were approximately three times higher than Alternative 4, but Alternative 6 emissions were classified as medium."*

Response 9-03:

The qualifiers provide a relative summary in the total range in estimated GHGs. The total range in high to low emissions varied by over 170. The numeric values were also included as point of reference to allow a more detailed comparison; however, detailed comparisons are cautioned as sustainability assessment was a semi-quantitative process (refer to response 9-01) and did not include all aspects of the alternatives (refer to response 9-01 and 9-02).

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 9-04:

> *"The sustainability assessment in the Draft FS is inaccurate, and insufficient information regarding inputs for each alternative was provided for the results to be meaningful."*

Response 9-03:

Per response 9-01, a subset of SiteWise modules was used to evaluate and semi-quantitatively rank the sustainability of each of the remedial alternatives as part of a preliminary sustainability assessment. As indicated in Section 7.1 of the Draft OU2 FS Report, sustainability assessment was included in addition to the seven NCP criteria. The sustainability assessment, like the Threshold and Balancing Criteria, should be used in the remedy selection process, although it may be considered in some instances to be a secondary consideration relative to the Threshold and Balancing Criteria. More detailed sustainability assessment will be conducted during the design phase to integrate green principles into the overall processes.

Revisions to the Draft OU2 FS Report are not necessary.

COMMENT 10: COMMENTS REGARDING THE ENGINEERING ANALYTICS, INC. NUMERICAL GROUNDWATER FLOW MODEL

The comments regarding EA Numerical Groundwater Flow Model were presented in SOCO's comment letter as Attachment 1, which was prepared by GSI Environmental (GSI).

Comment 10-01:

> *"The South Basin Groundwater Protection Project (SBGPP) is a project created by the Orange County Water District (OCWD) to address groundwater contamination in an approximate five square mile area in the south-central portion of the Orange County Groundwater Basin (the Basin) defined as the "Study Area." Engineering Analytics (EA) prepared a Draft Feasibility Study (Draft FS) for OCWD in which it developed remedial alternatives for what it defined as "Operable Unit 2" (OU2). OU2 consists of off-property groundwater contamination in the Shallow Aquifer System from numerous groundwater contamination "Source Sites" located within the Study Area. Figure 1 (Draft FS Figure 1-2) shows the Study Area and the Source Sites, and Figure 2 (Draft FS Figure 1-27) shows the claimed lateral extent of contamination in the upper portion of the Shallow Aquifer System.*
>
> *The Draft FS included numerical groundwater flow and particle tracking modeling to support development of remedial alternatives, including a no action scenario, monitored natural attenuation, P&T systems, and in-situ treatment to contain the plume. The model evaluates hydrogeologic behavior under the various remedial alternative scenarios across the Study Area. On behalf of Soco West, Inc (Soco), GSI Environmental Inc. (GSI) evaluated the model construction and its use. Our comments fall into three general areas:*
>
> 1) *EA's numerical model is not consistent with its Conceptual Site Model.*
> 2) *EA's model did not evaluate the impact of Alternatives 3 and 4 on Soco's remedy, which was approved by the Department of Toxic Substances Control (DTSC).*
> 3) *EA's P&T hydraulic containment strategies in Alternatives 3 and 4 are not consistent with US EPA guidance or EA's Remedial Action Objectives, and the goals are not sufficiently defined.*
>
> *Each of these issues is further discussed in greater detail below."*

Response 10-01:

Refer to responses 10-02 to 10-04 below.

Refer to below.

Comment 10-02:

> *"The numerical model does not accurately represent known local conditions or hydrogeologic parameters at various sites in the Study Area. Several important examples are discussed below."*

Response 10-02:

Refer to responses 10-02A to 10-02C below.

Revision to Draft OU2 FS Report:

Refer to below.

Comment 10-02A:

> *"EA's numerical model is inconsistent with the Conceptual Site Model or accepted aquifer parameters in several important ways.*
>
> - First, EA's calibrated numerical model requires that there are large mergence zones that connect Model Layers 2 and 4 without an intervening aquitard. This is shown in Figure 4.24 of the Draft FS report Appendix E. This is inconsistent with all the cross sections prepared by Hargis in the 2020 Supplemental Remedial Investigation. "

Response 10-02A:

There are several mergence zones which are outside the OU2 study area but within the OU2 FS Model domain. These mergence zones were identified based primarily on water level elevations measured in water table monitor wells in the area of the mergence zones. The water level elevations in the mergence zones were lower than sea level, indicating that shallow groundwater could not flow into surface water features with water level elevations near or above sea level. These mergence zones were not identified on SRI cross sections because the cross sections were within the OU2 Study Area and did not extend into the southern portion of the model domain where these zones exist.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 10-02B:

- *"Second, the horizontal hydraulic conductivities (K's) used in the numerical model for Layer 2 are substantially lower than those measured in the aquifer tests. For example, at the Holchem Property, K values ranged from 64 to 174.8 feet/day. K values used by EA were 15 and 70 feet/day in the area around the Holchem Property (Figure 4.25 of the Draft FS report Appendix E). Appropriate K values are important to assess several critical parameters, including the number and spacing of extraction wells, the total flow those extraction wells, and the impact of the P&T system on groundwater conditions at individual properties. The OU2 remedy developed by EA needs to work in concert with the site-specific remedies and should use locally obtained parameters rather than one that calibrates a larger scale model. Each of these parameters significantly affects the cost analysis for Alternatives 3 and 4. "*

Response 10-02B:

As indicated in response 1-01B, the OU2 FS Model, as with any groundwater flow model, is an approximate representation of subsurface conditions. Site-specific measurements are valuable in assessing hydraulic conditions in the area of each test location; however, even with appropriate analysis, these tests only provide an approximation of hydraulic properties in the immediate vicinity of the test, not necessarily the hydraulic properties of large-scale model features. The site-specific tests indicate variability in hydraulic conductivity, which are on the same order of magnitude as the OU2 FS Model.

As indicated in responses 02-02 and 02-03, the OU2 FS Model was not intended for design purposes, rather it was meant to compare alternatives. As presented in the Draft OU2 FS Report, a sensitivity analysis was performed during groundwater flow remedial simulations. From this sensitivity analysis, it was determined that the differences in hydraulic properties generally influenced the evaluated alternatives in a similar way, allowing for alternative comparison using the existing OU2 FS Model. For example, higher or lower hydraulic conductivities would require more or less groundwater extraction and/or more or less injection points and dosing applications of in situ chemical oxidant.

As a point of comparison, the groundwater model prepared for the SOCO FS/RAP used a single hydraulic conductivity value for HSU 3 over the entire SOCO property and throughout the larger model domain (HSU 3 is similar to Layer 2 in the OU2 FS Model). This was done without performing sensitivity analysis even though the above SOCO comment suggests variability in hydraulic conductivity at the site.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 10-02C:

- *"Third, EA's numerical modeling does not consider the impact of matrix back-diffusion on the remedy selection. Matrix diffusion has an impact over the entire length of the VOC plume, not just at the source areas as implied by EA (page 9) and provides a prolonged source of elevated concentrations of COCs. "*

Response 10-02C:

As indicated in response 7-01, the IRM focus is on stabilizing operable unit and/or preventing further migration of contaminants, without specifying cleanup goals or estimating time for groundwater cleanup. Matrix diffusion in areas downgradient of the source areas along the entire length of the plume was described in Section 1.5 of the Draft OU2 FS Report. Matrix diffusion processes are expected to slow COC migration by transferring mass from primary transport zones within the coarse intervals to the surrounding finer grained material. Over time, however, matrix back diffusion from the finer grained intervals back into coarse intervals is expected to prolong conditions that result in elevated COPC concentrations in groundwater that will prolong the remedy duration. The prolonged duration applies to all alternatives.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 10-03:

"EA claims in its report that it evaluated the impact of the groundwater extraction systems for each property. This is incorrect. EA's model simply estimates the change in groundwater flow directions and rates before and after the P&T remedies in Alternatives 3 and 4 are implemented. It does not simulate the impact of the groundwater extraction systems on Soco's remedy, as discussed below."

Response 10-03:

Refer to responses 10-03A to 10-03D below.

Revision to Draft OU2 FS Report:

Refer to below

Comment 10-03A:

"<u>The Soco Approved Remedy</u>

Geosyntec (2014) conducted fate and transport modeling in support of a Remedial Action Plan (RAP) that included installation of a slurry wall, flow control gates, and a PRB around the source area, as *well as off-property Monitored Natural Attenuation (MNA) and contingency remedies if MNA is found to be ineffective (Geosyntec, 2014). "*

Response 10-03A:

As indicated in response 0-01A, SOCO states that their remedy has a contingency plan to address failure in meeting remediation goals. However, the proposed contingency would implement EISB only 150 feet downgradient of their source remedy (PRB), while their furthest downgradient monitoring well is 2,100 feet downgradient of Warner Avenue. This contingency plan does not cover MNA failure as indicated in the above SOCO comment.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 10-03B:

"It [Geosyntec added for context] *developed a local model over the property and downgradient area consisting of two hydrogeologic zones - Zone 1 (Geosyntec Model Layer 1), which includes HSU1 and HSU2, and Zone 2 (Geosyntec Model Layer 2), which consists of HSU3. Groundwater flow was simulated based on groundwater elevation measurements and average values for soil parameters for HSU2 and HSU3 based on Site investigation reports. The Geosyntec Model used site-specific and literature values for most flow and transport parameters and performed a transport calibration for horizontal transverse and vertical dispersivity coefficients and tortuosity against data from 4Q2002 through 4Q2012.*

The Geosyntec Model was then used to evaluate conditions for 50 years from 2012 through 2063. Baseline conditions were evaluated to note how the plume would evolve under a no-action scenario (which is not the remedy proposed by Soco or approved by DTSC). The design of a PRB was also simulated. The PRB system, which is depicted on Figure 3, consists of slurry walls and flow control gates to achieve the minimum residence time required for the designed PRB gate thicknesses. The slurry wall system can divert approximately 72% of groundwater flow to reduce the volume of water passing through the Property's subsurface and reduce seepage velocities through the PRB gates. The resulting mounding upstream of the diversion was less than 0.5 feet, which indicates no significant flooding risk. Significant downstream hydraulic impacts extending up to 500 feet to the south of the Holchem Property in HSU3 were noted due to the slurry wall system. Predictive transport simulations indicated that VOC concentrations exiting the PRB system will be below MCLs. "

Response 10-03B:

As indicated in responses 0-01A and 0-01B, the SOCO FS Model did not address the leading edge (as defined by MCL) of contamination emanating from the SOCO property, and as such does not address the entirety of the SOCO contamination. In addition, the SOCO FS Model did not include sensitivity analysis to assess uncertainty in the model hydraulic and chemical parameters.

Revisions to the Draft OU2 FS Report are not necessary.

Comment 10-03C:

"EA's Modeling of Remedial Alternatives

EA's numerical flow modeling evaluated eight feasibility study extraction sites distributed throughout the Study Area (Figure 4; Draft FS Figure 3.15). The model was used to simulate the impact of the various extraction systems on capture and the potential impact at Source Sites. Each extraction site was simulated such that extraction rates provided hydraulic containment at various locations throughout the plume, not simply at the leading edge.

The proposed extraction systems cause changes in the groundwater flow magnitude and direction at one or more Source Sites. The simulated groundwater flux magnitude scaling factor at Source Sites as a result of each proposed extraction system is shown on Figure 4 (Draft FS Figure 3.15) to be 1.34, 2.38, and 2.23 in model layers 1, 2, and 3, respectively, at the Holchem Property (monitoring point ISRA2). The change in groundwater flow direction at Source Sites is shown on Figure 5 (Draft FS Figure 3.16) to be 6.8, 28.2, and 3.3 in model layers 1, 2, and 3, respectively, at the Holchem Property. Thus, the extraction systems can more than double the flux magnitude at the Holchem Property and change flow direction by as much as 28 degrees. EA did not perform any sensitivity analyses to evaluate the accuracy or uncertainty of these numbers. "

Response 10-03C:

As indicated in response 2-02, the intent of the Draft OU2 FS Report is to provide a comparison of the presented remedial alternatives, not to perform remedial design. For Alternatives 3, 4 and 6, the potential effects of well field operation would be further assessed during the pre-design investigation. This additional investigation would refine remedy design prior to implementation to minimize potential negative effects on source site remediation activities. In addition, contingency actions are available during the operation of pump and treat remedies to mitigate undesirable changes in groundwater gradients and fluxes in the vicinity of source areas, as indicated in the draft OU2 FS.

As described in response 2-03, the OU2 FS Model was modified in the vicinity of the SOCO site to evaluate the effect of OU2 groundwater extraction on SOCOs source remedy, which incorporates slurry walls. During this evaluation it was determined that the placement of the SOCO slurry walls may have a more pronounced affect in the change in direction of groundwater flow in the vicinity of the SOCO property than the OU2 FS groundwater pump and treat options. ITRC explicitly states that flow problems may arise with PRB despite detailed site characterization and a thorough design process due to uncertainties in subsurface installations. These uncertainties exist with and without the OU2 FS pump and treat system. Some of these uncertainties can be mitigated through PRB modifications.

Revisions to the Draft OU2 FS Report will be made per responses 2-02 and 2-03.

Comment 10-03D:

> *"Evaluation of EA's Modeling on Local Impacts at the Holchem Property*
>
> *The model used for Draft FS evaluation is at the scale of the Study Area, which encompasses the plumes of several Source Sites, and is inappropriate for evaluation of the impact of feasibility study extraction site operations on each of the specific Source Sites.*
>
> *Figure 6 (Draft FS Figure 4.15) shows the model grid and Figure 7 shows a zoom view of the model grid over the Source Sites. As noted, the resolution of the grid is not sufficient to evaluate the impact of groundwater extraction systems on Source Sites. Specifically, the entire Holchem Property is contained in just 1% grid-blocks. Also, the proposed extraction systems are just downgradient of the Holchem Property, with extraction sites G3 and G2 being just 3 grid-blocks away.*
>
> *EA's model does not include details of the Soco slurry wall or PRB design. The resolution of the model is not sufficient to even include these details. However, these flows are critical to operation of the PRBs and may be critically impacted. A local model, with local property values and local remediation design details, is necessary to evaluate the impact of the FS remedial alternatives on the current Soco remedy*
>
> *The change in flow magnitude and direction indicated by the EA's model will be significant to operation of the PRB system. A change in flow direction of 28 degrees can impact how water enters the gates and a change in flow magnitude by over a factor of two will impact residence times within the PRBs. There are similar magnitude changes in flow direction in the area south and downgradient of the Holchem Property, which is within the Site and associated DTSC approved remedy. "*

Response 10-03D:

Refer to response 2-03.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report will be made per responses 2-02 and 2-03.

Comment 10-04A:

"EA's pump-and-treat (P&T) designs are poorly conceived and are not consistent with EPA's guidance documentation or EA's own Remedial Action Objectives (RAOs).

EPA Guidance for Pump-and-Treat Systems

The EPA has published several guidance documents related to P&T systems for cleanup and containment of solutes in groundwater (EPA, 1990, 1997; EPA, 2008). According to the EPA: "In order to determine an appropriate strategy to manage contaminated ground water, it is necessary first to evaluate site conditions and define remediation goals. Historically, the goal of ground-water remediation has been to protect human health and the environment and to restore ground water to beneficial uses where practicable." (EPA, 1997).

The EPA identified numerous strategies for managing groundwater contamination, including hydraulic/physical containment, groundwater quality restoration, and mixed objective strategies. (EPA, 1997). The purpose of these strategies are:

- *Hydraulic containment designs prevent continued expansion of the contamination zone. Containment P&T systems are designed to be located at the distal end of a plume to prevent it from expanding further. Capture zone evaluations are conducted to gauge the effectiveness of the hydraulic barrier created by the P&T operations.*

- *Groundwater quality restoration strategies are designed to attain clean-up goals during a finite period. Solute transport evaluations are required to determine whether the strategies are effective and whether clean-up goals can be achieved within a reasonable period.*

- *Mixed objective strategies are designed to contain the downgradient edge of the plume and attempt to restore the source area and downgradient plume area. Mixed strategies may include non-P&T approaches to handle different portions of the contaminated region with different remediation approaches. When mixed approaches are used, the impact of one strategy on the other must be analyzed.*

Figure 8 (from EPA's Guidance document) shows the various uses of P&T systems for site management (EPA, 1997). EPA guidance on designing P&T systems also emphasizes the need to optimize well locations, depths, and extraction rates to maintain effective hydraulic flushing of the plume, minimize stagnation zones (typically located downgradient of containment well arrays), and contain groundwater plumes (EPA, 1997). This was not considered in EA's analysis."

Response 10-04A:

As established in RAO 1 of the Draft OU2 FS Report, one of the goals of the interim remedy is to "Protect groundwater resources from further degradation by preventing lateral and vertical migration of high concentration COCs into zones with lower concentrations of COCs". As such, hydraulic containment at OU2 is not reserved only to the distal end of plumes to prevent lateral migration, as implied by SOCO's response, it can also be used as a means of preventing vertical migration of plumes.

Groundwater restoration strategies (also referred to as Cleanup/Restoration) are more difficult to achieve than hydraulic containment [28] . As indicated in response 7-01, the IRM focus is on stabilizing the operable unit and/or preventing further migration of contaminants. The optimization of well locations to maximize flushing as described in the SOCO comment is more relevant to a cleanup/restoration remedy, which, as the Draft OU2 FS Report indicated, may be part of the final remedy.

To the extent pump and treat alternatives are selected for the OU2 IRM, optimization of well locations would be conducted during remedial design based on updated information collected during the pre-design investigation, not as part of the Draft OU2 FS Report. The final remedy could also be further optimized based on performance monitoring information obtained during the operation and five-year remedy reviews implemented as part of the IRM.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 10-04B:

> *"Potential limits to P&T include tailing and rebound when the system is shut off and then turned back on, especially when aquifer restoration is the remediation goal. These may occur due to physical processes of diffusion to/from low conductivity sediments, or chemical processes of adsorption or mass transfer from another phase (EPA, 1997). An appropriate conceptual site model tested using analytical or numerical methods may help estimate the relative significance of different processes, such as matrix back diffusion, that cause tailing and rebound. EA did not do that analysis."*

Response 10-04B:

Refer to response 10-02C.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 10-04C:

> *"Consistency of the Remedial Alternatives with the RAOs*
>
> *The Draft FS defines the RAOs as protection of human health and the environment from COCs from the various Source Sites. Specific RAOs were described in the Draft FS:*

[28] Page 2 of USEPA/540/S-92/504. September 1997

1. *"Protect groundwater resources from further degradation by preventing lateral and vertical migration of high concentration CO Cs into zones with lower concentrations of COCs within OU2, to the extent practicable;*

2. *Protect groundwater resources by preventing the potential for vertical migration of high concentration COCs from the upper/middle portions of the Shallow Aquifer System to the Principal Aquifer System through Legacy Water Supply Wells, to the extent practicable;*

3. *Protect groundwater resources from further degradation by preventing the spread of COCs exceeding MCLs in the Leading-Edge areas of the plume, to the extent practicable;*

4. *Implement a reliable interim groundwater remedy(s) that is compatible with ongoing and planned remediation at source sites and associated off-property locations, where applicable;*

5. *Prevent discharge of COCs exceeding ecological risk-based concentrations from the Shallow Aquifer System to surface water channels; and*

6. *Prevent human exposure to contaminated groundwater with COC concentrations exceeding MCLs or other ARARs".*

The proposed P&T remedial alternatives are shown on Figure 4 (Draft FS Figure 3.15) and includes groundwater extraction wells and trenches. The Source Sites are also shown on Figure 4. Figure 5 (Draft FS Figure 3.16) shows the groundwater extraction locations for the proposed remedial alternatives and the plume of COCs. The alternatives that EA selected as viable include:

- *Alternative 3--Containment and Treatment of relatively High Concentration and Leading• Edge Areas Using Groundwater Extraction and Treatment with Discharge to POTW and GWRS for further treatment*
.
- *Alternative 4-- Containment and Treatment of relatively High Concentration and Leading• Edge Areas Using Groundwater Extraction and Treatment with Injection to the Basal Sand."*

Response to 10-04C:

The Draft OU2 FS Report identified Alternatives 3 and 4 as potentially feasible and provided a comparison and ranking of alternatives, for which Alternatives 3 and 4 ranked highest[29].

[29] Section 8.2 of the draft OU2 FS Report.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 10-04D:

> *"EA's overall strategy is not appropriate. Its remedial alternative analysis fails to include sufficient details of current and proposed remediation systems at Source Sites and therefore EA's P&T alternatives could interfere with the operation of Source Site systems."*

Response to 10-04D:

Refer to responses to comments 2-01 to 2-07.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report will be made per responses 2-02 and 2-03.

Comment 10-04E:

> *In addition, groundwater extraction systems within the middle of the plume, as proposed by EA, do not achieve stated remediation goals for the following reasons:*
>
> - *The Shallow Aquifer System is not a drinking water resource as the water is not potable due to high TDS and chlorides.*

Response to 10-04E:

As stated in Section 1.2.1 of the Draft OU2 FS Report, the Shallow and Principal Aquifer Systems are components of the Orange and Irvine Groundwater Management Zones which are defined in the Water Quality Control Plan for the Santa Ana River Basin (Basin Plan). The Basin Plan designates beneficial uses for the Orange and Irvine Groundwater Management Zones, including the Domestic and Municipal (MUN) beneficial use. OU2 groundwater, including groundwater in the Shallow Aquifer, is designated for beneficial use.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 10-04F:

> - *"The proposed in-plume extraction systems do not prevent further degradation of the resource due to migration of high concentration VOCs into lower concentration zones because the downgradient portions of the plumes are not being captured by the P&T systems. For instance,*

extraction site G2 (see Figure 9; Draft FS Figure 2.3) has high concentrations of VOC immediately downgradient of the extraction system. A similar situation exists with extraction sites G3, G8 and G5. In fact, the design and placement of these extraction well arrays will prolong the duration of the remedy because they will likely create stagnation zones in the downgradient areas."

Response to 10-04F:

Stagnation zones develop in areas where the P&T operation produces low hydraulic gradients.[30] By definition, the amount of groundwater flowing through stagnation zones is low, which can create isolated pockets of higher concentration water. Because of this low flow, stagnation zones limit the mass flux of contaminants, which is consistent with OU2 FS RAOs 1 and 2 presented in the Draft OU2 FS Report. Stagnation zones that develop as part of pump and treat alternatives, can be identified during operation of the IRM, if one of these alternatives are selected. The size, magnitude, and duration of stagnation zones can be diminished by changing pumping schedules, locations, and rates[31]. These types of evaluations can be conducted during an IRM and support the final remedy.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 10-04G:

- *"The in-plume treatment system was designed for containment, not optimal mass removal. Therefore, these systems were not placed in the highest concentration areas of the plume. Also, EA's modeling to evaluate system design was optimized based on the pumping required to contain and capture water from upstream sources instead of evaluating the optimal capture of VOCs based on physical and chemical properties of the solutes and back diffusion effects from lower permeability zones."*

Response to 10-04G:

The OU2 area is within a densely utilized urban area that creates challenges for siting and operating remedial alternatives. As such, the draft OU2 FS Report used public rights of way for the analysis, which was consistently applied to all alternatives with the exception of procurement property for the larger treatment system associated with Alternative 4. It is difficult to optimize remedial alternatives in areas such as OU2 given access constraints; however, as indicated in a portion of response 10-04A, optimization of well locations would be conducted during design based on updated information collected during the pre-design investigation, not part of the draft OU2 FS Report.

[30] Page 13 of USEPA/540/S-92/504. September 1997
[31] Page 13 of USEPA/540/S-92/504. September 1997

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 10-04H:

- *"The remedial alternative does not promote plume cut-off as noted in the second panel of Figure 8, or downgradient aquifer restoration as in the third through fifth panels of Figure 8, because there are multiple Source Sites"*

Response 10-04I:

OU2 groundwater is impacted by multiple plumes from multiple source sites that vary by depth and location within the OU2 Study Area. Some of the OU2 Alternative transects are downgradient of some source sites, but upgradient of others. These transects do reduce the mass flux of commingled plumes from upgradient of the respective transect to areas downgradient. Achieving OU2 FS RAOs is the focus of the IRM as indicated in the Draft OU2 FS Report (refer to response 7-01).

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 10-04J:

- *"If the postulated but unknown "Legacy Water Supply Wells" as defined by EA exist within the Study Area and are acting as conduits as speculated by EA, Alternatives 3 or 4 do nothing to address such pathways."*

Response 10-04J:

Alternatives 3 to 6 have transects that intercept/treat higher concentration groundwater thereby reducing the threat potential in areas downgradient of the transects. This is presented in the Draft OU2 FS Report in sections 6.2.3 to 6.2.6. The respective alternative would be applied in transects within relatively high COC concentration area to decrease lateral and vertical migration of high concentration COCs into zones with lower concentrations within OU2; decrease the threat of COC migration from the Shallow Aquifer System to the Principal Aquifer System through Legacy Water Supply Wells that cannot be located or properly destroyed; and begin to treat and reduce the concentration of COCs in OU2 groundwater.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 10-04K:

- *"There is little or no data that shows VOCs are present in surface water channels even after decades of contamination in the OU2 area. Furthermore, the remedial alternatives preferred by EA do not prevent water from entering the surface-water system, nor has it been demonstrated that it does. Alternative 3 and 4 do nothing to address this unproven pathway."*

Response 10-04K:

Section 4.2 of the SRI indicated there was some limited surface water sampling in the Lane Channel to the south of the Ricoh Electronics Facility located on Pullman Drive in 2000. The results of this sampling indicated that tetrachloroethylene (PCE) was detected in the surface water. This data, along with water level elevations measured at the time, indicated that a portion of the groundwater in the upper portion of the Shallow Aquifer System was flowing into this surface water channel. As a point of clarification, OU2 FS RAO 5 "Prevent discharge of COCs exceeding ecological risk-based concentrations from the Shallow Aquifer System to surface water channels;" applies to hexavalent chromium not VOCs (Section 1.6.2 of the Draft OU2 FS Report).

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 10-04L:

- *"The remedial alternatives do not specifically address human exposure to groundwater with VOCs exceeding their respective standards. The Shallow Aquifer System water is not potable and there are no downstream potable water wells in the Shallow Aquifer System that are or may be threatened."*

Response to 10-04L:

As indicated in response 7-01 and in Table 8-2 of the Draft OU2 FS Report, RAO 6 (human exposure to groundwater) is maintained through ICs for Alternatives 2 through 6. As stated in response 10-04E and Section 1.2.1 of the Draft OU2 FS Report, the Shallow and Principal Aquifer Systems are components of the Orange and Irvine Groundwater Management Zones which are defined in the Water Quality Control Plan for the Santa Ana River Basin (Basin Plan). The Basin Plan designates beneficial uses for the Orange and Irvine Groundwater Management Zones, including the Domestic and Municipal (MUN) beneficial use. OU2 groundwater, including groundwater in the Shallow Aquifer, is designated for beneficial use.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 10-04M:

> *"The remedial alternatives do not address details of ongoing or planned onsite remedial strategies. For instance, the Soco approved remedy includes a slurry wall system to control flow through permeable reactive barriers that would remove mass from the system. This system will be affected by the proposed remedial alternative, but EA did not evaluate that effect on a local scale. Even from regional trends, it was noted that the remedial alternative would change direction and magnitude of flow around the entire Soco Site thus interfering with approved Site remedial implementation.*

Response to 10-04M:

Refer to response to comments 2-01 through 2-07.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report will be made per responses 2-02 and 2-03.

Comment 10-04N:

> *"As explained above, the proposed remedial alternatives and analyses thereof are inadequate. The main objective of a remedial alternative is to protect human health and the environment and to restore ground water to beneficial uses where practicable. The remedial alternatives proposed do not improve the protection of human health in terms of preventing COCs from reaching drinking water sources. The Shallow Aquifer System groundwater is not potable and has not been put to any beneficial uses. The aquifer restoration potential has not been analyzed. The practicality of clean-up and time to reach appropriate standards have not been estimated. The system operation was not designed to be optimal for mass removal considering matrix diffusion or other chemical and physical properties of the COCs and the site conditions; instead, it was designed for containment and capture while needlessly creating numerous stagnation zones. Furthermore, many of the extraction systems do not prevent further degradation of the resource because the high concentrations are already downgradient of the extraction wells.*

Response to 10-04N:

Refer to response to comments 10-04A to 10-04M.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

COMMENT 11. COMMENTS REGARDING THE REPLENISHMENT ASSESSMENT AND BASIN EQUITY ASSESSMENT IN ENGINEERING ANALYTICS, INC. DRAFT FS

The comments regarding Replenishment Assessment and Basin Equity were presented in SOCO's comment letter as Attachment 2, which was prepared by GSI.

Comment 11-01:

> *"1. The cost estimates for selected Alternatives 3 and 4 include Replenishment Assessment (RA) and Basin Equity Assessment (BEA) Fees. Neither the RA nor the BEA is appropriate for the pump and treat system in the Shallow Aquifer System of the SBGPP."*

Response to Comment 11-01:

Given that the main purpose of the Draft OU2 FS Report is to describe and evaluate interim remedial alternatives that would be implemented by the OCWD, rather than another entity, it is appropriate that the costs for the RA and BEA be deleted from these alternatives, explained as follows. Per the OCWD Act, including but not limited to Sections 24, 27, 27.1, and 31.5, the groundwater extracted by OCWD under Alternatives 3, 4 and 6 would be subject to payment of the RA and BEA. Under this scenario, however, OCWD would in essence be billing and paying itself in equal amounts for each billing cycle. Therefore, there would be no net costs for the RA and BEA and, as such, they will be deleted from the costs for Alternatives 3, 4 and 6 in the FS report.

Revision to Draft OU2 FS Report:

The RA and BEA items will be removed from the cost estimates for Alternatives 3, 4 and 6 in the Draft OU2 FS Report. This revision, reduces the estimated cost for Alternatives 3, 4 and 6 by approximately $9.6, $1.9 and $9.4 million dollars, respectively. These changes affect the overall estimated costs for the different remedial alternatives, but do not affect the overall cost ranking for any of the Alternatives presented in Draft OU2 FS Report. These revisions will be incorporated into the Final Draft FS Report.

Comment 11-01a:

> *"Pump and treat as designed will pump shallow aquifer system groundwater at a rate of 343.28 GPM"*

Response to Comment 11-01a:

Refer to response to comments 10-04E, 10-04L and 11-01.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report will be made per response 11-01.

Comment 11-01b:

> *"The Shallow Aquifer System is not usable groundwater"*

Response to Comment 11-01b:

Portions of the Shallow Aquifer System in the South Basin contain groundwater that is of suitable quality for potable water supply or other uses, while other portions of the Shallow Aquifer System contain groundwater that would need to be treated prior to potable or other water supply uses. Also see response to Comment 11-01.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report will be made per response 11-01.

Comment 11-01c:

> *"The Basin Equity Assessment (BEA) is not an applicable cost to levy for the extraction of non-potable water"*

Response to Comment 11-01c:

Refer to response to comment 11-01.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report will be made per response 11-01.

Comment 11-01d:

> *"The Replenishment Assessment (RA) is not an appropriate charge to non-potable water sources, and it overestimates the cost to treat SBGPP groundwater at the GWRS"*

Response to Comment 11-01d:

Refer to response to comment 11-01.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report will be made per response 11-01.

Comment 11-02:

> *"2. Although the Shallow Aquifer System groundwater is currently not used for municipal water supply and is largely discharged to Newport Bay, any perceived reduction in groundwater storage can be replaced at a far lower cost by acquiring water from the Metropolitan Water District (MWD).."*

Response to Comment 11-02:

The three aquifer systems in the South Basin Groundwater Protection Project Study Area, with increasing depth, are the Shallow Aquifer System, the Principal Aquifer System, and the Deep Aquifer System. Although identified as separate systems, the aquifer systems are known to be hydraulically connected as groundwater flows between them by way of discontinuities in the aquitards or leakage through the intervening aquitards (Orange County Water District Groundwater Management Plan 2015, Updated June 17, 2015; Supplemental Remedial Investigation Report, Orange County Water District South Basin Protection Project, Operable Unit 2, prepared by Hargis + Associates, Inc., dated May 6, 2020). Some near-surface groundwater in the Shallow Aquifer System discharges to surface water channels tributary to Newport Bay. No net reduction in basin groundwater storage will occur as a result of implementation of any of the Alternatives in the FS, due to OCWD's basin management programs including groundwater replenishment of the Shallow, Principal, and Deep Aquifer Systems.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 11-02a:

> *"The total cost to pump and send water to the POTW and then to OCWD's GWRS for 30 years with an NPV of 2.5% is approximately $37.3M"*

Response to Comment 11-02a:

Refer to response to comment 11-01. A discount rate of 2.5% was selected based on OCWD's anticipated rate of return on its investments and inflation.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report will be made per response 11-01.

Comment 11-02b:

> *"The cost to buy an equivalent volume of water from the MWD for that same period is $9M to $13M"*

Response to Comment 11-02b:

Comparing costs of the interim remedial alternatives to purchasing MWD water ignores the purpose of the interim remedial alternatives which is to achieve the remedial action objectives listed in the Draft OU2 FS Report.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

LIST OF TABLES

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TABLES

Table 1a: Simulated Groundwater Discharge through the SOCOWest Feasibility Study Slurry Wall (with and without FSES Remediation)

	SOCOWest (Slurry Wall only)		FSES (Slurry Wall and FSES)		Factor[1]
Layer 1	(f^{t3}/d)	(gpm)	(ft^3/d)	(gpm)	(unitless)
In-Lateral	39.9	0.21	66.0	0.34	1.65
In Recharge	3.2	0.02	3.2	0.02	1.00
Total In	43.1	0.22	69.2	0.36	1.6
Out-Lateral	15.6	0.08	22.2	0.12	1.43
Out-Bottom	27.7	0.14	47.1	0.24	1.7
Total Out	43.3	0.22	69.4	0.36	1.6
Layer 2					
In-Lateral	66.0	0.34	118.3	0.61	1.79
In-Top	27.7	0.14	47.1	0.24	1.70
Total In	93.7	0.49	165.4	0.86	1.76
Out-Lateral	71.3	0.37	141.9	0.74	1.99
Out-Bottom	22.5	0.12	23.5	0.12	1.04
Total Out	93.7	0.49	165.4	0.86	1.76
Totals (Layer 1 + 2)					
In-Lateral	105.9	0.55	184.3	0.96	1.74
In Recharge	3.2	0.02	3.2	0.02	1.00
In-Top	27.7	0.14	47.1	0.24	1.7
Total In	136.9	0.71	234.6	1.22	1.71
Out-Lateral	86.9	0.45	164.2	0.85	1.89
Out-Bottom	50.2	0.26	70.6	0.37	1.41
Total Out	137.0	0.71	234.8	1.22	1.71

<u>Notes:</u>

[1] Factor is FSES (ft^3/day) divided by SOCOWest (ft^3/day)

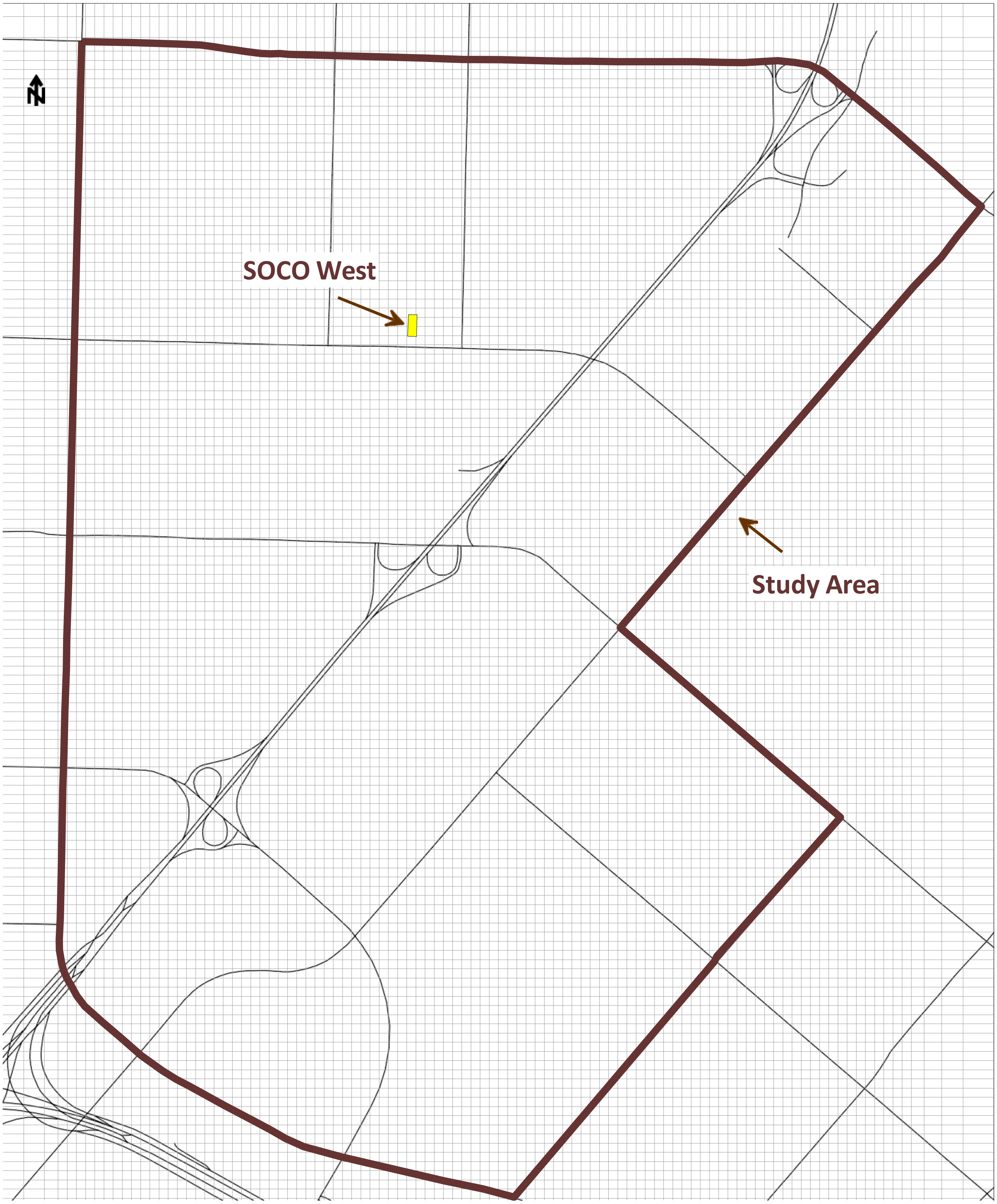
Table 1b: Simulated Groundwater Discharge through the SOCOWest Remedial Design Slurry Wall (with and without FSES Remediation)

	SOCOWest (Slurry Wall only)		FSES (Slurry Wall and FSES)		Factor[1]
Layer 1	**(ft^3/d)**	**(gpm)**	**(ft^3/d)**	**(gpm)**	**(unitless)**
In-Lateral	38.0	0.20	63.3	0.33	1.67
In Recharge	3.2	0.02	3.2	0.02	1.00
Total In	41.2	0.21	66.6	0.35	1.62
Out-Lateral	13.4	0.07	19.7	0.1	1.47
Out-Bottom	28.0	0.15	47.0	0.24	1.68
Total Out	41.4	0.21	66.7	0.35	1.61
Layer 2					
In-Lateral	56.0	0.29	103.6	0.54	1.85
In-Top	28.0	0.15	47.0	0.24	1.68
Total In	84.0	0.44	150.7	0.78	1.79
Out-Lateral	61.3	0.32	127.0	0.66	2.07
Out-Bottom	22.7	0.12	23.7	0.12	1.04
Total Out	84.0	0.44	150.7	0.78	1.79
Totals (Layer 1 + 2)					
In-Lateral	94.0	0.49	167.0	0.87	1.78
In Recharge	3.2	0.02	3.2	0.02	1.00
In-Top	28.0	0.15	47.0	0.24	1.68
Total In	125.2	0.65	217.2	1.13	1.73
Out-Lateral	74.7	0.39	146.7	0.76	1.96
Out-Bottom	50.6	0.26	70.7	0.37	1.40
Total Out	125.4	0.65	217.4	1.13	1.73

Notes:

[1] Factor is FSES (ft^3/day) divided by SOCOWest (ft^3/day)

FIGURES



Engineering Analytics, Inc.

0 1000 2000
feet

Minimum cell size is 125 ft x 125 ft

Figure 1. Original Model Grid In the Study Area, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099

Engineering Analytics, Inc.

0 1000 2000
feet

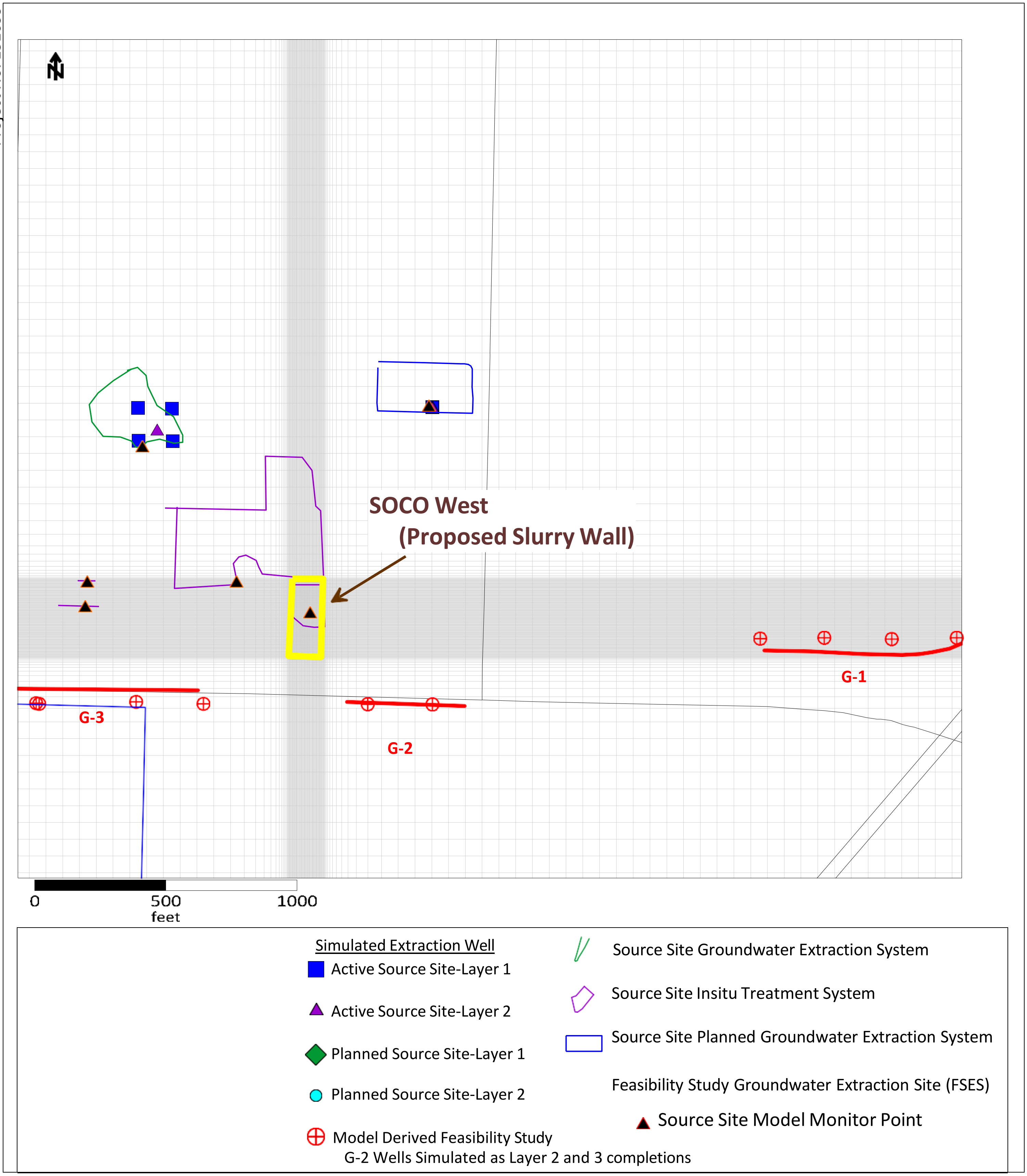
Minimum cell size is 2 ft x 2 ft

Figure 2. Revised Model Grid In the Study Area, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

SBGPP_ModelDomain_grid.srf (04/12/21)

Project No. 151099



SBGPP_SourceSiteLocations.srf (06/11/21)

Minimum cell size is 2 ft x 2 ft

Engineering Analytics, Inc.

Figure 3. Revised GriddingNear SOCO West Site, SBGPP Model

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South Basin Groundwater Protection Project

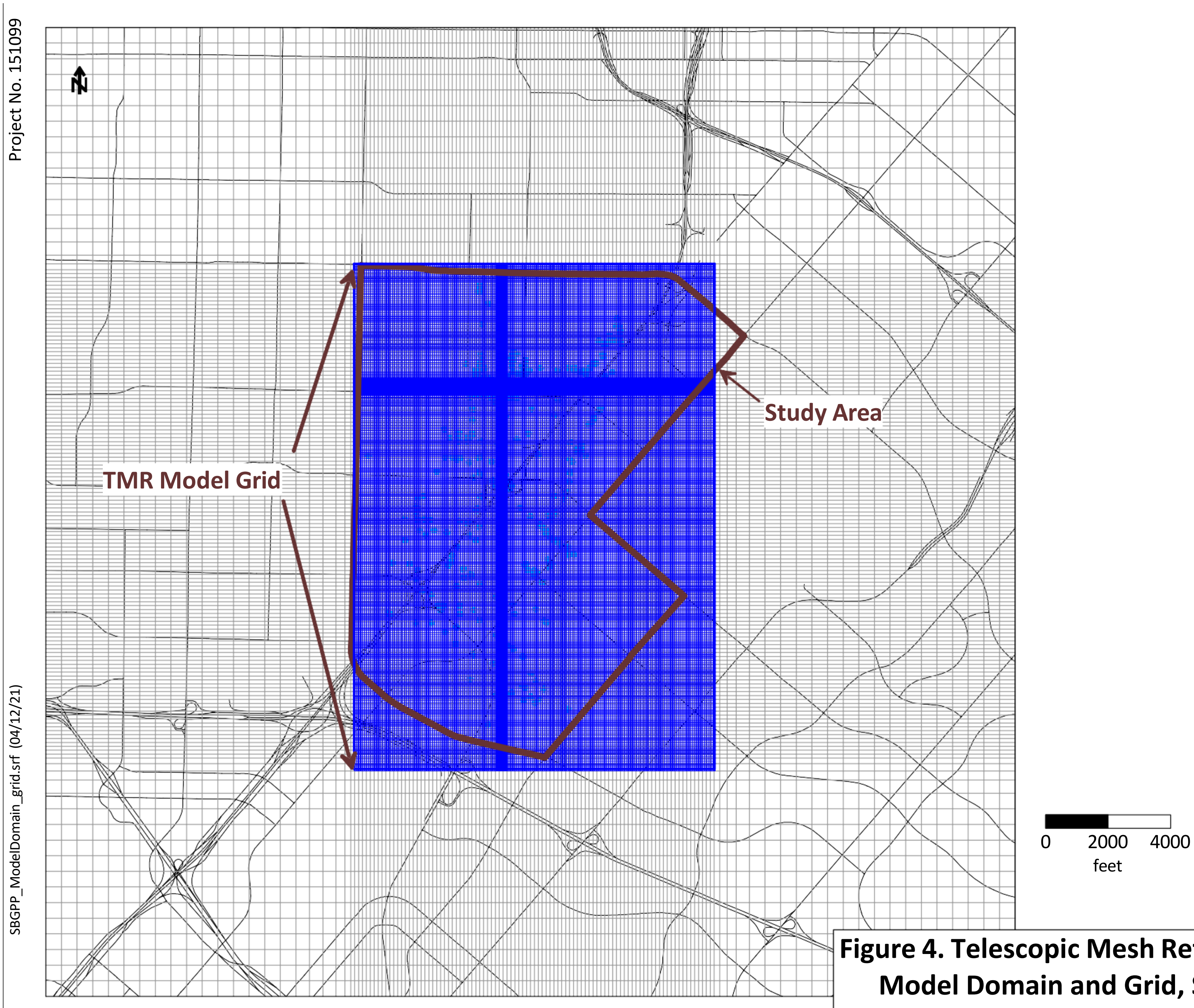

Figure 4. Telescopic Mesh Refinement (TMR) Model Domain and Grid, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

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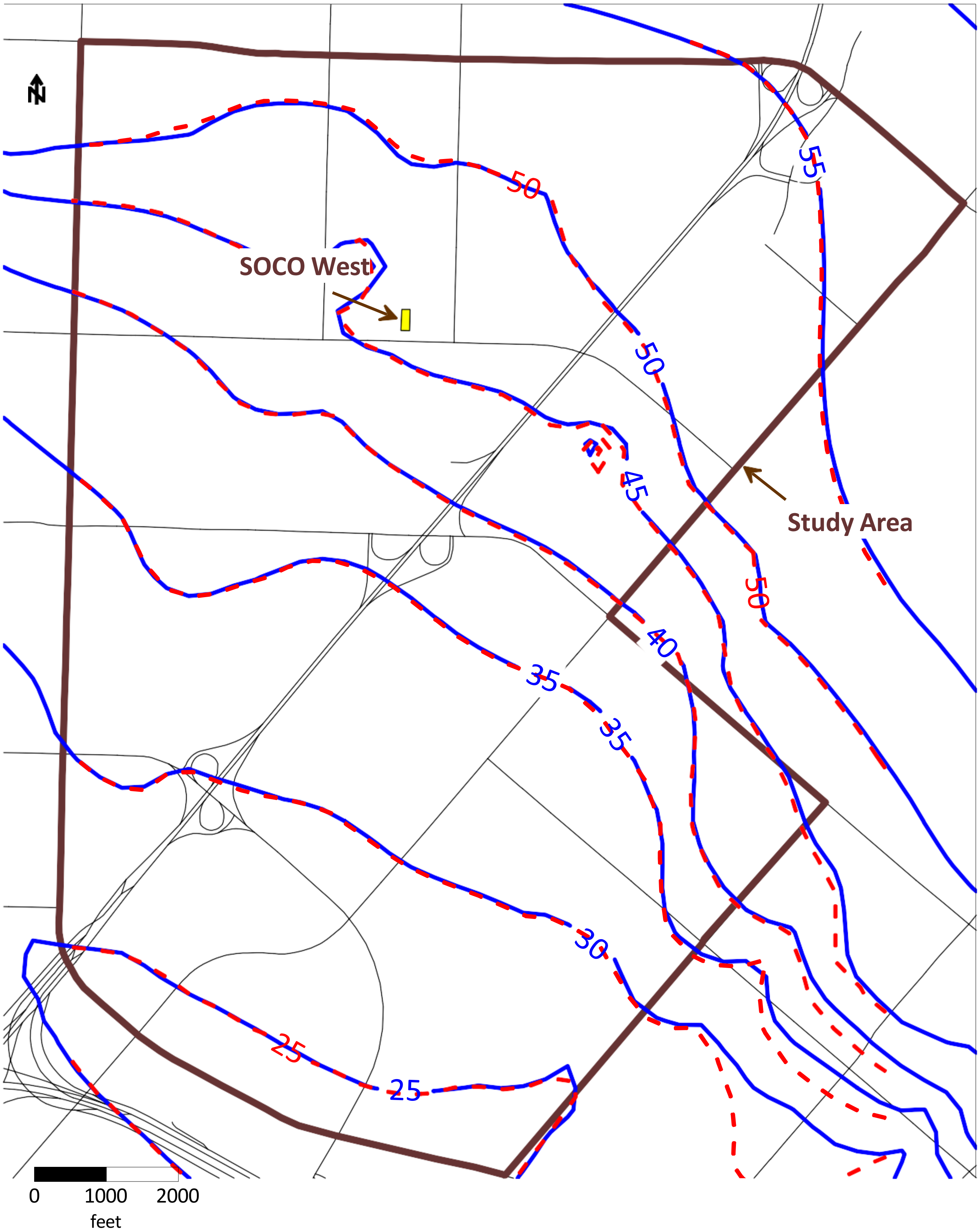

SBGPP_TMRModelDomain_grid.srf (08/30/22)

Figure 5a. Comparison of Layer 1 Potentiometric Surface Baseline Simulation for Original and Telescopic Mesh Refinement Grid SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

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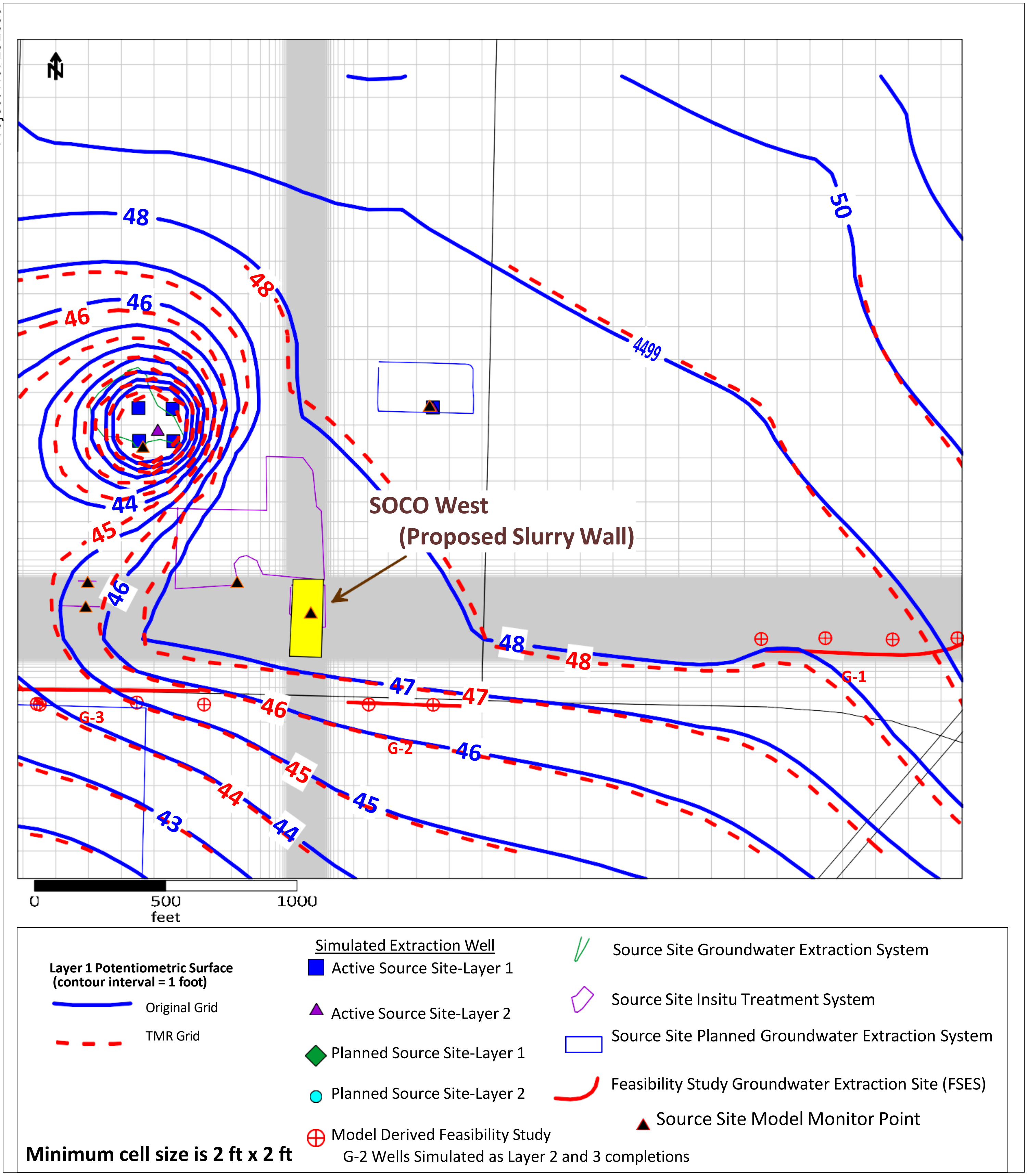

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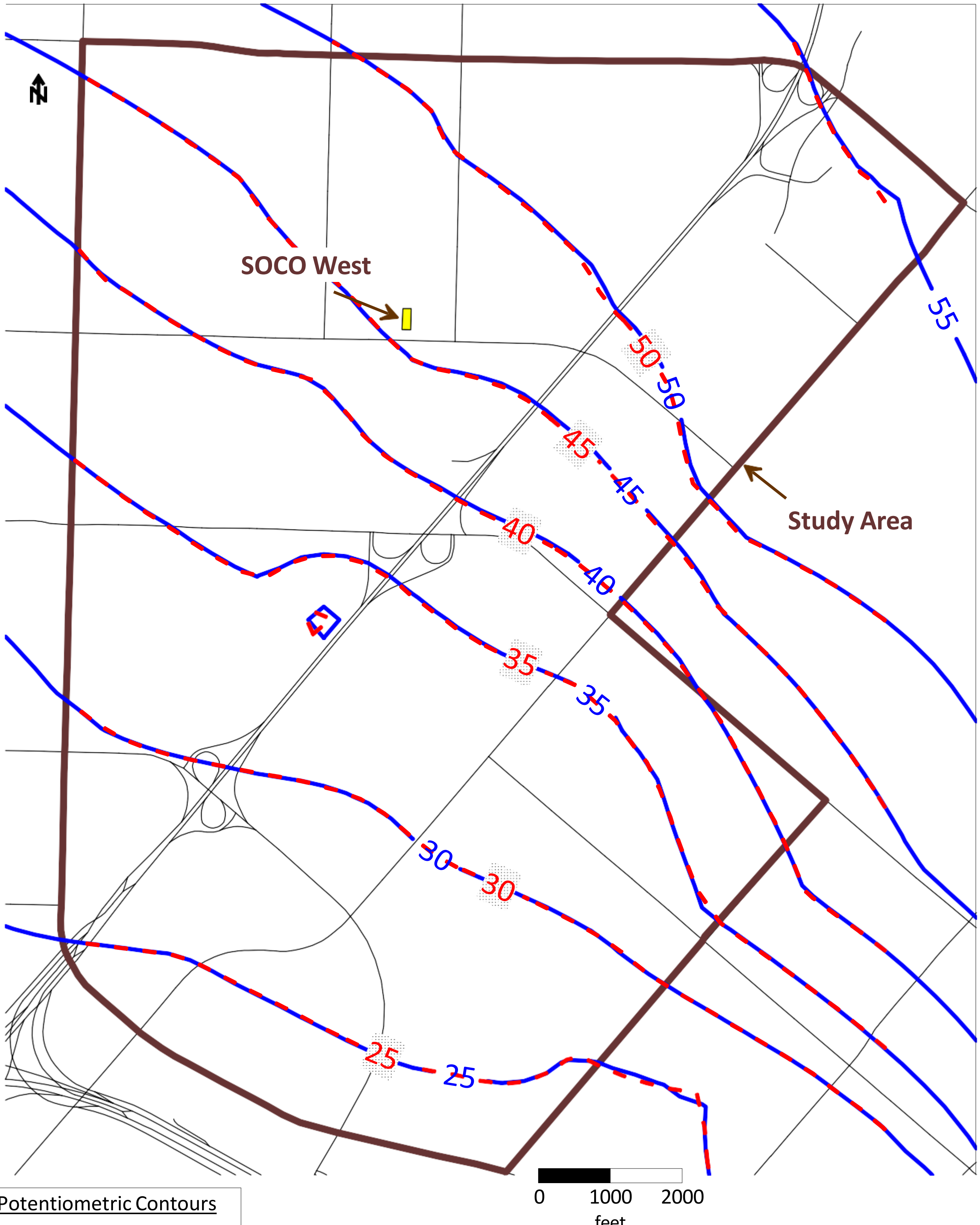
Figure 5b. Comparison of Layer 1 Potentiometric Surface Baseline Simulation for Original and Telescopic Mesh Refinement Grid, Near SOCOWest Site, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



Potentiometric Contours

Original SBGPP Model

TMR SBGPP Model_

SBGPP_ModelDomain_grid.srf (04/12/21)

Engineering Analytics, Inc.

Figure 6a. Comparison of Layer 2 Potentiometric Surface Baseline Simulation for Original and Telescopic Mesh Refinement Grid, SBGPP Model

ORANGE COUNTY WATER DISTRICT

South Basin Groundwater Protection Project

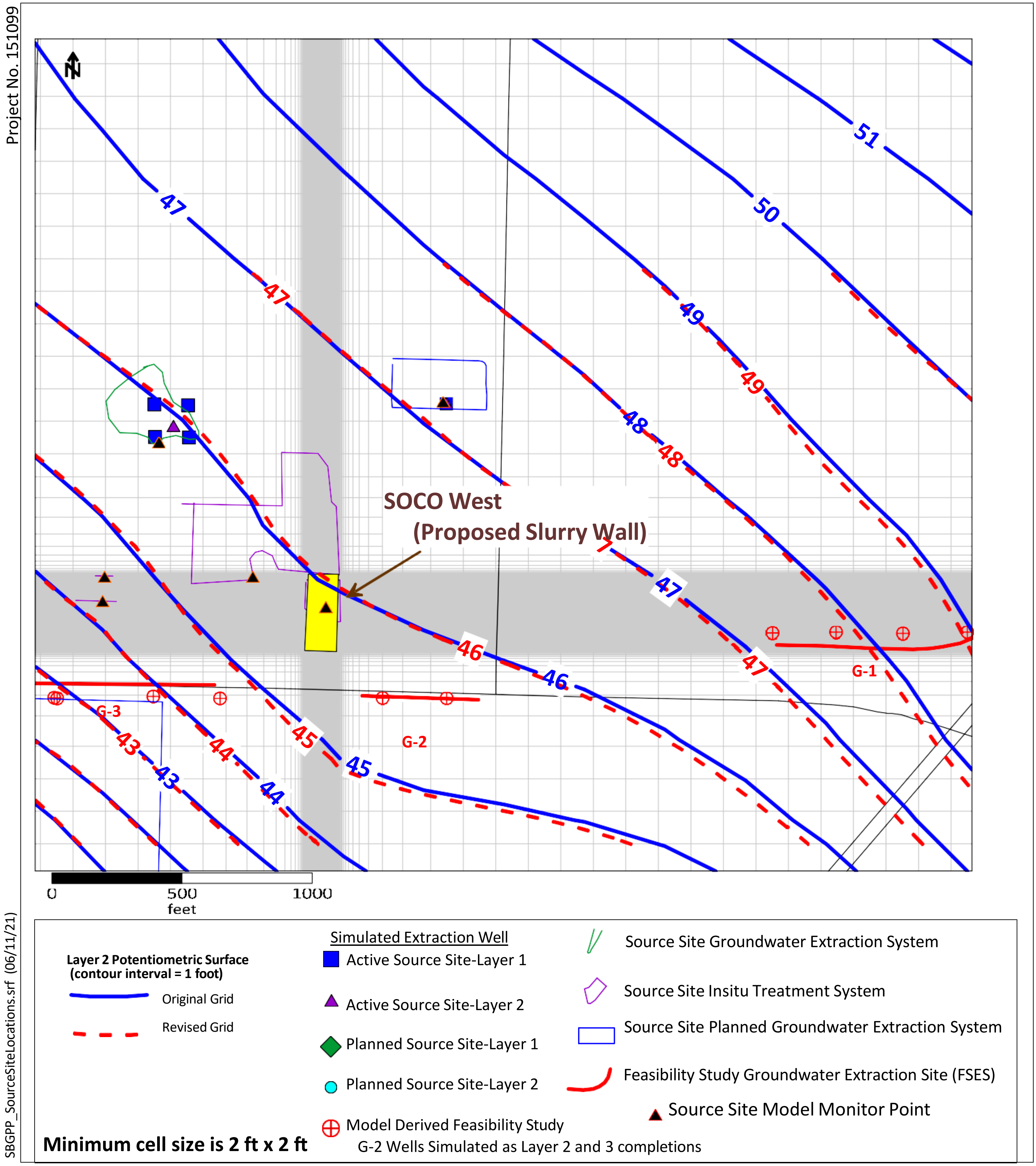


Figure 6b. Comparison of Layer 2 Potentiometric Surface Baseline Simulation for Original and Telescopic Mesh Refinement Near SOCO West Site, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

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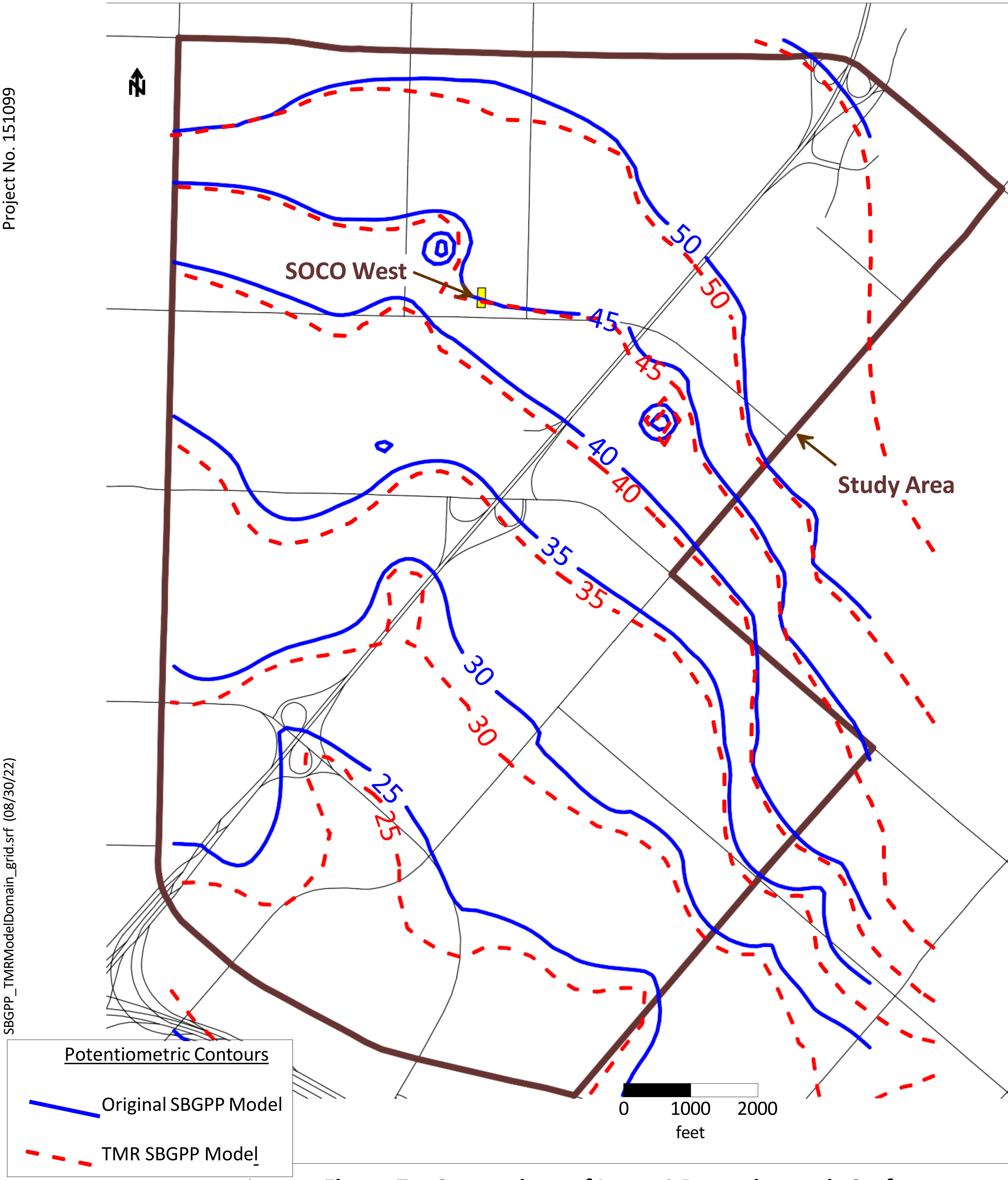
Project No. 151099



SBGPP_TMRModelDomain_grid.srf (08/30/22)

Figure 7a. Comparison of Layer 1 Potentiometric Surface
OU2 FS Simulation for Original and Telescopic Mesh Refinement Grid
SBGPP Model

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South Basin Groundwater Protection Project

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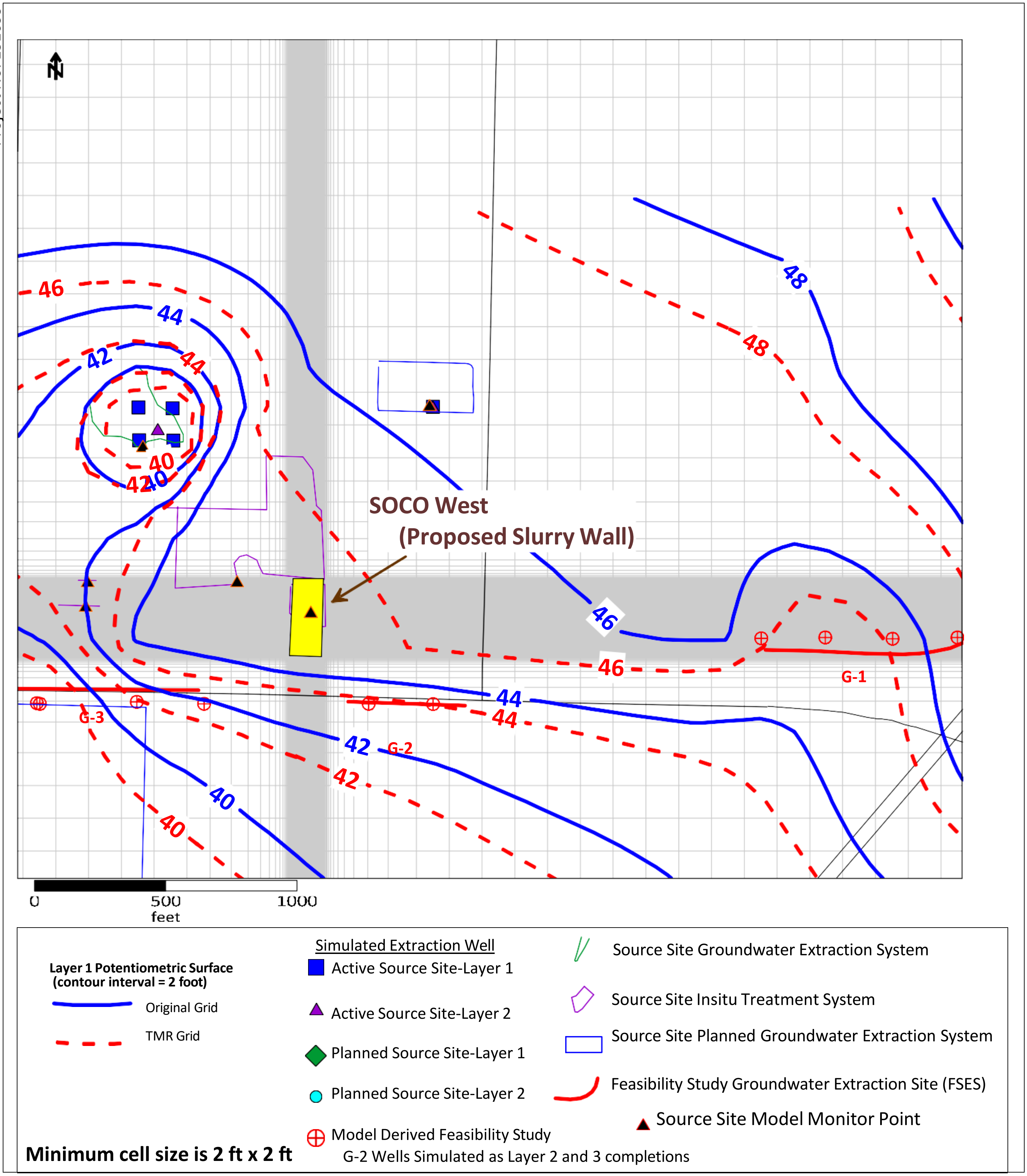

Project No. 151099

SBGPP_SourceSiteLocations.srf (06/11/21)

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Figure 7b. Comparison of Layer 1 Potentiometric Surface OU2 FS Simulation for Original and Telescopic Mesh Refinement Grid, Near SOCOWest Site, SBGPP Model

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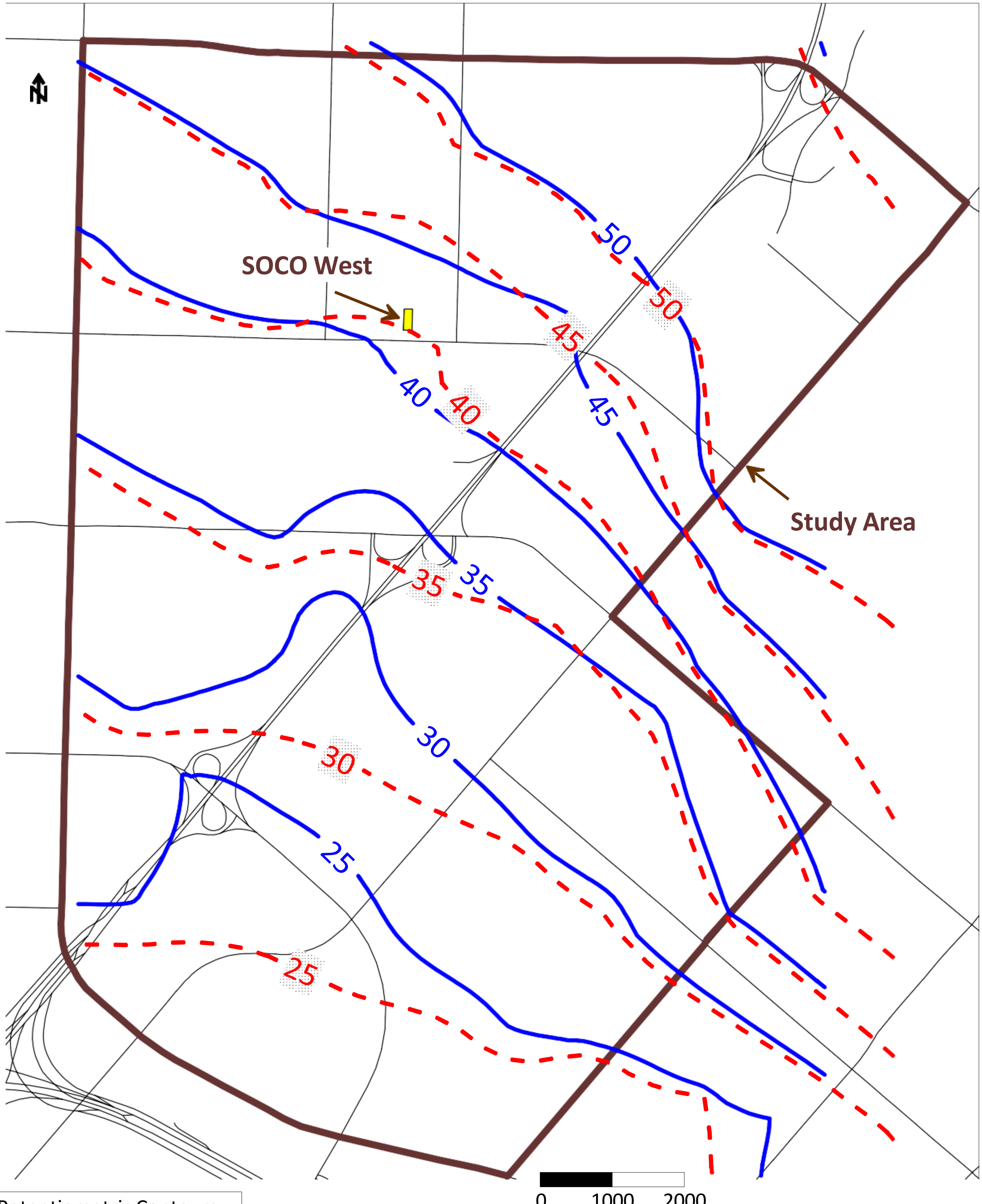
South Basin Groundwater Protection Project

Project No. 151099



Potentiometric Contours

Original SBGPP Model

TMR SBGPP Model

Engineering Analytics, Inc.

Figure 8a. Comparison of Layer 2 Potentiometric Surface OU2 FS Simulation for Original and Telescopic Mesh Refinement Grid, SBGPP Model

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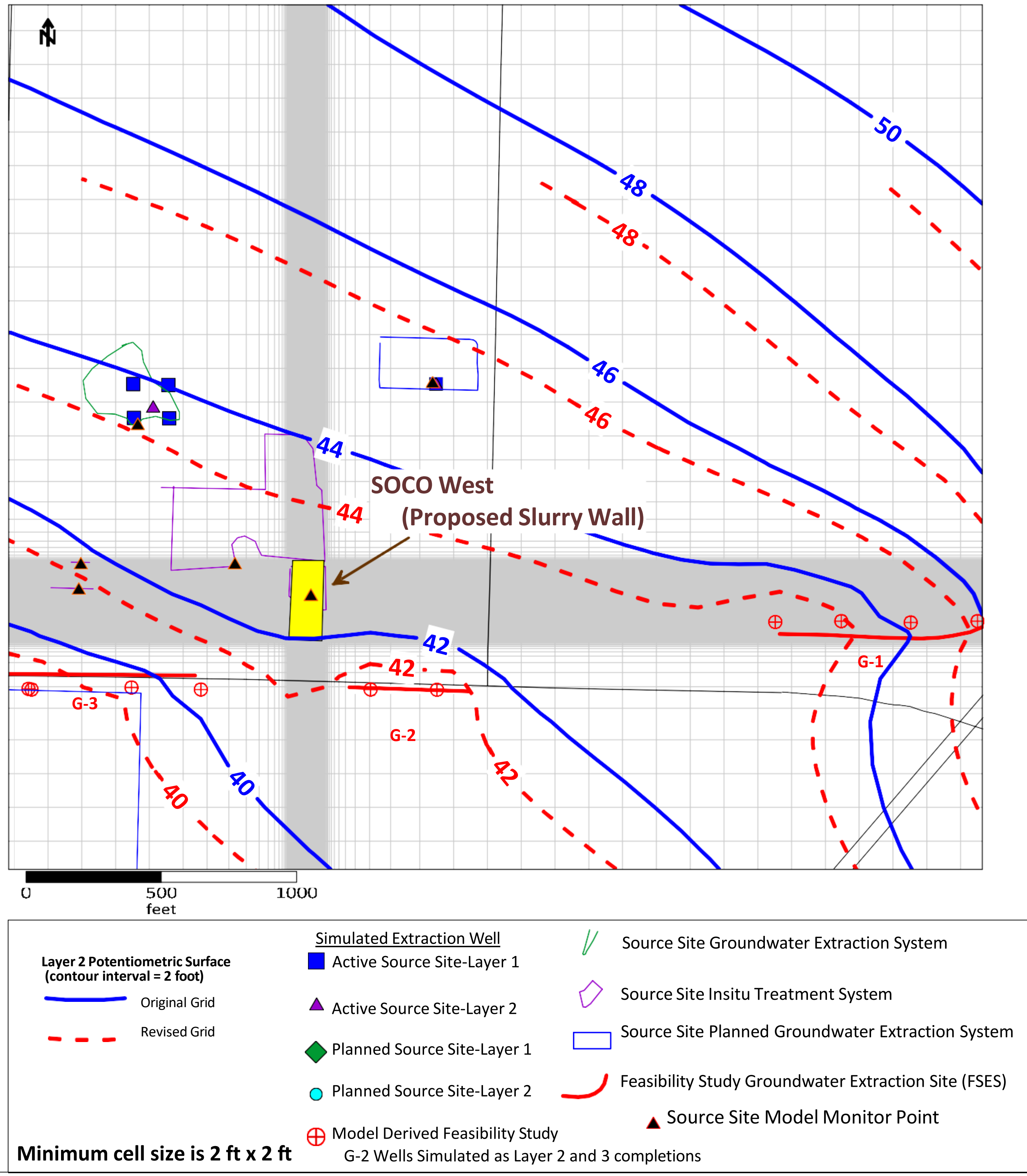
South Basin Groundwater Protection Project

SBGPP_ModelDomain_grid.srf (04/12/21)

Project No. 151099



SBGPP_SourceSiteLocations.srf (06/11/21)

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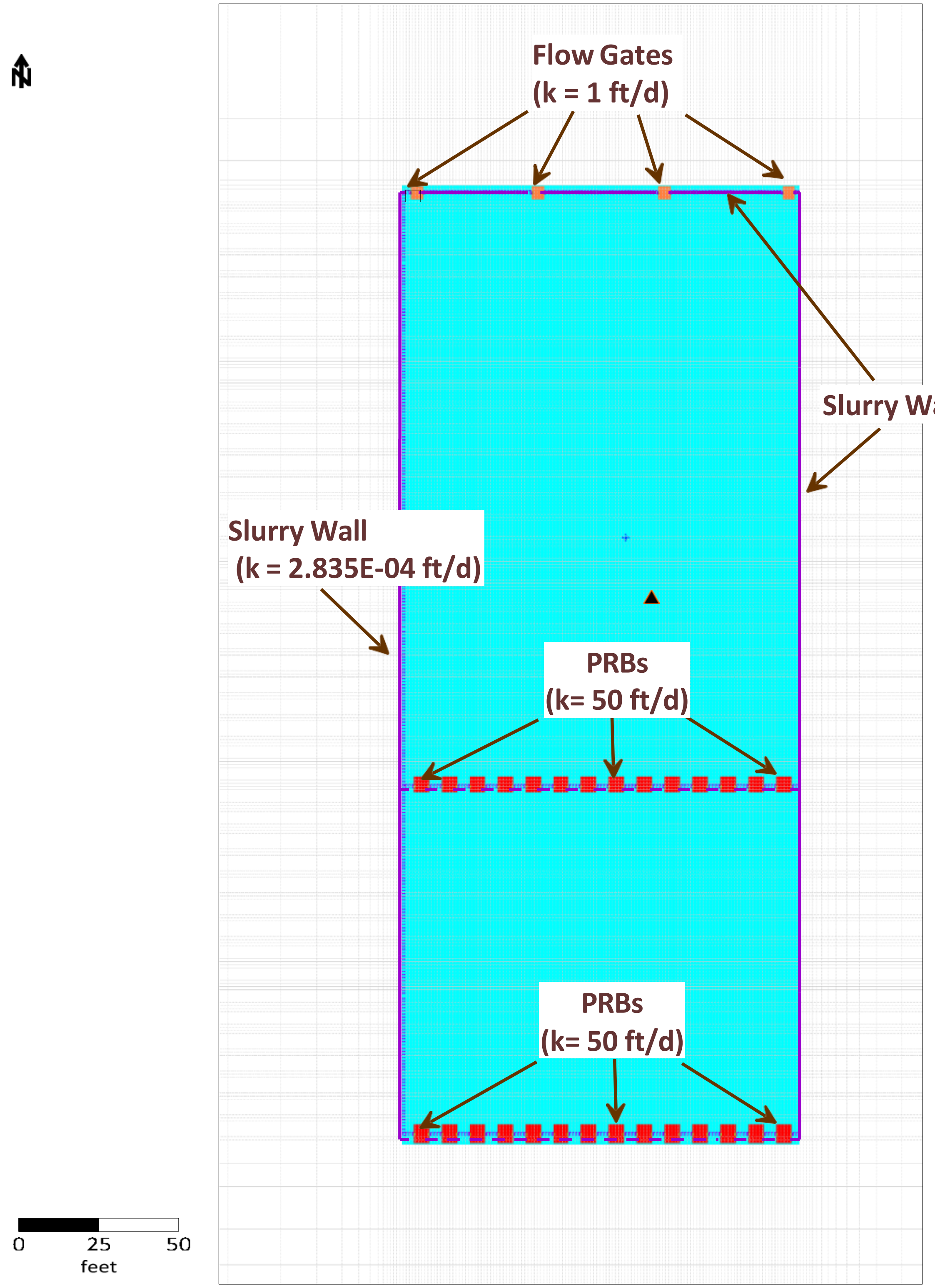
Figure 8b. Comparison of Layer 2 Potentiometric Surface OU2 FS Simulation for Original and Telescopic Mesh Refinement Grid, Near SOCO West Site, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



Each Flow Gate unit is 4 feet x 4 feet with slurry wall between units
Each PRB unit is 4 feet x 4 feet with slurry wall between unit

Hydraulic conductivity (k) of the aquifer inside of and surrounding the slurry wall is
45 ft/d for Layer 1; and
70 ft/d for Layer 2.

SBGPP_SourceSiteLocations.srf (06/11/21)

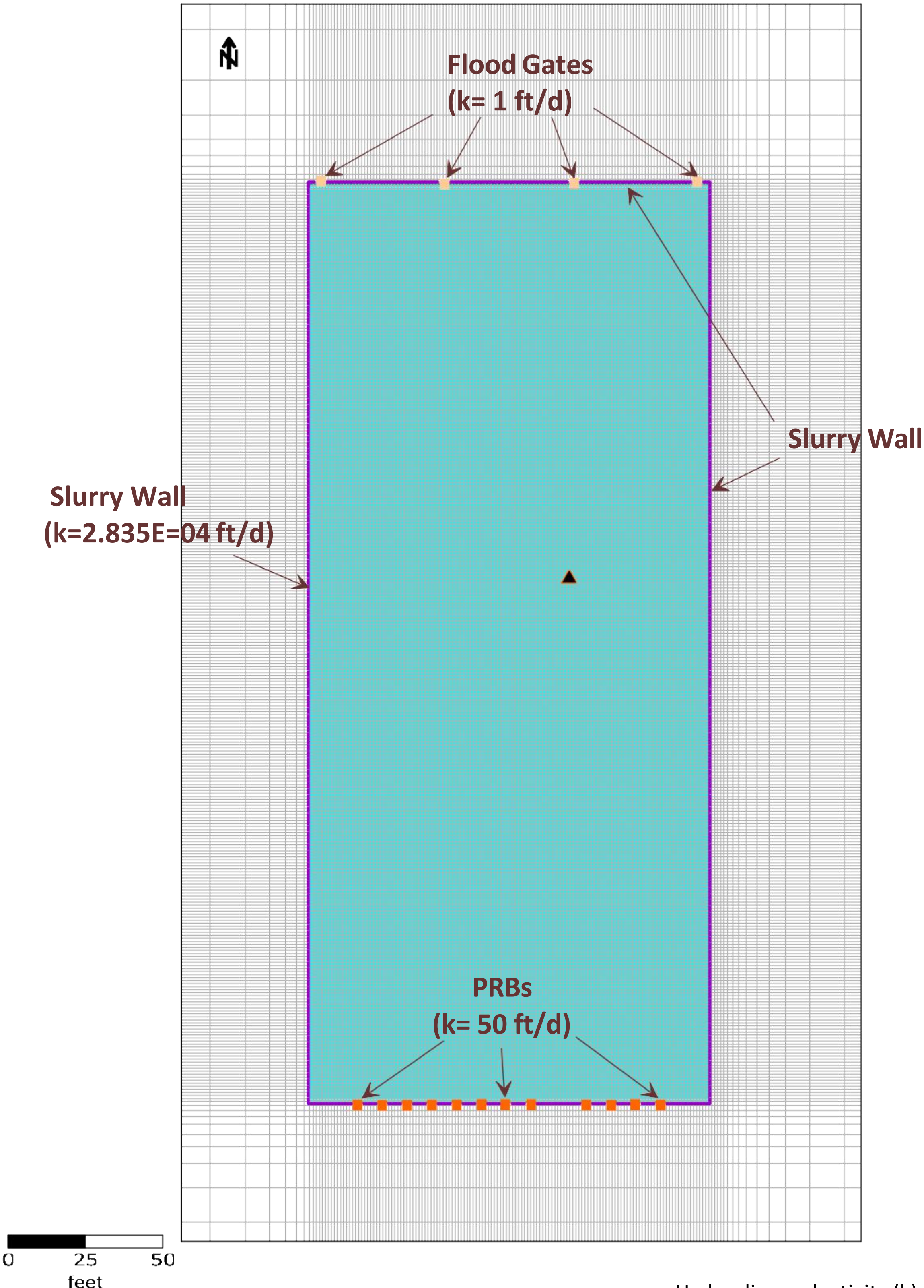
▲ Source Site Model Monitor Point
Minimum cell size is 2 ft x 2 ft

Engineering Analytics, Inc.

Figure 9a. Simulated SOCOWest Feasibility Study Slurry Wall, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



Each Flow Gate unit is 4 feet x 4 feet with slurry wall between units
Each PRB unit is 4 feet x 4 feet with slurry wal between units

Hydraulic conductivity (k) of the aquifer inside of and surrounding the slurry wall is
45 ft/d for Layer 1; and
70 ft/d for Layer 2.

SBGPP_SourceSiteLocations.srf (06/11/21)

▲ Source Site Model Monitor Point

Minimum cell size is 2 ft x ft

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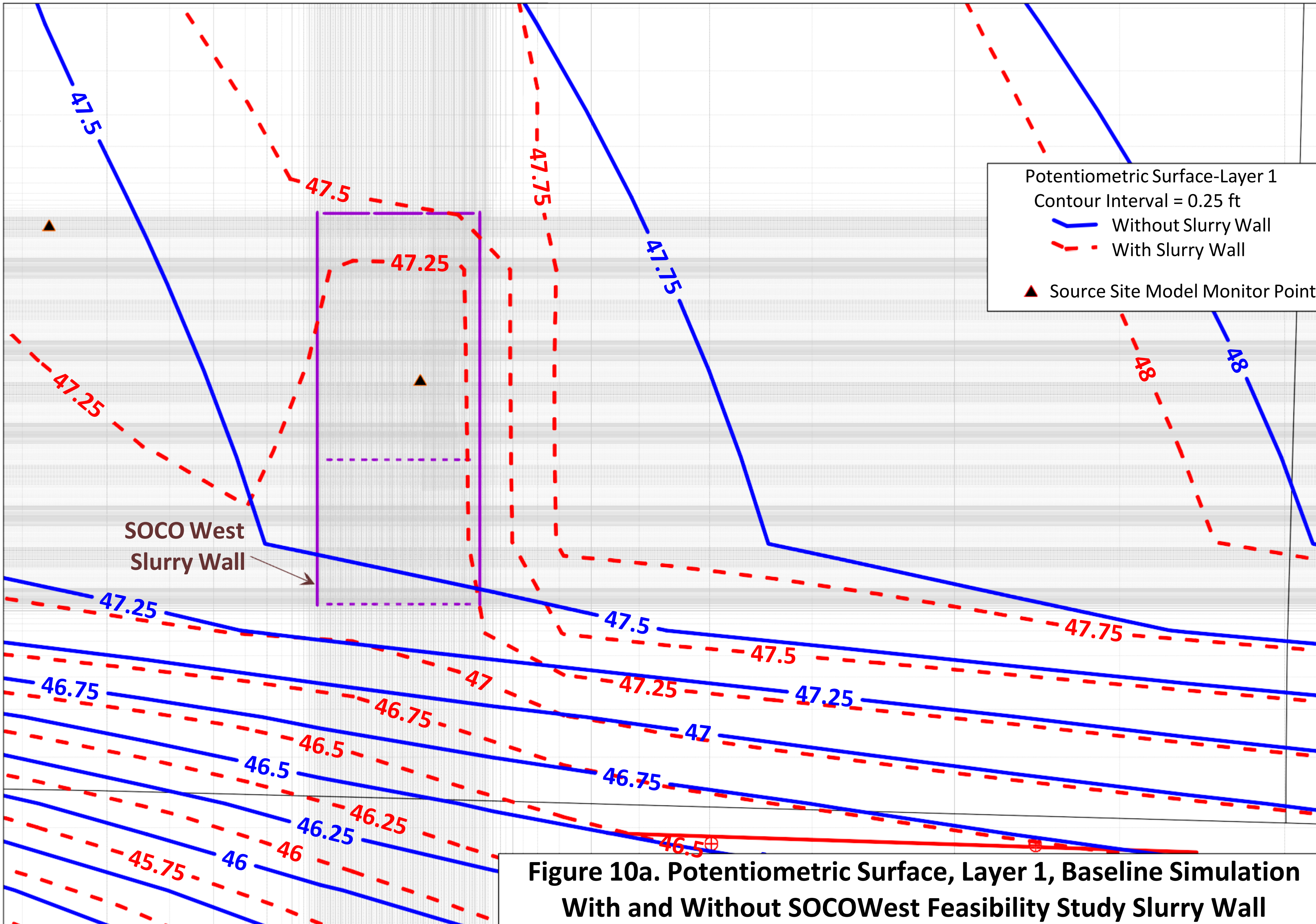
Figure 9b. Simulated SOCO West Remedial Design Slurry Wall, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project



Engineering Analytics, Inc.

0 25 50
feet

Figure 10a. Potentiometric Surface, Layer 1, Baseline Simulation With and Without SOCOWest Feasibility Study Slurry Wall Telescopic Mesh Refinement Grid, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

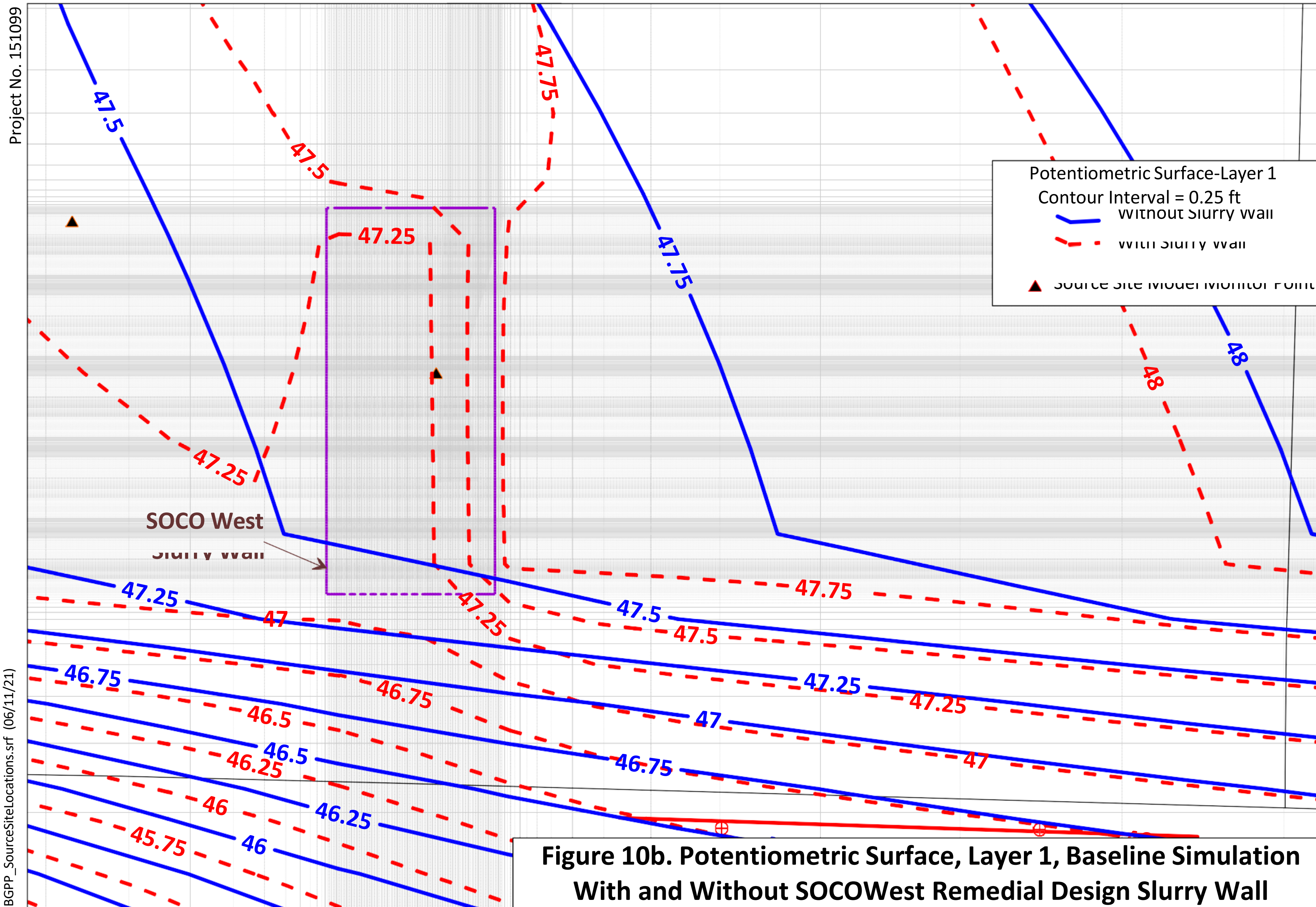


Figure 10b. Potentiometric Surface, Layer 1, Baseline Simulation With and Without SOCOWest Remedial Design Slurry Wall Telescopic Mesh Refinement Grid, SBGPP Model

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ORANGE COUNTY WATER DISTRICT

South Basin Groundwater Protection Project

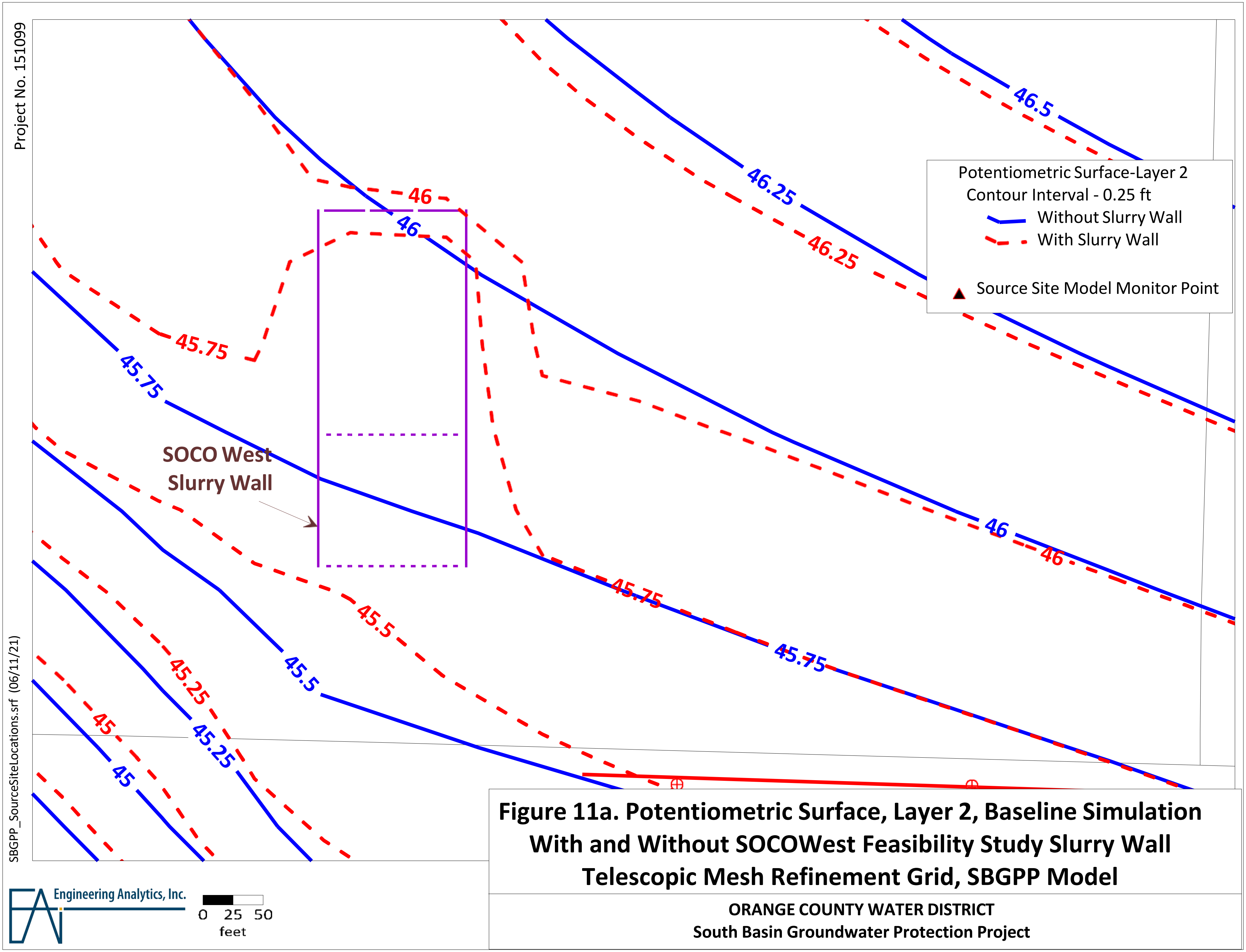

Figure 11a. Potentiometric Surface, Layer 2, Baseline Simulation With and Without SOCOWest Feasibility Study Slurry Wall Telescopic Mesh Refinement Grid, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

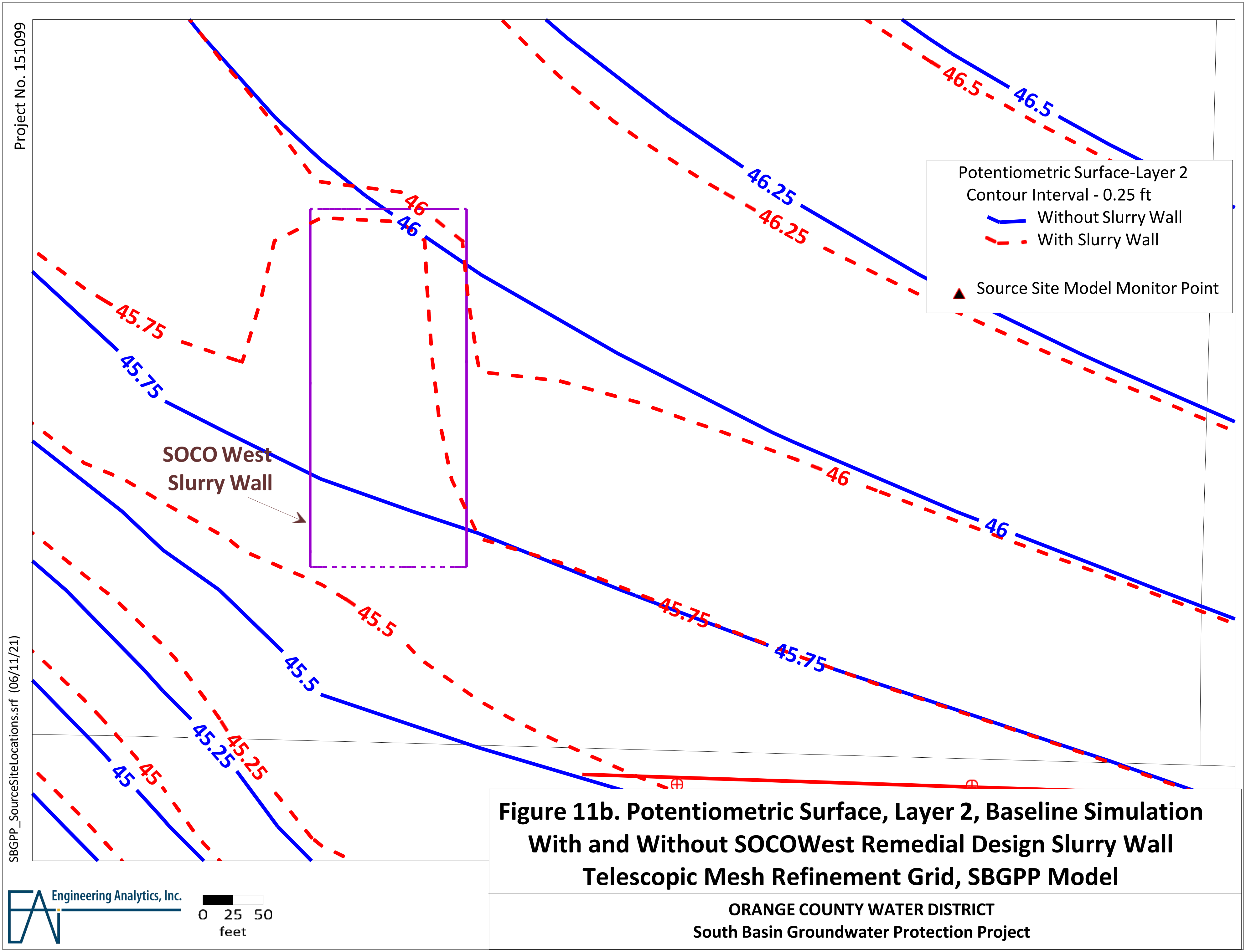

Figure 11b. Potentiometric Surface, Layer 2, Baseline Simulation With and Without SOCOWest Remedial Design Slurry Wall Telescopic Mesh Refinement Grid, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

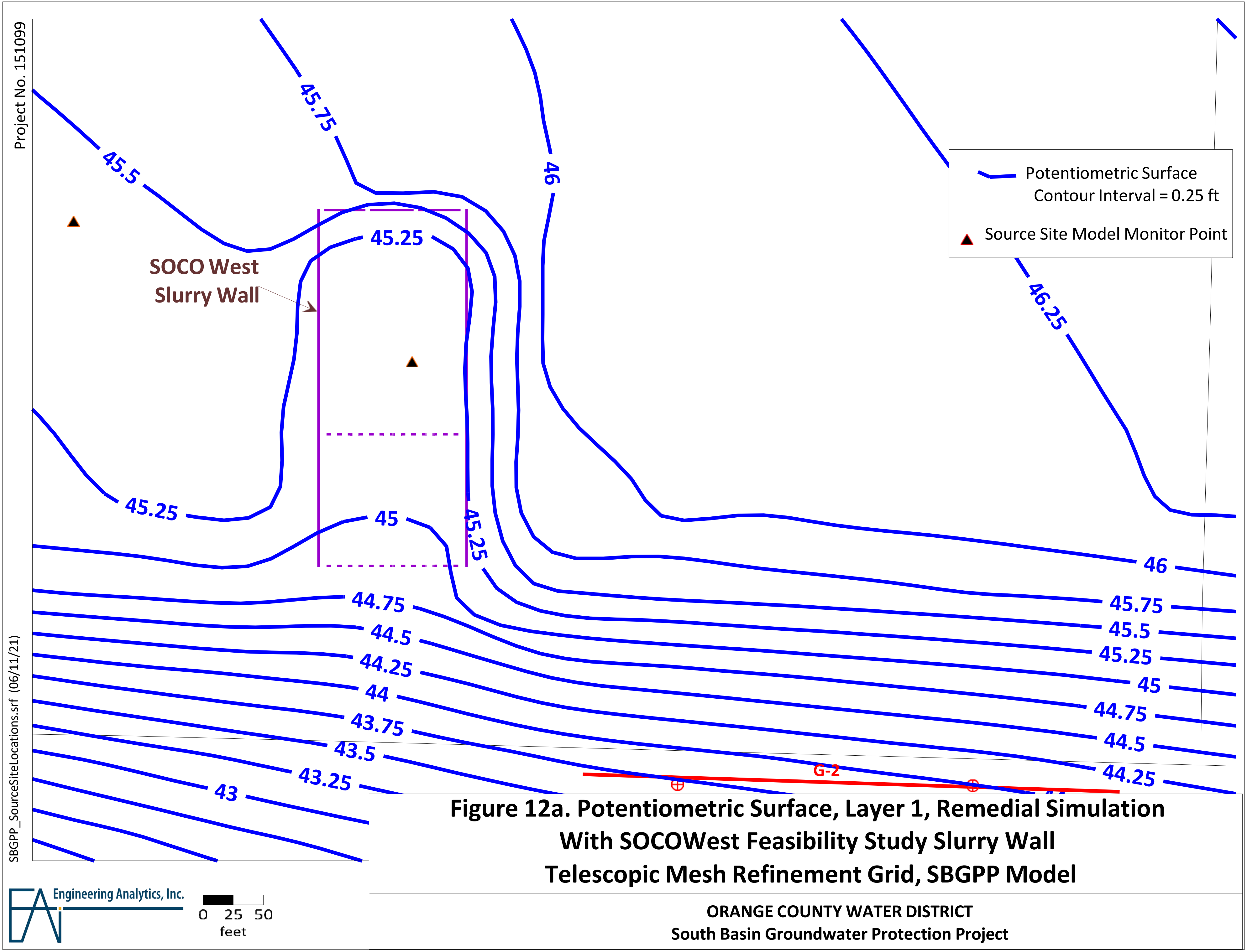

Figure 12a. Potentiometric Surface, Layer 1, Remedial Simulation With SOCOWest Feasibility Study Slurry Wall Telescopic Mesh Refinement Grid, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

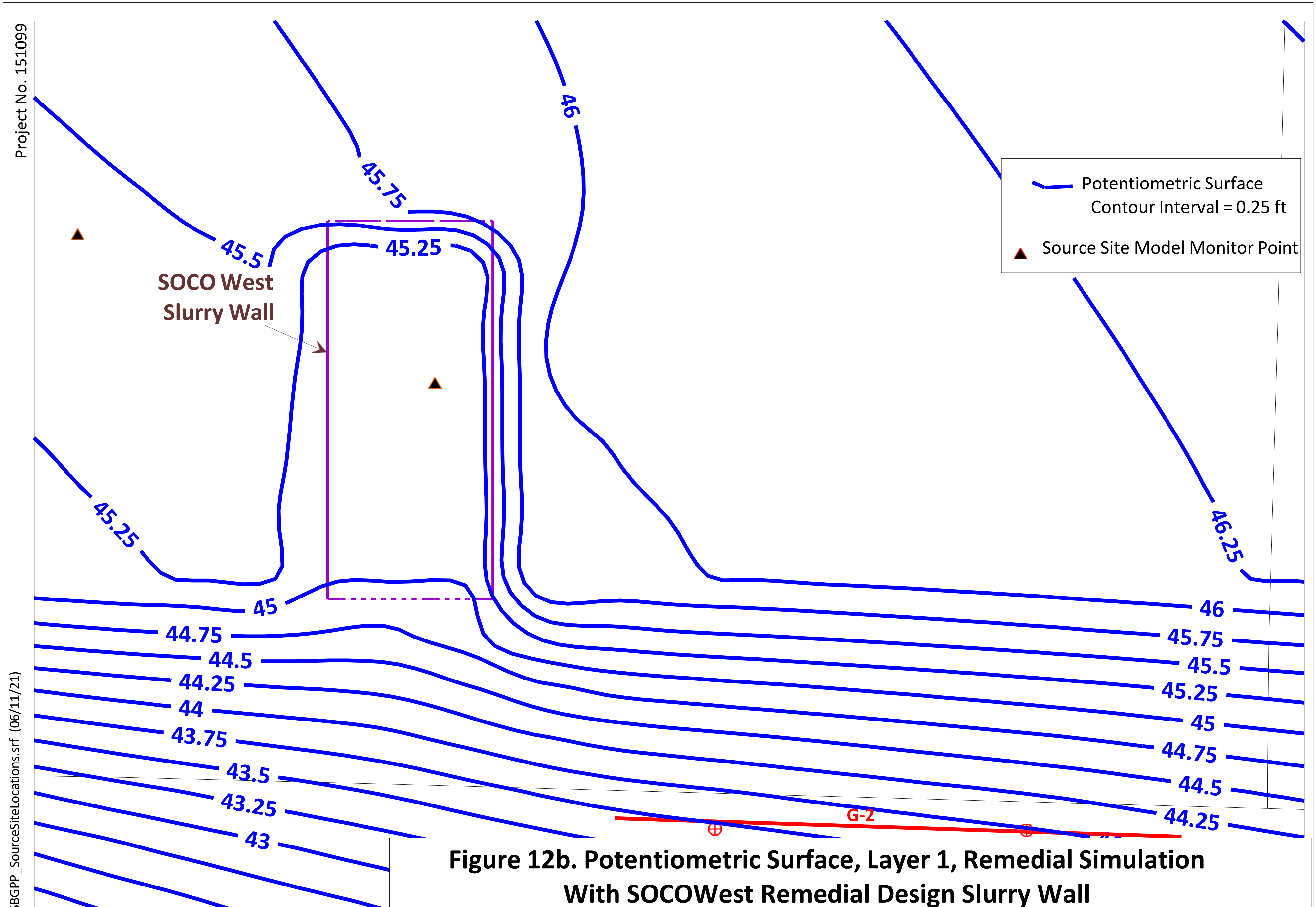

Figure 12b. Potentiometric Surface, Layer 1, Remedial Simulation With SOCOWest Remedial Design Slurry Wall Telescopic Mesh Refinement Grid, SBGPP Model

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South Basin Groundwater Protection Project

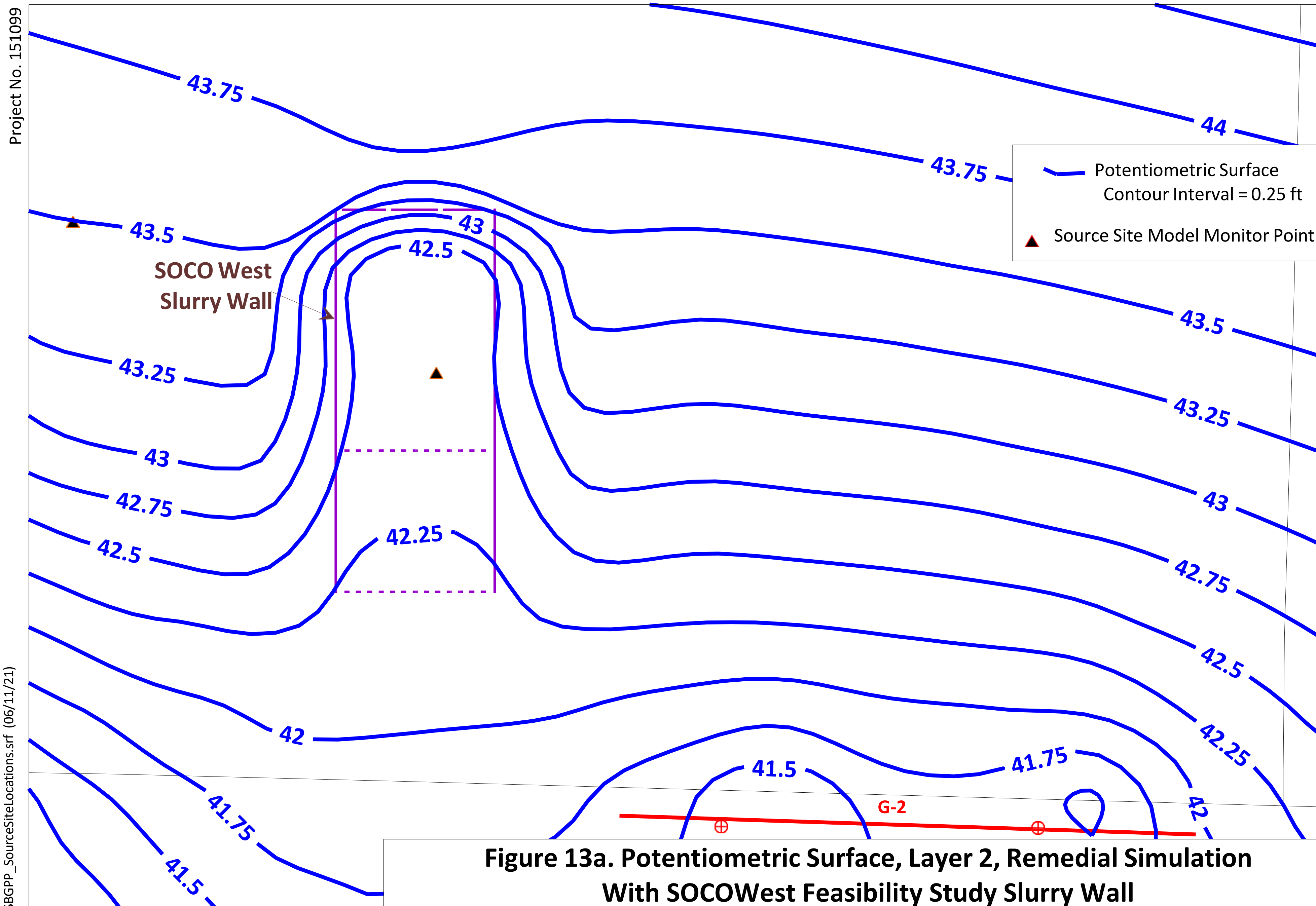


Figure 13a. Potentiometric Surface, Layer 2, Remedial Simulation With SOCOWest Feasibility Study Slurry Wall Telescopic Mesh Refinement Grid, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

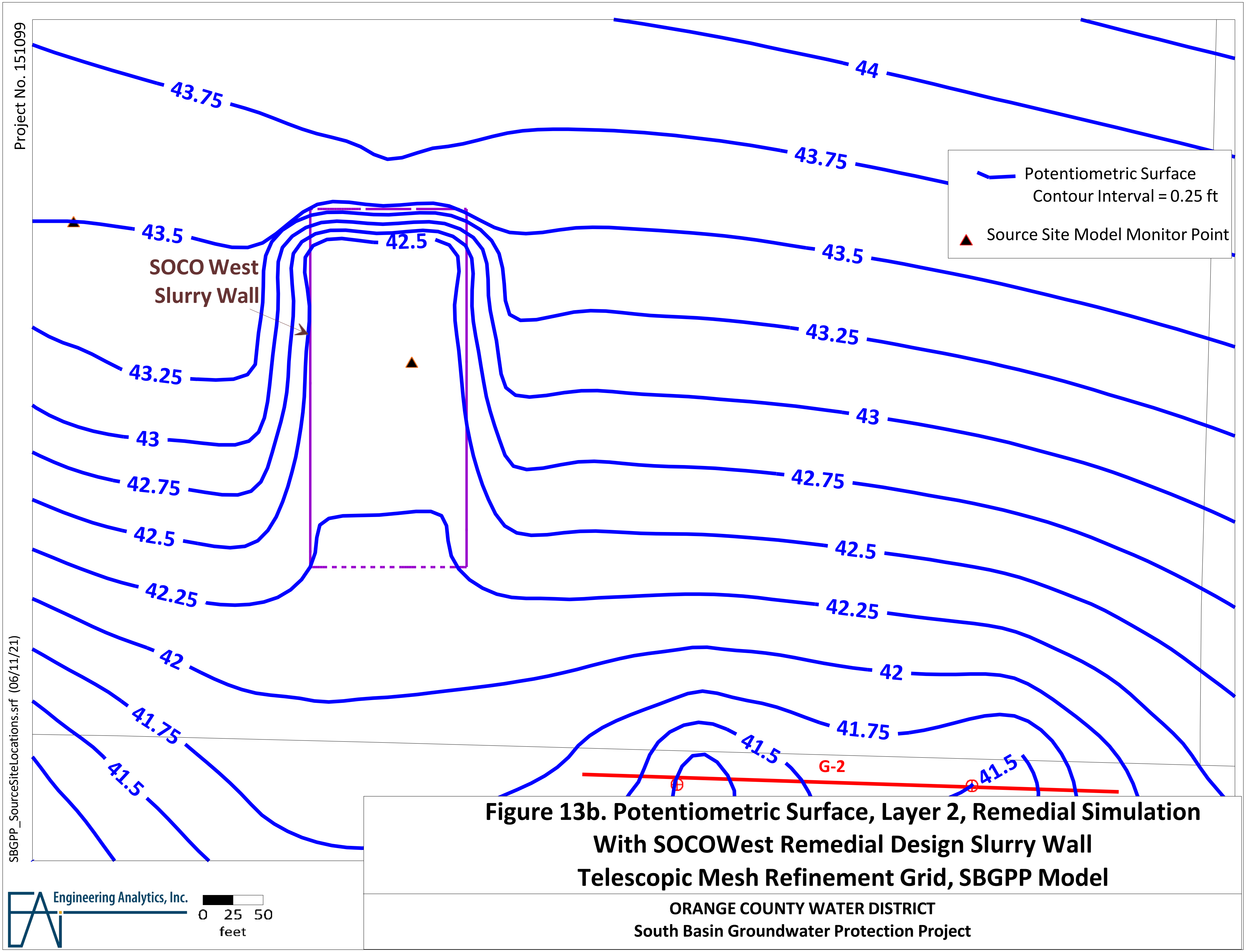


Figure 13b. Potentiometric Surface, Layer 2, Remedial Simulation With SOCOWest Remedial Design Slurry Wall Telescopic Mesh Refinement Grid, SBGPP Model

ORANGE COUNTY WATER DISTRICT

South Basin Groundwater Protection Project

Project No. 151099

SBGPP_SourceSiteLocations.srf (06/11/21)

Engineering Analytics, Inc.

0 25 50
feet

Figure 14a. Hydraulic Gradient Comparison, SOCOWest Feasibility Study Slurry Wall, Layer 1 with and without FSES Telescopic Mesh Refinement Grid, SBGPP Model

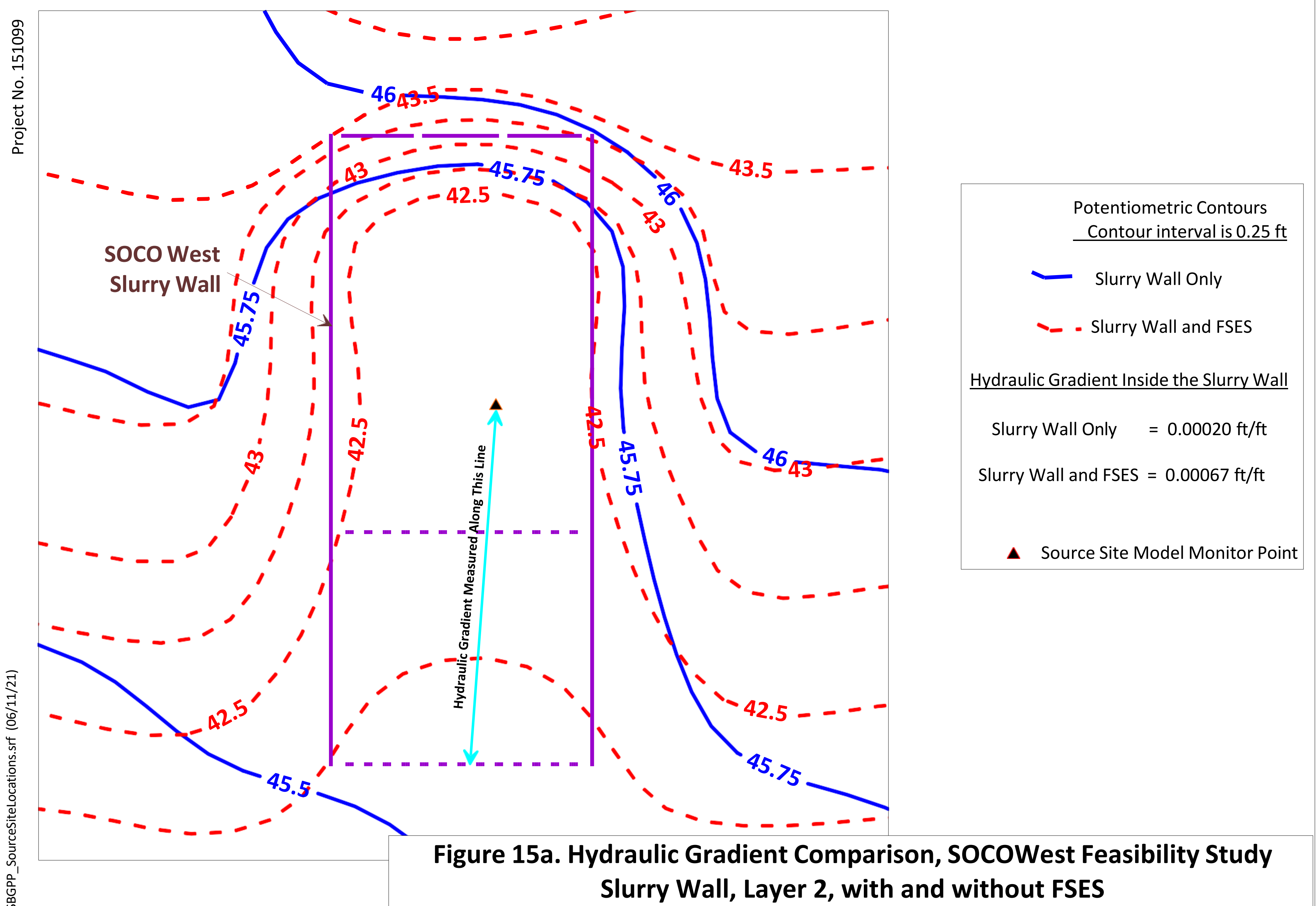
ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Engineering Analytics, Inc.

0 25 50
feet

Figure 14b. Hydraulic Gradient Comparison, SOCOWest Remedial Design Slurry Wall, Layer 1 with and without FSES Telescopic Mesh Refinement Grid, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

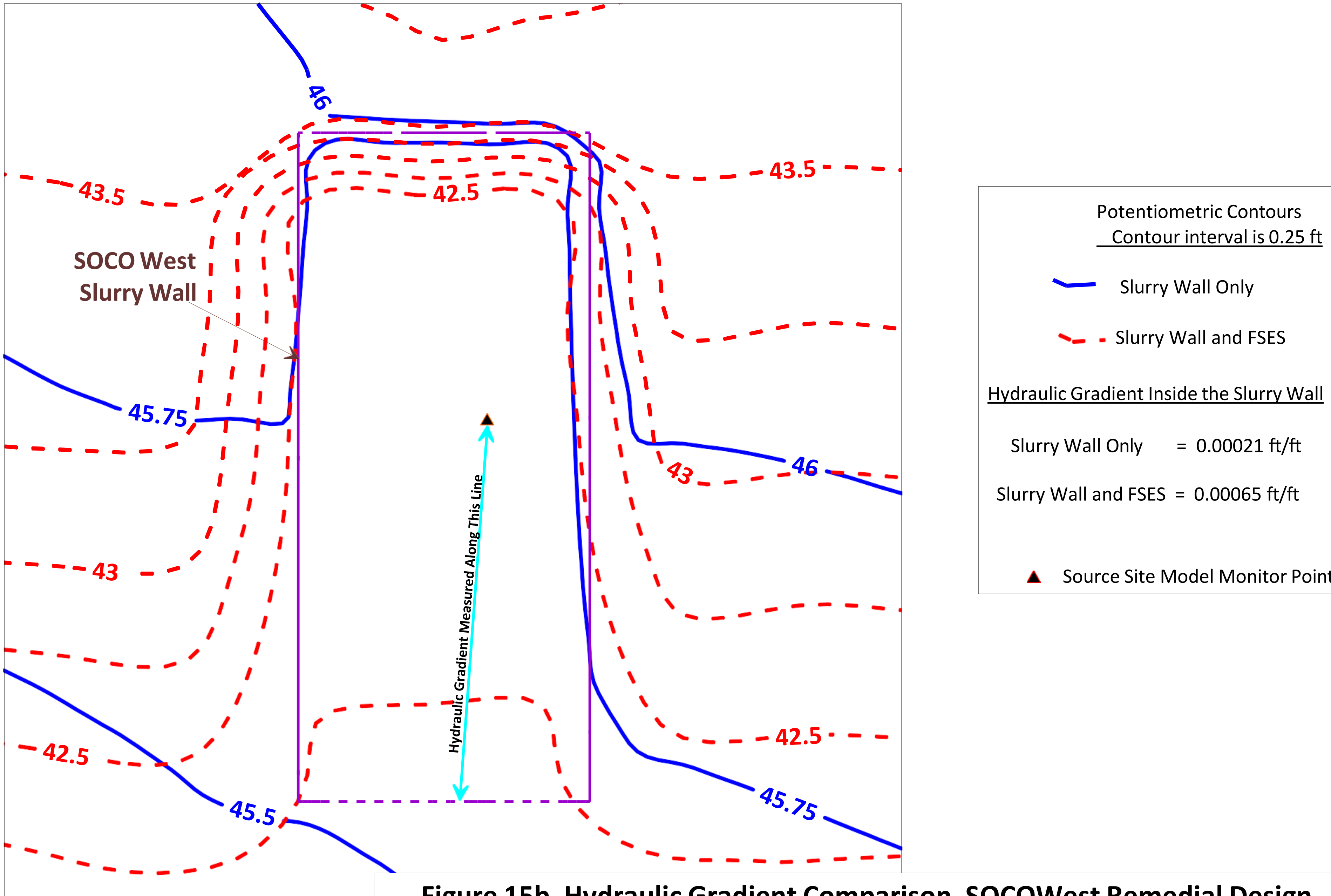


Engineering Analytics, Inc.

Figure 15a. Hydraulic Gradient Comparison, SOCOWest Feasibility Study Slurry Wall, Layer 2, with and without FSES Telescopic Mesh Refinement Grid, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

Project No. 151099



SBGPP_SourceSiteLocations.srf (06/11/21)

Engineering Analytics, Inc.

0 25 50
feet

Figure 15b. Hydraulic Gradient Comparison, SOCOWest Remedial Design Slurry Wall, Layer 2, with and without FSES Telescopic Mesh Refinement Grid, SBGPP Model

ORANGE COUNTY WATER DISTRICT
South Basin Groundwater Protection Project

ATTACHMENT 2
RESPONSE TO DRSS-I, LLC COMMENTS
DRAFT FEASIBILITY STUDY REPORT,
SOUTH BASIN GROUNDWATER
PROTECTION PROJECT,
OPERABLE UNIT 2

ATTACHMENT 2
RESPONSE TO
DRSS-I, LCC COMMENTS,
DRAFT FEASIBILITY STUDY REPORT, SOUTH BASIN GROUNDWATER PROTECTION PROJECT, OPERABLE UNIT 2

This response to comments document has been prepared by Engineering Analytics, Inc. (EA) on behalf of the Orange County Water District (OCWD) in support of the South Basin Groundwater Protection Project (SBGPP).

This attachment is in response to Newmeyer Dillon's July 5, 2022 comments (Subject Comment Document) regarding the April 5, 2022 SBGPP OU2 Feasibility Study report (Draft OU2 FS Report) prepared by EA. Newmeyer Dillon provided these comments on behalf of the Stakeholder Advisory Group (SAG) member DRSS-I, LCC (DRSS).

ORGANIZATION

Comments in the Subject Comment Document were divided into selected categories developed by the author. These categories included comment topics, some of which were repeated between the selected categories. Given the number of comment topics within the individual selected categories. This Attachment organizes the responses to comment topics as follows:

- The text from the Subject Comment Document is presented under the "Comment" subsection. Each "Comment" heading incorporates the major section information (Subject Comment Document Comment ID, e.g 1,2,3, etc) and the sequence of the respective comment within the major section (1 to n). For example, the resultant "Comment" identifier for the second major section (eg Subject Comment Document comment 2) and the third comment topic would be "Comment 2-03".
- A response is presented to each comment immediately following the "Comment" subsection; and
- A statement as to whether the draft FS is being revised with respect to the subject comment.

RESPONSE TO COMMENTS

Comment 0-01:

"Given Judge Claster's "Gateway Issues" ruling last Tuesday in the South Basin trial finding that OCWD failed to comply with the public participation aspects of the National Contingency Plan (NCP) for nearly 11 years when it had a duty to do so, DRSS hopes that OCWD remains receptive to the below comments. The District must now finally realize that the NCP requires "meaningful

> *public participation" (42 U.S.C. § 9607(a)(4)(B) and Carson Harbor Village v. County of Los Angeles, 433 F.3d 1260, 1265-66 (9th Cir. 2006)); that "the public – both PRPs and concerned citizens – have a strong interest in participating in cleanup decisions that may affect them" (NCP Preamble, 55 Fed. Reg. 46, 131); and as OCWD cross-references in its own Community Involvement Plan (CIP) for the South Basin – a proper "public participation program is not a public relations tool in the sense that public relations is 'one-way' communication" but rather is "to create a dialogue with all stakeholders to ensure that their concerns and priorities are incorporated into each project." We hope there will not be a repeat of how OCWD handled comments to the draft Remedial Investigation (RI) Report. OCWD received extensive comments. Yet, while OCWD acknowledged such, it did not change a word in the Final RI Report in response."*

Response to 0-01:

OCWD prepared detailed responses to the comments received regarding the Supplemental Remedial Investigation (SRI) Report. As indicated in the responses to SRI comments, revisions to the SRI Report were not warranted. Both the response to comments (RTCs) and determination that no revisions were required were reviewed and accepted by the Technical Advisory Committee (TAC). OCWD will continue the community involvement program, obtain comments from stakeholders, provide continued opportunities for the public to be involved and will provide responses to the comments and update public participation documents to the extent necessary.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 1-01:

> *"<u>Labeling Error/Omission Regarding DRSS's Second Treatment Area</u>. The Draft FS credits only one of two current and future in-situ treatment zones associated with the 2040 Site. Specifically, while Draft FS Figures 2-2, 2-3, 2-4, and 2-5, and Draft Figure 2.1 from the Numerical GW Flow Model Part II – Remedial Simulations & Engineering Analytics (April 1, 2022) properly identify the GE Plastics perchlorate bio-barriers (see below example from Draft FS Figure 2.2), they fail to include the 2040 Site's on-going southern boundary injection (see orange highlights below). To be clear, while the 2040 Site has injected in various on- and off- site locations over the years, its current and future RWQCB-approved injections are in two locations – not one. This appears to be a simple oversight. DRSS asks that OCWD add a second white line to the "BFM Energy Prod" label and correct the omission for all the figures referenced above in the Final FS.*

Response to 1-01:

The figures in the Draft OU2 FS Report will be revised to include an additional leader to the referenced feature.

Revision to Draft OU2 FS Report:

The figures in the Draft OU2 FS Report will be revised.

Comment 2-01:

> *"The Alleged "Mega-Plume" is Misleading. The Draft FS continues to use the outdated, discredited, and admittedly inaccurate "mega-plume" set forth in the Draft FS's Figure ES-2 (and all other figures using the same depiction). This is misleading, inappropriate, and causes false impressions that underlie the FS analysis and resulting decisions. At least three points associated with the mega-plume warrant mention here."*

Response 2-01:

The DRSS comment regarding use of outdated data was responded to in the SRI Report RTCs. The following is an excerpt of the response from the SRI RTC[1] that addressed the data sufficiency.

> "*Regarding the nature and extent of COPCs, the distribution of principal COPCs in the SRI was compiled using data available as of September 2018 for plan view maps and September 2019 for cross sections. The COPC distribution maps in the SRI represent a valid interpretation of the distributions of COPCs in OU2 groundwater using data from 2018/2019.*
>
> *There is sufficient RI data for use in preparing a FS*."

The above response included an introductory statement that the RWQCB and the SWRCB have indicated that the SRI is complete and final. Thus, the existing RI data are sufficient to conduct a FS. The SRI data set was used to prepare the Draft OU2 FS Report.

Revision to Draft OU2 FS Report:

No revisions were required for the SRI Report. The SRI Report clearly stated that this data set was sufficient for the purposes of preparing the FS Report. Revisions to the Draft OU2 FS Report are not necessary.

Comment 2-02:

a. "Continued Use of Obsolete Data. As OCWD's long-time Chief Hydrogeologist Roy Herndon admitted under oath in the recent South Basin trial: "If the remediation caused a reduction in concentrations subsequent to the time that this map was prepared, then it would not take that into account." (Rough Trial Transcript (RTT) 1927:7-12, emphasis added)."

[1] Comment excerpted from response to Consortium General Comment FF. DRSS was one of the members of the consortium.

Response 2-02:

As indicated in response 2-01, the SRI data set is sufficient for the FS. The Draft OU2 FS Report indicates that additional data will be collected during the pre-design investigation (PDI) to support the design of the selected alternative[2]. The groundwater data from the DRSS property that are readily available at the time of the PDI, will be used to evaluate the scope of the PDI to the extent it influences decision on the PDI scope of work for the selected remedy.

As indicated above, the Draft OU2 FS is consistent with Mr. Herndon's statement.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 2-03:

> *"The 2040 Site's remedial efforts for over 30 years have caused such reductions. As OCWD's long-time technical consultant and expert Anthony Brown summarized in response to a question by the Court during the 2040 Site segment of the South Basin trial: "What we have seen at this site is generally a dramatic reduction in concentrations at the site and immediately south of the site because of the remedial actions that have been implemented. . . . So we have seen a dramatic reduction in concentrations onsite and immediately offsite." (RRT 9039:9-9040:10, emphasis added.) It should be expressly stated in the Final FS that the mega-plume map does not take into account the admitted "dramatic reduction" resulting from the most updated remedial efforts associated with the 2040 Site."*

Response 2-03:

The Draft OU2 FS Report presents remedial alternatives to address commingled plumes within OU2. The Draft OU2 FS Report incorporates data collected at and in the vicinity of the DRSS property[3], which is based on the data and evaluations presented in the Supplemental Remedial Investigation (SRI). The Draft OU2 FS Report overview of the extent of principal compounds of potential concern[4] incorporates DRSS site data. As indicated in the DRSS comment, the area of reduction was *"at the site and immediately south of the site"*. The alternatives that are presented in the Draft OU2 FS Report are approximately 1,000 feet or more to the south of the DRSS

[2] Draft OU2 FS Section 7.2.1 states that alternatives 2 to 6 will require a pre-design investigation to support more specific design aspects of the respective alternative.
[3] Figure 1-5 of the Draft OU2 FS Report illustrates the locations of groundwater sample locations. Figures 1-6 to 1-25 of the Draft OU2 FS Report present the concentration of principal chemicals of potential concern in groundwater samples.
[4] Figure 1-27 of the Draft OU2 FS Report, which was developed as part of the Supplement Remedial Investigation Report, incorporates groundwater data collected from the DRSS site.

property (for Area 6 monitoring) and over 4,000 feet south (for groundwater extraction or in-situ chemical oxidation [ISCO]).

As indicated above, the Draft OU2 FS is consistent with Mr. Brown's statement and incorporates representative data collected from the DRSS site that was collected within the time period identified in the SRI.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 2-04:

> *b. "Perchlorate is Not Associated with the 2040 Site. Brown also testified at the South Basin trial that "there is other contaminat[ion], such as perchlorate, which I'm not attributing to releases at the subject site, at the BFM/DRSS facility." (RRT 9090:2-4, emphasis added.) In this vein, OCWD's Herndon confirmed about the mega-plume figure at trial: "[Q] So what's reflected on this exhibit includes the extent of perchlorate plume that comes from the Sabic site No. 15 and flows under and past the DRSS, or former BFM Energy site at No. 7; correct? [A] Correct." (RRT 1929:16-22, emphasis added.) The Final FS should therefore make it clear that there are perchlorate impacts depicted under and beyond the 2040 Site that did not originate there."*

Response 2-04:

As described in the introduction to the Draft OU2 FS Report, groundwater contamination in the Shallow Aquifer System is from numerous groundwater contamination source sites located within the SBGPP Study Area. The Draft OU2 FS Report does not indicate which OU2 COCs are attributed to specific source sites. It does reference the Preliminary RI Report with respect to identification of COCs for specific source sites.[5]

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 2-05:

> *"According to OCWD, Five Times the MCL is the Real Threshold for Active Remediation. In the Draft FS at ES-4, the third recommended remedial action objective is to prevent "the spread of COCs exceeding maximum contaminant levels (MCLs) in the leading-edge areas of the plume." Yet, the much-touted MCLs are not the relevant standard for these solvent plumes. Indeed, Brown has sworn under oath for almost a decade that the real threshold for the OU 2 shallow aquifer is five times the MCL: "You've testified many times, going back to 2012 in this case, that for concentrations of offsite contamination in groundwater at less than five times the MCL, there would be no need for active remediation, as such concentrations could be addressed over longer*

[5] Section 1.6, page 12 of the draft OU2 FS Report.

> *periods by monitored natural attenuation, right? A: Yes, that's my opinion…" (RRT 996:22-997:5, emphasis added). It should be made clear in the Final FS that while remediation of VOCs to MCLs may be a goal, contamination at less than five times the MCL will not need active remediation."*

Response 2-05:

As stated in the Draft OU2 FS Report, USEPA guidance with respect to interim actions can include stabilizing the site or operable unit and/or preventing further migration of contaminants or further environmental degradation[6]. Given the potential for further environmental degradation, remedial action objective (RAO) 3 includes reference to COC maximum contaminant levels (MCLs), not some multiple of MCL.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 2-06:

> *"OCWD is actually using the 5x MCL standard – just not for the South Basin! As OCWD relayed in a 2021 webinar (later posted to OCWD's YouTube channel), the District uses 5x MCL contours for mapping for VOCs in groundwater in the North Basin"*

Response 2-06:

The 5x MCL is a contour interval, not a standard. As indicated in the source cited by DRSS, "the objective of the interim remedy is to contain groundwater contamination above drinking water standards…"[7]. The cited concentration contour interval (multiples of NL or MCL) was used for the North Basin RI/FS. The South Basin RI/FS used different, yet commonly used, contour intervals, e.g., 1, 10, 100, etc. parts per billion.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 2-07:

d. "Yet, OCWD never asked Anthony Brown, or Chris Ross (Project Manager for the RI/FS at two firms) to contour anything at 5x MCL in the South Basin – nor has it done so itself. (RRT 8757:11-22 – Herndon; RRT 1607:21-24 – Ross.) While OCWD has known of Brown's 5x MCL reality for almost a decade, it chose to suppress the fact from years of iterations of its South Basin RI Report – and does so again in the South Basin Draft FS.

The alleged plumes should be contoured at 5x MCL so the public and decision-makers can see

[6] Section 1.1, page 3 of the draft OU2 FS Report
[7] https://www.youtube.com/watch?v=KrEbVAiliqk (time about 24:27, Commentary)

what they actually look like. DRSS believes that doing so will demonstrate that certain remedial features are not necessary or cost-effective. In fact, DRSS is confident that if this reality-based contouring is done, the plume(s) requiring active remediation will shrink if not disappear. Thus, DRSS asks that in the Final FS OCWD contour the solvent plumes at 5x MCL. This is the information upon which OCWD should be making its decisions before spending millions more in the South Basin."

Response 2-07:

Refer to responses 2-04 and 2-05.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 3-01:

3. *The Distal End Just-In-Case Pump and Treat Wells Should Be Eliminated.*

   a. *DRSS's Response Actions Have Been Satisfactory to the RWQCB and OCWD. If DRSS wasn't doing a good job, maybe there would be more need for the proposed just-in-case groundwater extraction wells at the distal end near Baxter Health Care (Baxter) and Edwards Lifesciences (Edwards). Yet, that is not the case. For example, OCWD's prior head of Special Projects for the South Basin, Bill Hunt, testified: "I think the DRSS plume is defined." (RRT 9517:14-15, emphasis added). Likewise, RWQCB's Dr. Mona Behrooz testified: "[Q] Has DRSS adequately delineated the offsite groundwater plume vertically? A. Yes." (RRT 9494:18-20, emphasis added.) Anthony Brown was impeached at the South Basin trial with deposition testimony where he admitted that DRSS's in situ remedial approach, coupled with natural attenuation, would ultimately achieve the remedial goals for groundwater. (RRT 9186:11-19.) Moreover, in a 2020 meeting with the RWQCB, the District's top technical staff (Herndon, David Bolin, and Hunt) admitted that they were satisfied with DRSS's work and it was mutually agreed that future planned remedial efforts by DRSS would be sufficient and no OCWD action was necessary. (RRT 9435:21-9436:3, 9437:4-12 – RWQCB's Dr. Nick Amini.) All of this should be acknowledged in the Final FS as one reason why the 2040 Site isn't the basis for any planned just-in-case wells.*

Response 3-01:

OCWD prepared the Draft OU2 FS in cooperation with the Department of Toxic Substances Control and California Regional Water Quality Control Board to develop an interim remedy that addresses contamination that has migrated off of source properties where releases have occurred and are commingled downgradient of the source sites[8]. The transect along the southeast portion of the Study Area[9] is required to ensure that OU2 FS RAO 3 is achieved. This transect is meant

[8] Section 1.3 of the Draft OU2 FS.
[9] Transect "G-7" on Figures 7-2, 7-3 and 7-4 of the Draft OU2 FS Report, also referred to as Transect "I-7" on Figure 7-4.

to address the commingled plume downgradient of the DRSS and other sites. Based on on-going groundwater assessment activities being conducted by DRSS downgradient of the BFM site[10], the extent of impacts from the DRSS site have not been delineated[11] and DRSS has not initiated groundwater remediation in the area downgradient of Alton Parkway[12].

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 3-02:

b. *"Using 5x MCL is More Realistic Given OCWD's Anthony Brown.* *Acknowledging that no active remediation is necessary for solvents at less than 5x MCL, compels the elimination of the just-in-case wells. Apart from two high levels of contamination at Baxter and Edwards (orange below in original), even the misleading mega-plume figures show that for thousands of feet upgradient from those proposed wells there are only impacts in the 1-10 parts per billion (ppb) range (see below from Draft FS Figure 7-2 and Figure 1-2).*

Since the MCL for both perchloroethylene (PCE) and trichloroethylene (TCE) is 5 ppb, 5x MCL for each is 25 ppb. Thus, according to Anthony Brown, no active remediation is necessary for the non-Baxter/Edwards distal end of the alleged mega- plume! "

Response 3-02:

Refer to responses 2-04, 2-05 and 3-01.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 3-03:

Anthony Brown has also been helpful in confirming that the 2040 Site does not drive the just-in-case distal end wells. When asked about the length of the 2040 Site impacts when viewed under his active remediation threshold, Brown admitted: "I would anticipate that the chlorinated solvent plume associated with releases at the DRSS facility at concentrations greater than five times the MCL would extend to the south beyond the area marked for Kaiser Electroprecision,

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[10] Leymaster Environmental Consulting, LLC., Off-Site Groundwater Monitoring Well Installation and Grab Sampling Report dated July 29, 2021.
https://documents.geotracker.waterboards.ca.gov/esi/uploads/geo_report/9054438710/T0605900807.PDF

[11] Figure 7 in Leymaster Environmental Consulting, LLC., Second Half 2021 Groundwater Sampling Report dated January 14, 2022 includes a query on the 100 microgram per liter isopleth for total VOCs in Zone B neat Alton Parkway indicating the extent of contaminants are not defined downgradient of existing monitoring well network.
https://documents.geotracker.waterboards.ca.gov/esi/uploads/geo_report/8416164696/T0605900807.PDF

[12] Leymaster Environmental Consulting, LLC., Report of Waste Discharge: Downgradient Treatment Zone Pilot Test Former BFM Energy Products Corporation 2040 East Dyer Road Santa Ana, California 92705dated January 17, 2022.
https://documents.geotracker.waterboards.ca.gov/esi/uploads/geo_report/2867816329/T0605900807.PDF

but realistically not much further than that, as all of the concentrations further downgradient are less than five times the MCL." (RRT 9201:3-10, emphasis added.)

Response 3-03:

Refer to responses 2-04, 2-05, and 3-01.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 3-04:

c. *"Only the Baxter Site Could Provide Justification for the Proposed Contingency Wells. The OU2 FS did evaluate whether the 2040 site had defined the extent of its plume and did not allocate responsibility for OU2 cleanup. If the just-in-case distal end wells remains, it must be made clear in the Final FS that the driver is high levels of 1,4-dioxane at Baxter. Below is Draft FS Figure 1-19 showing Baxter's 1,4-dioxane at over 100x MCL immediately up- gradient of the proposed wells:*

OCWD knows there is no 1,4-dioxane associated with the 2040 Site. As Anthony Brown testified: "And 1,4-dioxane is not a contamination of concern for the 2040 Site either; correct? [A] That is correct." (RRT 9165:14-16, emphasis added.) This should be made clear in the Final FS."

Response 3-04:

Refer to response 3-01.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 3-05:

d. *"Pump and Treat is Disfavored Modernly. As the EPA depicts in its most recent Superfund Remedy Report (July 2020), pump and treat (P&T) is now clearly disfavored as a groundwater remedy (red data line in the adjacent graph). The trend is based upon EPA's own evaluation of over 5,000 decision documents spanning 35 years. In 1982, EPA selected P&T 100% of time; by 2017, EPA selected of P&T had dropped to only 19%. On the other hand, in situ treatment (like at the 2040 Site) shows exactly the opposite trend – steadily going from 0% in the early 1980s to over 50% as of 2013 (dark blue data line in the above graph).*

Many reasons underlie these trends, including the poor performance of P&T in the long run,

> *its high cost, and the proven effectiveness of in situ remedies. Moreover, P&T is not a green solution. As stated by the EPA in late 2021: "More than 80 percent of the groundwater remedies selected for Superfund sites in the early 1990s included P&T systems, some of which still operate. Although selection of remedies involving P&T has since declined significantly, to about 20 percent in fiscal year 2017, newer P&T systems are anticipated to similarly operate for long time periods. As a result, the most significant opportunities to minimize the environmental footprint of P&T implementation concern usage of energy and treatment materials over multiple years, in some cases decades." DRSS finds no evaluation by OCWD in the Draft FS of the "environmental footprint" of adding the just-in-case P&T system at the alleged distal end adjacent to Baxter. This is improper.*
>
> *As a result of at least the above reasons, the Final FS should eliminate the distal end just- in-case P&T extraction wells."*

Response 3-05:

As the DRSS comment indicates, the number of pump and treat (P&T) systems have declined over time, but it is clear that P&T is still being used. As stated on page A-10 of the EPA document that the DRSS comment references[13] "'(P&T) systems also are used to 'contain' the contaminant plume. Containment of the plume keeps [the plume] from spreading by pumping contaminated water toward the wells. This pumping helps keep contaminants from reaching drinking water wells, wetlands, streams, and other natural resources' (EPA, 2012h)"[14]. This is consistent with OU2 FS RAOs 1 to 3 and 5.

The Draft OU2 FS Report did evaluate the use of in-situ chemical oxidation (ISCO) in lieu of P&T (Alternative 5). The estimated cost to implement ISCO in lieu of P&T was extraordinarily higher than P&T (Alternatives 3 or 4) even though it would be operated for a similar duration as P&T. In addition, the preliminary sustainability assessment also indicated that the ISCO (Alternative 5) was the least energy efficient and had the highest carbon dioxide emissions for all of the alternatives evaluated

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 3-06:

> *"If OCWD is committed to installing them regardless of these facts, then OCWD should at least state the wells are a contingency for the Baxter site, not the 2040 Site which is implementing an admittedly satisfactory in situ remedy.*

[13] https://www.epa.gov/sites/default/files/2020-07/documents/100002509.pdf
[14] A Citizen's Guide to Pump and Treat. OSWER. September. EPA 542-F-12-017.

Response 3-06:

Refer to response 3-01.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

Comment 4-01:

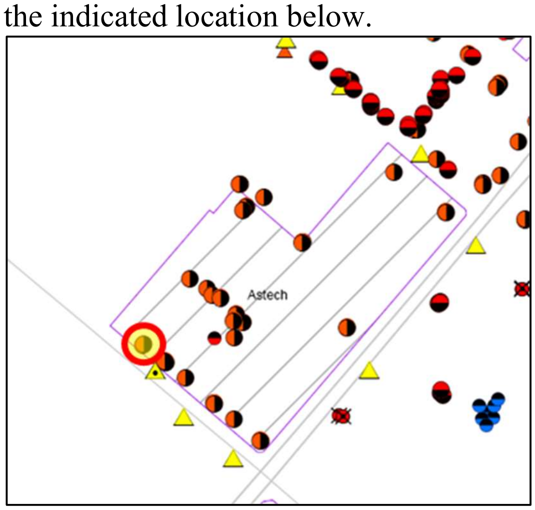
4 *<u>"Missing Historic Data.</u> The Draft FS says it is based upon data and results from various public databases "and a host of individual source site investigators that have conducted or are conducting various source site groundwater assessment and remediation activities for responsible and potentially responsible parties…" Reference response 202 Yet, the Draft FS ignores certain off-site historic investigation data associated with the 2040 Site. For example, directly below is a highlighted version of Figure 2 from Environ's August 1, 1995 Interim Remedial Action Plan (with highlights showing the monitoring well numbers):*

Despite this publically-available information generated under RWQCB oversight, the Draft FS does not include any information regarding MWs 37A, 41A/B, 53A/B, or 54A/B. For example, below is Figure 1-5 from the Draft FS (blue highlighted added to approximate the railroad track and orange for the missing MWs)

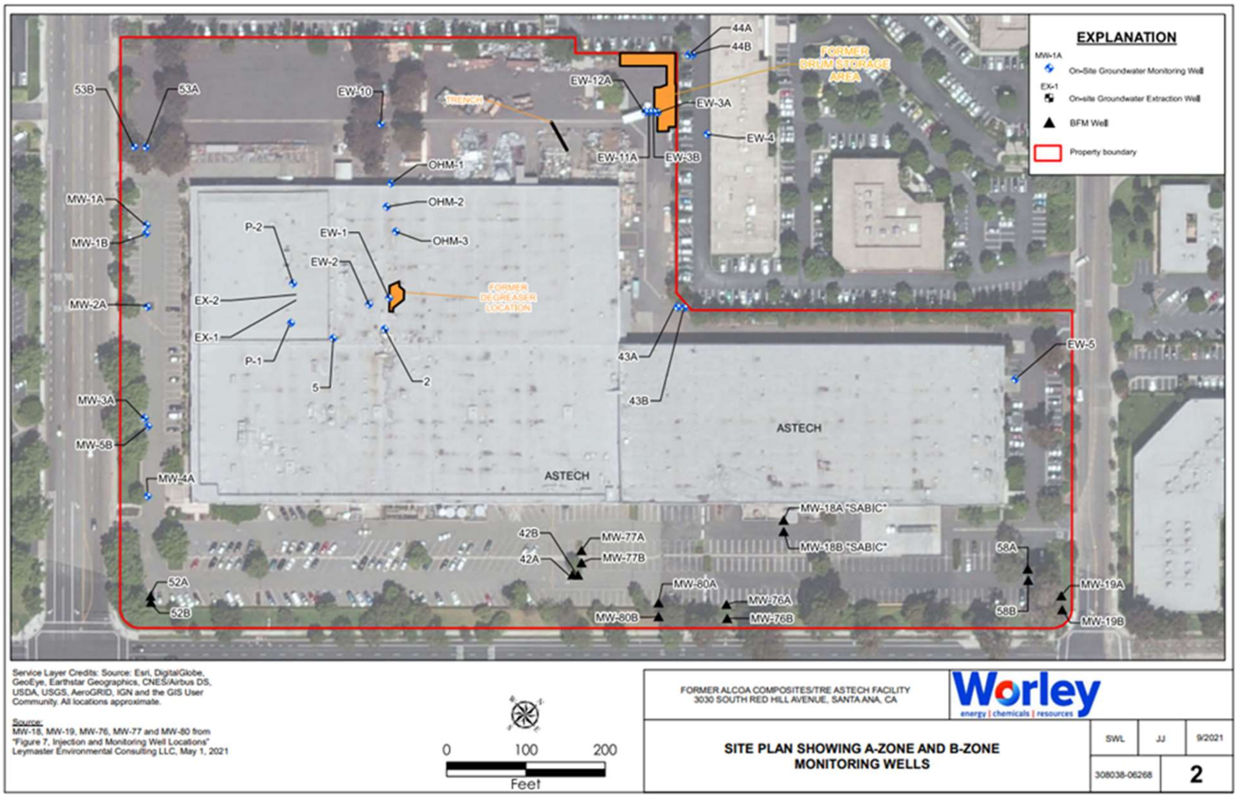
This oversight should be corrected in the Final FS."

Response to 4-01:

Existing monitoring wells MW-53A/B are included in Figure 1-5 of the Draft OU2 FS Report at the indicated location below.



The purple-outlined polygon labeled as "Astech" in the above figure represents the approximate location of the property boundaries, not to be confused with the building footprint. See below site plan figure of 53A/B's location in comparison to the property boundary[15].



It does not appear that water quality data are readily available for the other monitoring wells referenced in the DRSS comment. According to Table 2 of the BFM First Half 2022 GW Sampling Report[16], MW-37A and MWs-41A/B were abandoned in January 2004. Monitoring wells MW054A/B were also identified as abandoned in Figure 2 of the same report; however, no information could be found on the date of abandonment for these wells in the above-mentioned report or in the most recent former Alcoa Semi-Annual GW monitoring report[17]. These historic wells had no data presented in Table 2 of the BFM report or Attachment 3 of the former Alcoa report. In addition, no historic data for these abandoned locations could be found in the Geotracker project database or in the Environmental Data ESIs for the BFM[18] or either of the Alcoa[19] sites.

[15] The referenced figure is from the former Alcoa July-December 2021 Semi-Annual GW monitoring report.
[16] https://documents.geotracker.waterboards.ca.gov/esi/uploads/geo_report/4175143241/T0605900807.PDF
[17] https://documents.geotracker.waterboards.ca.gov/esi/uploads/geo_report/6267840802/SLT8R1034104.PDF
[18] https://geotracker.waterboards.ca.gov/profile_report?global_id=T0605900807
[19] https://geotracker.waterboards.ca.gov/profile_report?global_id=SLT8R1034104&mytab=esidata&subcmd=edfsummarytable#esidata

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

ATTACHMENT 3
RESPONSE TO CARL BENNINGER COMMENTS, DRAFT FEASIBILITY STUDY REPORT, SOUTH BASIN GROUNDWATER PROTECTION PROJECT, OPERABLE UNIT 2

ATTACHMENT 3
RESPONSE TO
CARL BENNINGER COMMENTS,
DRAFT FEASIBILITY STUDY REPORT, SOUTH BASIN GROUNDWATER PROTECTION PROJECT, OPERABLE UNIT 2

This response to comments document has been prepared by Engineering Analytics, Inc. (EA) on behalf of the Orange County Water District (OCWD) in support of the South Basin Groundwater Protection Project (SBGPP).

This attachment is in response to an e-mail from Carl Benninger dated July 6, 2022 (Subject Comment Document) regarding the April 5, 2022 SBGPP OU2 Feasibility Study report (Draft OU2 FS Report).

Comment:

> *"Thank you for the presentation on the plan for the clean up shallow aquifer in the Delhi are of Santa Ana.*
>
> *I am in support of alternative 3 which is pumping the water to the GWRS. There is equipment already in place at the GWRS that can clean up the water. I know from the close watch and testing that the contamination from the shallow aquifer will not make it through to the water being returned to the ground.*
>
> *The two concerns I have is the possible exposure of vaporization of the chlorinated solvents from the water as it travels from Delhi to the GWRS.*
>
> *And the problem I have had in my past dealing with the DTSC. They love the words possible, may happen, could happen rather then look at the safeguards in place. I feel they are more interested in their fee collection than the company they are putting out of business or people losing their jobs. So to hear they will need several more years to study the problem bothers me. Lets pick an alternative and start the clean up"*

Response:

With respect to concern regarding possible exposure from vaporization of chlorinated solvents from the extracted water that is conveyed from OU2 to the Groundwater Replenishment System, the Orange County Sanitation District (OCSD) has ordinances with respect to discharges to industrial sewers. In the past, OCSD had allowable concentrations of total toxic organic (TTO)[1] compounds in water discharged to the sewer system. TTO includes many of the chemicals of concern (COC) which include chlorinated solvents for OU2. The current OCSD standard does not include a reference to TTO[2]. Since TTO are no longer referenced in the OCSD ordinance, the Draft OU2 FS Report has been revised to include use of liquid phase granular activated carbon (LGAC) as a pre-treatment for Alternatives 3 and 6 prior to sewer discharge. The addition of LGAC to these alternatives, while not being added in response to this comment, effectively mitigates the concern regarding vapor intrusion from extracted groundwater that is not treated for VOCs.

The other concern listed concern is not related to the Draft OU2 FS Report.

Revision to Draft OU2 FS Report:

The Draft OU2 FS Report will be revised to include LGAC treatment for extracted groundwater for the relevant alternatives. No other revisions are required.

[1] OCSD Ordinance OCSD-39 https://records.ocsan.gov/WebLink/Browse.aspx?id=89699&dbid=0&repo=OrangeCountySanitationDistrict&cr=1

[2] OCSD Ordinance OCSD-53 https://records.ocsan.gov/WebLink/Browse.aspx?id=89699&dbid=0&repo=OrangeCountySanitationDistrict&cr=1 .

ATTACHMENT 4
RESPONSE TO DTSC COMMENTS
DRAFT FEASIBILITY STUDY REPORT,
SOUTH BASIN GROUNDWATER
PROTECTION PROJECT,
OPERABLE UNIT 2

ATTACHMENT 4
RESPONSE TO
DTSC COMMENTS,
DRAFT FEASIBILITY STUDY REPORT, SOUTH BASIN GROUNDWATER PROTECTION PROJECT, OPERABLE UNIT 2

This response to comments document has been prepared by Engineering Analytics, Inc. (EA) on behalf of the Orange County Water District (OCWD) in support of the South Basin Groundwater Protection Project (SBGPP).

This attachment is in response to an e-mail from The California Environmental Protection Agency, Department of Toxic Substances Control (DTSC) transmitted comments prepared on June 16, 2022 within an e-mail to OCWD on July 11, 2022 regarding the April 5, 2022 SBGPP OU2 Feasibility Study report (Draft OU2 FS Report).

Comment:

> *"Geological Services Branch (GSB) reviewed the "Draft Feasibility Study, South Basin Groundwater protection Project, Operable Unit 2." The Draft Feasibility Study (Draft FS) is dated April 5, 2022 and was prepared by Engineering Analytics, Inc. (EA) for Orange County Water District (OCWD). The Draft FS was revised from a previous version dated September 2021 to address Technical Advisory Committee (TAC) review comments, including November 15, 2021 GSB comments. Responses to Comments were provided in a Comment Summary Table in Appendix S. GSB has no additional comments regarding the FS Report content. As an administrative item, GSB notes the Draft FS was not stamped and signed by a Professional Geologist or Professional Engineer in accordance with the Business and Professions Code; and the Response to Engineering and Special Projects Office (ESPO) Comment Number 2 states "The document will be signed by a California Professional Geologist or Professional Civil Engineer with relevant experience."*

Response:

The Final Draft OU2 FS Report will be signed and stamped in accordance with the referenced Business and Professions Code.

Revision to Draft OU2 FS Report:

The Final Draft OU2 FS Report will be signed and stamped in accordance with the referenced Business and Professions Code. No other revisions are required.

ATTACHMENT 5
RESPONSE TO TEXTRON COMMENTS
DRAFT FEASIBILITY STUDY REPORT,
SOUTH BASIN GROUNDWATER
PROTECTION PROJECT,
OPERABLE UNIT 2

ATTACHMENT 5
RESPONSE TO
TEXTRON COMMENTS,
DRAFT FEASIBILITY STUDY REPORT, SOUTH BASIN GROUNDWATER PROTECTION PROJECT, OPERABLE UNIT 2

This response to comments document has been prepared by Engineering Analytics, Inc. (EA) on behalf of the Orange County Water District (OCWD) in support of the South Basin Groundwater Protection Project (SBGPP).

This attachment is in response to an e-mail from CDM Smith on behalf of Textron dated July 5, 2022 regarding the April 5, 2022 SBGPP OU2 Feasibility Study report (Draft OU2 FS Report).

Comment:

> *"Thank you for providing Textron with the opportunity to review the draft FS for the South Basin Groundwater Protection Project OU2, dated April 5, 2022 and the May 25 SAG presentation slides. The draft FS is a very detailed, well prepared document that not only provides a detailed and accurate representation of the numerous groundwater contamination source sites located within the South Basin including comingled plumes but presents a comprehensive and well-thought out detailed evaluation of remedial alternatives for the regional groundwater plumes. These alternatives have been developed with very careful consideration of the various remedial actions either ongoing or planned at the various source sites including the groundwater extraction and treatment (GET) and sewer discharge at and downgradient of the Cherry Aerospace site, planned by Textron. We fully agree with the analysis and the comparative evaluation of the alternatives, which ranks the two GET alternatives (No. 3 and 4) the highest and hence recommended for the next steps. These alternatives also appear to be compatible with the proposed GET system at Cherry Aerospace. Two other alternatives that were considered, Alternatives 5 and 6, involved in-situ chemical oxidation (ISCO) without or with GET, respectively. In the event one of these ISCO-based alternatives are selected, it may be detrimental to the Cherry GET system which could capture the chemical injectants and associate by products of this process and significantly impact the GET, depending on the final placement of this injection wells. As a result, we do not recommend that Alternatives 5 and 6 be considered moving forward. Furthermore, these two alternatives scored much lower compared to Alternatives and 4 and it therefore appears highly unlikely that these will be selected as the final alternatives anyway.*
>
> *We truly appreciate OCWD's massive efforts and comprehensive approach in addressing the comingled plumes in the South Basin and look forward to the next steps in this process. Thank you again for the opportunity to comment."*

Response:

As the comment points out, the In-Situ Chemical Oxidation Alternatives 5 and 6 are scored lower than the groundwater extraction alternatives (Alternatives 3 and 4) which influences remedy selection. In addition, the Draft OU2 FS Report Table 8-2 indicates the potential for generation of persistent undesirable byproducts upgradient of Cherry Aerospace (Textron), which is consistent with the commenters concern.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.

ATTACHMENT 6
RESPONSE TO IRWD COMMENTS
DRAFT FEASIBILITY STUDY REPORT, SOUTH BASIN GROUNDWATER PROTECTION PROJECT, OPERABLE UNIT 2

ATTACHMENT 6 RESPONSE TO IRWD COMMENTS, DRAFT FEASIBILITY STUDY REPORT, SOUTH BASIN GROUNDWATER PROTECTION PROJECT, OPERABLE UNIT 2

This response to comments document has been prepared by Engineering Analytics, Inc. (EA) on behalf of the Orange County Water District (OCWD) in support of the South Basin Groundwater Protection Project (SBGPP).

This attachment is in response to a letter from the Irvine Ranch Water District dated June 27, 2022 regarding the April 5, 2022 SBGPP OU2 Feasibility Study report (Draft OU2 FS Report).

Comments:

> *"Regarding the Draft Feasibility Study (Engineering Analytics, Inc. April 5, 2022), IRWD offers the following additional comments:*
>
> *1. IRWD believes that the Draft Feasibility Study is a great step forward to initiate remediation of the offsite contamination.*
>
> *2. Both Alternatives 3 and 4 appear to be effective, implementable options and both appear compatible with source site remediation. Alternative 3 is stated to be more technically feasible and sustainable at a lower cost."*

Response:

The comments are consistent with the Draft OU2 FS Report.

Revision to Draft OU2 FS Report:

Revisions to the Draft OU2 FS Report are not necessary.